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CORRELATION BETWEEN SOME OF CHEMICAL COMPOSITION ELEMENTS OF ZOOPLANKTON AS WELL AS PRODUCTION EFFICIENCY AND QUALITATIVE COMPOSITION OF HIGH FATTY ACIDS PROFILE IN CARP MEAT

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The goal of the experiment was to find essential correlation between glucosamine content in zooplankton, component of natural nourishment of carp as well as glucosamine content in ingesta and fishing efficiency of ponds. Purpose of investigations was to use index values related to glucosamine content to evaluate carp production with in short-term perspectives. The correlation between selected fraction of high fatty acids (HFA) in zooplankton and content of these fractions in carp meat were also examined. It was noticed that some parameters of glucosamine content in ingesta were statistically significant correlated ($P<0,05$) with ponds fishing efficiency, especially in reference to carp fry ponds. The correlation between percentage of PUFA-3, PUFA and PUFA-MUFA sum in high fatty acids profile in commercial carp meat and contest of these fraction in high fatty acids profile in zooplankton was also determined highly statistically significant or statistical significant ($P<0,05$). Taking into account qualitative composition of high fatty acids profile and PUFA-6/3 ratio it can be noticed that biennial production cycle of light commercial carp provides higher dietary value meat than meat obtained in triennial production cycle.

Fertilization of ground carp ponds with manure and to a lesser extent with liquid bovine manure has an advantageous influence on commercial carp carcase quality, their protection against accumulation of excess of some heavy metals from an environment and increase ponds fishing efficiency by enlarging the dynamic development of aquatic invertebrates which constitute fish food (Schroeder, 1974; Ligaszewski et al., 2003).

One of characteristic chemical compound of crustacean zooplankton armourhead, the fish food, is chitin, built from glucosamine chains, which is also the component of detritus delinquenting the pond bottom, the carp natural nutriment (Donnelly et al., 2004). In aquatic environment chitin is decomposed by numerous chitinolytic bacteria by-and-by (Donderski and Trzebiatowski, 1999), in turn fishes are able to digest animal chitin with an enzyme — chitinase (Fagberno et al., 2001).

Fish meat high fatty acids (HFA) profile investigation are particularly studied in sea fish in which significant polyunsaturated fatty acids (PUFA: PUFA-3, PUFA-6) with eicosapentaenoic acid (EPA), decosahexaenoic acid (DHA) and conjugated linoleic acid (CLA) content in HFA profile (Kuza et al., 2006). Profile of high fatty acids in freshwater carp (*Cyprinus carpio L.*) and rainbow trout (*Oncorhynchus mykiss*) in central Europe aquacultures, is also a matter of research. It was noticed that HFA profile in aliment has high influence on HFA profile in carp and other cyprinide fish meat. That means it also depends on fish access to crustacean zooplankton, their natural food (Domaizon et al., 2000; Hadjinikolova, 2000). HFA profile is also modified by physiological mechanisms determined by water temperature changes (Yeo et al., 1997; Kamler and Rakusa-Suszczewski, 2000; Rasoarahona, 2004; Ligaszewski et al., 2007).

The goal of carried research was to find statistically significant relation between glucosamine content in zooplankton and in commercial carp ingesta as well as ponds fishing efficiency and between HFA chosen fraction in carp meat and in zooplankton.

MATERIAL AND METHODS

The research were carried out taken during 4 years period at Roztropice carp entity belonging to Experimental Station of the National Research Institute of Animal Production at Grodziec Śląski. Study scheme and experiment configuration were shown in table 1. According to that, in 2004 and 2006 three experimental ponds (each 2,5 ha of area) were restocked with local carp fry in the second year of life (1+), using concentration 3000 pieces per hectare. In first year of project one of the pond was fertilized with 75 q of manure per year, second one with 150 q per year and the third one, treated as a control, was not fertilized. In 2005 and 2007 three ponds were fertilized according to the same scheme and cast with commercial carp in third year of life (2+), using concentration 1000 pieces per hectare. From May to the middle of August for each carp age group bovine or ovine manure, was applied at coastal line, depending on year of study. Carps were fed with crop seeds. In late spring (at the end of June) and two weeks before autumn catgut (middle of October) random probes of 6 carps were taken from each pond. Then from each fish probes of meat taken from entire body without skin and skeleton were taken to determine a profile of high fatty acids. Simultaneously one cumulative probe of ingesta was taken from each seasonal sample of 6 carps to determine a glucosamine content. Cumulative samples of zooplankton (200 g) were taken annually, from April to June, from each pond to identify HFA profile and glucosamine percentage. Ponds fishing efficiency ratio was carp biomass assumed increment (kg per hectare), ratio of number of carps collected during autumn catgut with difference between average body mass of collected carps and body mass of carps during ponds restocking in spring.

Ingesta and zooplankton glucosamine content was identified with Elson-Morgan method (Fiema, 1983). Carp ingesta was dried at 60°C during 36–48 hours and homogenized. Closed glass ampoules were used to ingesta hydrolysis — 3N HCl was added to 50 mg of sample at 100°C for 30 hours. In turn samples were centrifuged, twice rinsed with distilled water, ooze were collected and evaporated. Evaporated ooze were dissolved in eligible amount of distilled water. Glucosamine was determined spectrophotometrically at 530 nm wave length according to Elson-Morgan method.

High fatty acids profile was determined as methyl esters using gas chromatography. Samples preparing was performed based on Folch method (1957), using sample homogenization in chloroform:methanol (2:1) mixture, solvent evaporation, then saponification (0,5 N NaOH methanolic solvent) and estryfication (BF_3 methanolic solvent). Heksanoic extracts of fatty acids methyl esters derivatives were examined using gas chromatograph VARIAN 3400. Following high fatty acids profiles in commercial carp meat (2+) and in zooplankton was subjects of comparative analysis: PUFA, PUFA-3, PUFA-6, EPA, DHA, CLA, MUFA, MUFA+PUFA and PUFA-6/3 ratio.

Regression analysis and single-factor variation in Statistic 5.0 software were used to determined statistical results.

RESULTS

Correlation between zooplankton as well as carp ingesta glucosamine content and experimental ponds fishing efficiency

Carp fry and commercial carp restocks and catguts scale were shown in table 1. These data allowed fishing efficiency rate evaluation (tab. 2, fig. 1). It was noticed that average elementary increment and assumed increment of commercial carp (2+) after autumn catguts was higher when bovine manure was used comparing to ovine manure. This relation was not observed at

Table 1. **Restockings and catguts from experimental ponds specification in years 2004–2007**

Carp	Manure doze; Pond area	Manure; year	Restockings		Catguts	
			pieces/ha	kg/ha g/pcs	pieces/ha	kg/ha pcs/kg
Carp fry	control					
	0 q/ha;	bovine; 2004	3000	16,4 5,5	1696	376 221,7
	2,5 ha	ovine; 2006	3000	40,0 13,3	808	584 722,7
	75 q/ha;	bovine; 2004	3600	16,3 5,4	376	416 1106,4
	2,5 ha	ovine; 2006	3600	52,0 14,4	880	352 400,0
	150 q/ha;	bovine; 2004	3000	27,0 9,0	1260	400 317,5
	2,0 ha	ovine; 2006	3000	35,0 11,7	811	630 776,8
Commercial carp	control					
	0 q/ha;	bovine; 2005	1000	332,0 332,0	604	804 1331,1
	2,5 ha	ovine; 2007	1000	148,0 148,0	972	856 880,7
	75 q/ha;	bovine; 2005	1200	208,0 173,3	820	1060 1292,7
	2,5 ha	ovine; 2007	1200	176,0 146,7	700	776 1108,6
	150 q/ha;	bovine; 2005	1000	200,0 200,0	638	1010 1583,1
	2,0 ha	ovine; 2007	1000	145,0 145,0	840	880 1047,6

Table 2. **Farm results of carp restockings and catguts from experimental ponds fertilized with bovine and ovine manure**

Carp	Pond	Manure; year	Average elementary increment, g/pieces	Assumed increment, kg/ha
Carp fry	control	bovine; 2004	216,0	366,0
	0 q/ha	ovine; 2006	589,5	344,3
	75 q/ha	bovine; 2004	1101,0	414,0
		ovine; 2006	386,0	339,7
	150 q/ha	bovine; 2004	308,5	389,3
		ovine; 2006	765,1	620,5
Commercial carp	control	bovine; 2005	999,1	603,5
	0 q/ha	ovine; 2007	733,0	661,7
	75 q/ha	bovine; 2005	1120,0	918,4
		ovine; 2007	962,3	673,6
	150 q/ha	bovine; 2005	1384,0	882,3
		ovine; 2007	903,0	794,6

ponds with carp fry (1+). Average conclusions gained after four years of experiments, for manured ponds comparing to control pond, were advantageous for economic results without allowing for kind of manure. In such long-term point of view, assumed increment was increasing proportionally to manuration level in carp fry ponds (1+) and in commercial carp ponds (2+) alike. In carp fry ponds fertilized with 75 q per hectare of manure these increment was 6,1% higher comparing to the control pond and in pond fertilized with 150 q of manure per hectare these difference amount 42,1%. In commercial carp ponds the differences amount 25,8% and 32,5% respectively.

As it is shown in table 3 glucosamine percentage in zooplankton cumulative samples from April to June, expanded according to ponds fertilization level was increasing in

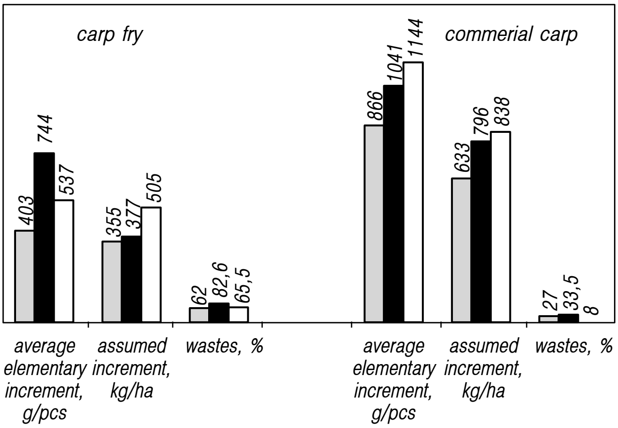

Figure 1. **Fundamental average values of farm results from manure fertilized ponds and control ponds in years 2004–2007.** ▫ — control; ▪ — 75 g/ha; ▫ — 150 g/ha

carp fry ponds (1+), from 1,25% in control pond to 1,54% in pond with highest manure amount used. By contrast, in the same ponds restocked in different years with commercial carp (2+) zooplankton glucosamine content was decreasing, from 1,49% to 1,18% respectively. Average ingesta glucosamine content in carp fry and commercial carp alike was descending in the spring (from 1,49% to 1,31% and from 1,55% to 0,93% respectively) and was increasing in the autumn (from 1,15% to 1,98% and from 1,20% to 2,06% respectively) according to ponds manuring level. As it was shown in table 4, average

Table 3. **Carp ingesta and zooplankton glucosamine content**

Year	Carp age	Glucosamine content, % dry matter		
		Ingesta		Zooplankton entire season
		Spring	Autumn	
Control pond without manuring				
2004	1+	1,52	1,20	1,19
2005	2+	1,30	1,64	1,40
2006	1+	1,45	1,10	1,31
2007	2+	1,80	0,76	1,58
	Average 1+	1,49	1,15	1,25
	Average 2+	1,55	1,20	1,49
	Average:	1,52	1,18	1,37
Pond fertilized with bovine or ovine manure (75 q/ha)				
2004	1+	1,46	1,24	1,18
2005	2+	0,72	1,76	1,16
2006	1+	1,54	1,40	1,31
2007	2+	1,40	1,13	1,23
	Average 1+	1,50	1,32	1,25
	Average 2+	1,06	1,45	1,20
	Average:	1,28	1,38	1,22
Pond fertilized with bovine or ovine manure (150 q/ha)				
2004	1+	1,36	1,80	1,31
2005	2+	1,15	1,52	1,56
2006	1+	1,26	2,16	1,76
2007	2+	0,70	2,60	0,80
	Average 1+	1,31	1,98	1,54
	Average 2+	0,93	2,06	1,18
	Average:	1,12	2,02	1,36

Table 4. **Carp ingesta and zooplankton glucosamine content differences**

Year	Carp age	Carp ingesta and zooplankton glucosamine content differences between spring and autumn samples, % D.M.	Carp ingesta and zooplankton glucosamine content difference, % D.W.		
			Spring	Autumn	Average
Control pond without manuring					
2004	1+	–21,1	27,7	0,8	14,3
2005	2+	26,2	–7,1	17,1	5,0
2006	1+	–24,1	10,7	–16,0	–2,7
2007	2+	–57,8	13,9	–51,9	–19,0
	Average 1+	–22,6	19,2	–7,6	5,8
	Average 2+	–15,8	3,4	–17,4	–7,0
	Average:	–19,2	11,3	–12,5	–0,6
Pond fertilized with bovine or ovine manure (75 q/ha)					
2004	1+	–15,1	23,7	5,1	14,4
2005	2+	144,4	–37,9	51,7	6,9
2006	1+	–9,1	17,6	6,9	12,3
2007	2+	–19,3	13,8	–8,1	2,9
	Average 1+	–12,1	20,7	6,0	13,4
	Average 2+	62,6	–12,1	21,8	4,9
	Average:	25,2	4,3	15,0	9,7
Pond fertilized with bovine or ovine manure (150 q/ha)					
2004	1+	32,4	3,8	37,4	20,6
2005	2+	32,2	–26,3	-2,6	–14,5
2006	1+	71,4	–28,4	22,7	–2,9
2007	2+	271,4	–12,5	225,0	106,3
	Average 1+	51,9	–12,3	30,1	8,9
	Average 2+	151,8	–19,4	111,2	45,9
	Average:	101,5	–15,9	70,6	27,4

difference between glucosamine content in both carp fry and commercial carp ingesta in autumn and in spring was increasing according to ponds manuring level, with autumn period advantage (from –22,6% to +51,9% and from –15,8% to 151,8% respectively). In turn the difference between glucosamine content in both carp fry and commercial carp ingesta with zooplankton glucosamine content was decreasing according to ponds manuring level, with ingesta glucosamine level in spring (from +19,2% to –12,3% and from +3,4 to –19,4% respectively). By contrast, for both carp kinds, these differences was increasing, with ingesta glucosamine content in autumn (from –7,6% to +30,1% and from –17,4% to 111,2% respectively).

Differences between spring and autumn glucosamine content in both carp fry and commercial carp ingesta with zooplankton glucosamine content were confirmed with single-factor regression analysis results shown in table 5. Statistically significant correlations ($P<0,05$) between carp ingesta and zooplankton glucosamine content from experimental and control ponds were noticed. Zooplankton glucosamine content increment was connected with fish ingesta glucosamine content decrement: in carp fry (+1) in spring ($r = –0,82$) and in commercial carp (2+) in autumn ($r = –0,81$). Comparable statistically significant relations ($P<0,05$) were found between carp fry and commercial carp ingesta glucosamine content in spring and its content in autumn ($r = –0,86$ and $r = –0,89$ respectively).

Single-factor variation results (table 6) exemplify at figures 2 and 3 showed a statistically significant correlation ($P<0,05$) between carp biomass assumed increment (kg per hectare) as well as some parameters

Table 5. **Results of ingesta and zooplankton glucosamine content single-factor regression analysis**

Dependent variable, Y Glucosamine content, %	Independent variable, x Glucosamine content, %	Regression equation	r	r^2	Differences significance (P<)
		Carp fry			
Ingesta spring	Zooplankton entire season	Y= –0,4x + 1,97	–0,82	66,7	0,05
Ingesta autumn	Ingesta spring	Y= –3,38x + 6,32	–0,86	74,2	0,05
		Commercial carp			
Ingesta autumn	Zooplankton entire season	Y= –1,73x + 3,79	–0,81	65,9	0,05
Ingesta autumn	Ingesta spring	Y= –1,31x + 3,12	–0,89	78,8	0,05

Table 6. **Results of farm fishing production and zooplankton and ingesta glucosamine content single-factor regression analysis**

Dependent variable, Y Carp biomass assumed increment, kg/ha	Independent variable (x) Glucosamine content, % D.M.	Regression equation	r	r^2	Differences significance (P<)
		Carp fry			
Total carp biomass assumed increment (kg/ha)	Ingesta and zooplankton glucosamine content difference (%)	Y= –4,47x+ 453,4	–0,86	74,0	0,05
	Spring and autumn ingesta glucosamine content difference (%)	Y= 2,38 + 398,6	0,86	74,1	0,05
	Ingesta glucosamine content;				
	spring;	Y=–854,6x+1635,8	–0,85	72,2	0,05
	autumn	Y=209,5x+101,5	0,82	66,9	0,05
	Zooplankton glucosamine content	Y= 436,0x — 173,4	0,88	77,2	0,05
		Commercial carp			
Total carp biomass assumed increment (kg/ha)	Spring ingesta and zooplankton glucosamine content (%)	Y= –5,17x+ 707,3	–0,84	70,86	0,05

related with fish ingesta and zooplankton glucosamine content. Ponds fishing efficiency was decreasing with different changes between glucosamine content in carp ingesta in spring and zooplankton glucosamine content in ranges from –28,4% to 0,0% and from 0,0% to 27,7% for carp fry (1+) and in ranges from –37,9% to 0,0% and from 0,0% to 13,9% for commercial carp (2+). For carp fry (1+) ponds fishing efficiency was increasing with different changes between glucosamine content in ingesta in autumn and in spring in ranges from –24,1% to 0,0% and from 0,0% to 71,4% (fig. 2). Additionally, this efficiency was increasing for carp fry (1+) proportionally to ingesta and zooplankton glucosamine content increment in autumn and was decreasing with ingesta glucosamine content in spring (fig. 3).

Correlation between some fraction of high fatty acids in commercial carp meat HFA profile and HFA fractions share in zooplankton

PUFA-3 content of HFA profile in 3 years old commercial carp meat from experi-

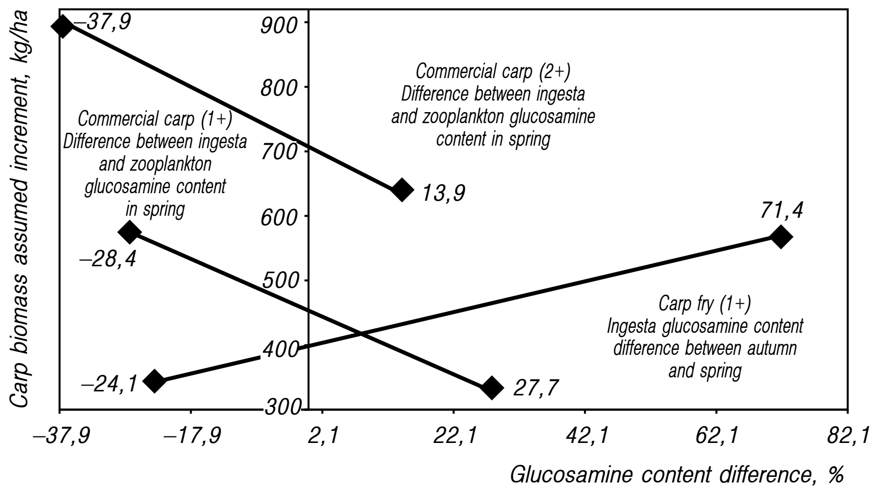

Figure 2. **Correlation between carp biomass total assumed increment in experimantal ponds and ingesta and zooplankton glucosamine content regression eguation plots based on table 6**

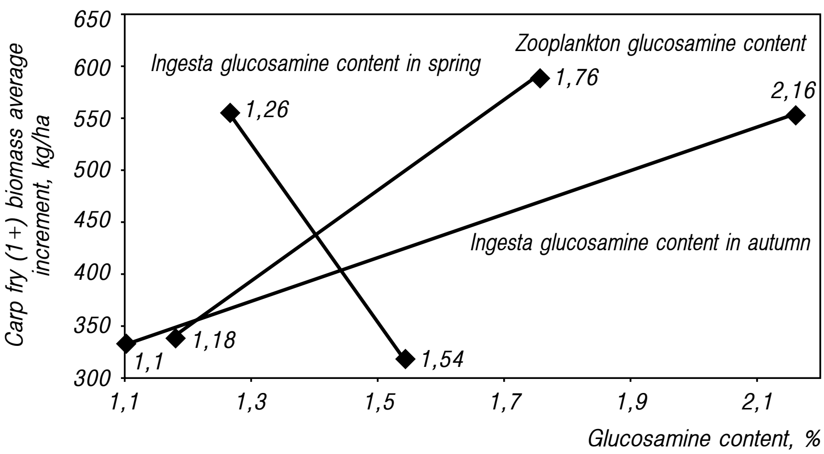

Figure 3. **Correlation between carp fry (1+) biomass total average increment and glucosamine content in ingesta and zooplankton, based on table 6**

mental ponds in autumn was oscillating at an average from 2,2% to 3,3%, PUFA-6 from 10,7% to 11,2%, PUFA from 14,7% to 15,4%, EPA from 0,5% to 0,9%, DHA from 0,7% to 0,9%, CLA from 2,9% to 3,3%, MUFA from 55,7% to 56,8%, MUFA+PUFA from 71,2% to 71,5% and PUFA-6/3 ratio from 2,83% to 5,40% (tables 7–9). Statistically significant correlation between high fatty acids profile in commercial carp meat was not found in spring and autumn between ponds with different manuring level. In autumn period in 2005 comparing to spring period in meat samples highly statistically significant relations ($P<0,01$) between some fractions of HFA (PUFA-3, PUFA-6, PUFA, EPA, DHA) percentages decrement and increment ($P<0,05$) or deficiency of between-seasonal difference of CLA, MUFA and MUFA+PUFA level were noticed. From spring to autumn PUFA-6/3 ratio was increasing in highly significant way ($P<0,05$). This ratio was highly significant ($P<0,01$) higher in pond fertilized with lower doze of manure than in control pond and pond fertilized with higher doze of manure. Meat samples analysis were not evaluated in spring 2007 and that is why between-seasonal differences can not be reviewed. Highly significant or significant correlations between PUFA-3, PUFA and MUFA+PUFA content in high fatty acids

Table 7. **Carp meat and zooplankton PUFA-3, PUFA-6 and PUFA content**

Year	Carp age	Carp meat						Zooplankton		
		PUFA-3		PUFA-6		PUFA		PUFA-3	PUFA-6	PUFA
		spring	autumn	spring	autumn	spring	autumn	entire season	entire season	entire season
Control pond without manuring										
2004	1+	30,4	21,2	23,4	31,1	57,0	55,1	46,9	14,6	61,9
2005	2+	19,4	3,0	25,8	15,1	47,2	21,2	33,0	17,3	51,1
2006	1+	8,5	3,2	11,4	9,0	18,3	14,3	24,8	10,1	35,7
2007	2+	–	2,4	–	6,4	–	8,8	34,1	11,3	45,3
Average 1+		19,4	12,2	17,4	20,0	37,7	34,7	35,8	12,3	48,8
Average 2+		–	2,7	–	10,7	–	13,4	33,6	14,3	48,2
Average:		19,4	7,5	20,2	15,4	40,8	24,9	34,7	13,3	48,5
Pond fertilized with bovine or ovine manure (75 q/ha)										
2004	1+	28,0	13,4	24,4	31,9	55,2	47,9	40,6	17,3	58,1
2005	2+	17,3	2,3	28,3	16,1	48,6	21,0	37,5	16,3	54,9
2006	1+	10,1	3,7	11,4	9,5	23,0	15,1	36,5	8,7	45,5
2007	2+	–	2,1	–	6,2	–	8,4	32,0	10,6	42,6
Average 1+		19,1	8,6	17,9	20,7	39,1	31,5	38,6	13,0	51,8
Average 2+		–	2,2	–	11,2	–	14,7	34,8	13,5	48,8
Average:		18,5	5,4	21,5	15,9	42,4	23,2	36,7	13,2	50,3
Pond fertilized with bovine or ovine manure (150 q/ha)										
2004	1+	23,4	19,0	19,4	36,4	45,7	58,2	45,9	16,2	62,5
2005	2+	17,8	4,6	28,6	15,1	47,7	22,5	34,0	22,5	56,9
2006	1+	12,4	3,2	12,7	9,1	26,2	14,3	37,4	9,8	47,3
2007	2+	–	2,1	–	6,3	–	8,4	32,3	5,7	38,0
Average 1+		17,9	11,1	16,0	22,7	35,9	36,3	41,7	13,0	54,9
Average 2+		–	3,3	–	10,7	–	15,4	33,2	14,1	47,5
Average:		17,9	7,2	20,2	16,7	39,9	25,8	37,4	13,6	51,2

Table 8. **Carp meat and zooplankton EPA, DHA and PUFA-6/3 ratio content**

Year	Carp age	Carp meat						Zooplankton		
		PUFA-6/3		EPA		DHA		PUFA-6/3	EPA	DHA
		spring	autumn	spring	autumn	spring	autumn	entire season	entire season	entire season
Control pond without manuring										
2004	1+	0,79	1,55	9,40	5,90	11,4	11,2	0,31	23,4	3,80
2005	2+	1,40	5,60	6,60	0,70	7,20	1,00	0,50	11,9	8,10
2006	1+	1,40	2,90	2,00	0,70	2,50	1,20	0,40	5,60	1,30
2007	2+	–	2,66	–	0,40	–	0,90	0,33	11,0	8,20
Average 1+		1,10	2,23	5,70	3,30	7,00	6,20	0,36	14,5	2,60
Average 2+		–	4,13	–	0,60	–	1,00	0,42	11,5	8,20
Average:		1,20	3,18	6,00	1,90	7,00	3,60	0,39	13,0	5,40

And of table 8

Year	Carp age	Carp meat						Zooplankton		
		PUFA-6/3		EPA		DHA		PUFA-6/3	EPA	DHA
		spring	autumn	spring	autumn	spring	autumn	entire season	entire season	entire season
Pond fertilized with bovine or ovine manure (75 q/ha)										
2004	1+	0,89	2,40	8,10	3,70	13,1	6,00	0,43	21,4	0,90
2005	2+	1,70	7,80	6,10	0,50	5,00	0,50	0,40	15,0	6,70
2006	1+	1,70	2,80	2,40	0,80	2,40	1,20	0,20	11,9	2,80
2007	2+	–	2,99	–	0,40	–	0,80	0,33	8,30	14,8
Average 1+		1,00	2,60	5,3	2,30	7,80	3,60	0,32	16,7	1,90
Average 2+		–	5,40	–	0,50	–	0,70	0,37	11,7	10,8
Average:		1,23	4,00	5,5	1,40	6,80	2,10	0,34	14,2	6,30
Pond fertilized with bovine or ovine manure (150 q/ha)										
2004	1+	0,85	1,98	7,10	5,10	8,00	10,1	0,35	25,7	2,80
2005	2+	1,60	3,00	6,00	1,40	3,90	0,90	0,70	16,1	5,10
2006	1+	1,00	2,50	3,10	0,70	2,80	1,20	0,30	11,4	0,50
2007	2+	–	2,66	–	0,40	–	0,80	0,18	10,7	12,0
Average 1+		0,93	2,24	5,10	2,90	5,40	5,70	0,33	18,6	1,70
Average 2+		–	2,83	–	0,90	–	0,90	0,44	13,4	8,60
Average:		1,15	2,54	5,40	1,90	4,90	3,3	0,38	16,0	5,10

Table 9. **Carp meat and zooplankton CLA, MUFA and MUFA+PUFA sum content**

Year	Carp age	Carp meat						Zooplankton		
		CLA		MUFA		MUFA+PUFA		CLA	MUFA	MUFA+PUFA
		spring	autumn	spring	autumn	spring	autumn	entire season	entire season	entire season
Control pond without manuring										
2004	1+	3,3	2,8	19,0	21,6	76,2	76,7	0,5	17,5	79,4
2005	2+	1,9	3,2	20,7	54,1	67,9	75,3	0,8	20,4	71,6
2006	1+	1,6	2,1	46,1	58,0	68,9	72,3	0,8	27,9	63,6
2007	2+	–	3,4	–	60,4	–	69,2	0,0	19,6	64,9
Average 1+		2,5	2,5	32,6	39,8	72,6	74,5	0,7	22,7	71,5
Average 2+		–	3,3	–	57,3	–	72,3	0,4	20,0	68,3
Average:		2,3	2,9	28,6	48,5	71,0	73,4	0,5	21,4	69,9
Pond fertilized with bovine or ovine manure (75 q/ha)										
2004	1+	2,7	2,6	14,7	25,6	70,4	74,0	0,3	19,5	77,6
2005	2+	3,0	2,6	22,0	53,4	70,6	74,4	1,1	15,9	70,8
2006	1+	1,5	2,0	43,7	57,0	66,7	72,1	0,3	18,2	63,7
2007	2+	–	3,2	–	60,1	–	68,5	0,0	19,0	61,6
Average 1+		2,1	2,3	29,2	41,3	68,6	73,1	0,3	18,9	70,7
Average 2+		–	2,9	–	56,8	–	71,5	0,6	17,5	66,2
Average:		2,4	2,6	26,8	49,0	69,2	72,3	0,4	18,2	68,4

And of table 9

Year	Carp age	Carp meat						Zooplankton		
		CLA		MUFA		MUFA+PUFA		CLA	MUFA	MUFA+PUFA
		spring	autumn	spring	autumn	spring	autumn	entire season	entire season	entire season
Pond fertilized with bovine or ovine manure (150 q/ha)										
2004	1+	2,9	2,9	23,8	19,8	69,6	78,0	0,4	16,1	78,7
2005	2+	1,3	2,9	21,3	51,5	69,0	74,0	0,5	18,5	75,4
2006	1+	1,2	2,0	38,8	56,0	65,0	70,2	0,2	22,3	69,6
2007	2+	–	2,8	–	59,9	–	68,3	0,0	19,7	57,7
Average 1+		2,1	2,5	31,3	37,9	67,3	74,1	0,3	19,2	74,2
Average 2+		–	2,9	–	55,7	–	71,2	0,3	19,1	66,6
Average:		1,8	2,7	28,0	46,8	67,9	72,6	0,3	19,2	70,4

Table 10. **Results of single-factor analysis for relation between some parameters of high fatty acids profile in carp meat and zooplankton**

Dependent variable (Y), %	Independent variable (x), %	Regression equation	r	r^2	Differences significance (P<)
Carp fry					
Carp meat	Zooplankton entire season				
PUFA-3 spring	PUFA-3	Y = 0,98x – 19,15	0,82	67,0	0,05
autumn		Y = 0,87x – 23,00	0,84	70,1	0,05
EPA spring	EPA	Y = 0,36x – 0,77	0,92	84,6	0,01
autumn		Y = 0,28x – 1,80	0,94	87,6	0,01
PUFA-6 spring	PUFA-6	Y = 1,53x – 2,39	0,93	86,9	0,01
autumn		Y = 3,45x – 22,9	0,96	92,4	0,01
PUFA spring	PUFA	Y = 1,47x – 38,79	0,92	85,1	0,01
autumn		Y = 1,88x – 63,55	0,93	86,7	0,01
Commercial carp					
Carp meat	Zooplankton entire season				
PUFA-6 autumn	PUFA-6	Y = 0,72x + 0,74	0,86	73,7	0,05
PUFA autumn	PUFA	Y = 0,9x – 28,30	0,93	86,4	0,01
MUFA + PUFA	MUFA + PUFA	Y= 0,44x + 41,91	0,91	83,0	0,01

profile increment in carp meat in autumn samples and zooplankton share increment of these fractions (table 10).

Current research did not allow to notice statistically significant correlations between ingesta and zooplankton glucosamine level and PUFA, MUFA and MUFA+PUFA percentage in high fatty acids profile of commercial carp meat. PUFA-6/3 ratio correlation was not also confirmed. It was confirmed (table 7–9) that PUFA-3, PUFA-6, PUFA, EPA, DHA shares in commercial carp (2+) meat were twice or triple lower than in carp fry (1+) meat. CLA and PUFA+MUFA percentage were constant in both kinds of carp meat, in turn MUFA shares were always higher in commercial carp meat. PUFA-6/3 index value in commercial carp meat in control pond and in pond fertilized with lower doze of manure was on the average twice higher than in carp fry meat. Another kind of correlation between percentages of examined high fatty acids fractions and shares of these fractions in zooplankton was found in carp fry (table 10). If in case of carp fry these relations regarded PUFA-3, EPA, PUFA-6 and PUFA, than in case of commercial carp the correlation between PUFA-3 and EPA shares in carp meat and in zooplankton was not found, in contrast to highly statistically significant relations ($P<0,01$) for MUFA+PUFA.

DISCUSSION

Using aquatic invertebrates as a source of natural carp food take on a new life because of rising prices of grain and need to change carp husbandry to more economic extensive breeding. Good example of such system is model of discussed pond experiment, in which carp fry and commercial carp density in experimental ponds in 1 hectare was 30%–50% lower than in intensive breeding where more than 90% of biomass growths come from feeding fish with grain. Reducing restock density and using fertilization with manure (150 q per hectare) caused carp fry and commercial carp biomass increment for about 30%–40% during one season, comparing to control pond. Ponds fertilization with bovine manure has given better results then fertilization with liquid bovine manure (Schroeder, 1974; Ligaszewski et al., 2003). Glucosamine percentage in freshwater zooplankton from experimental ponds reached 1,6% level, and was lower then glucosamine percentage in saltwater — 2,5% to 11,8%. It is important that in the same kind of shellfishes in winter it was 76,1% higher (Donelly et al., 2004). Cumulative samples were taken from spring to autumn. Later on it was impossible to take probes because of organic suspension and algae blooming. However based on glucosamine content in carp ingesta in autumn and in spring it was concluded that depending on ponds manuring level glucosamine content in autumn samples was increasing comparing to its content in spring samples, while in autumn samples from control ponds glucosamine content was lower than in spring samples. It was a proof for higher food consumption in autumn season by carps in ponds with higher manurating level or of increased glucosamine content in autumn zooplankton, analogically to examples of saltwater zooplankton. Decreased water temperature comparing to spring-summer season could be a third reason of ingesta glucosamine level increment in autumn season (Ligaszewski et al., 2006, 2007). Chitinase activity decrement in carp alimentary tract and chitinolytic bacteria activity abundant in bacterial plankton and microbentos could be a reason of such glucosamine level differences (Donderski and Trzebiatowski, 1999). Selective food intake could be a fourth hypothetical reason, because zooplankton with higher glucosamine content was preferably taken by carp. It can be interpreted from regression analysis between ingesta and zooplankton glucosamine content (table 5). Biomass increments of carp bred with natural food in ponds with intensive fertilization result from all four reasons previously mentioned. Regression analysis results between total assumed carp biomass increment (kg per hectare) and some glucosamine content parameters in ingesta and in zooplankton in different seasons showed that these parameters can be treated as one of evaluation indicator or economic results prediction in ground carp ponds. This indicators seem to be especially important to carp fry ponds fishing efficiency evaluation in triennial production cycle or to light commercial carp in biennial production cycle. However further research is required.

Qualitative composition of high fatty acids profile in carp fry meat (1+) was advantageous for consumer than its composition in commercial carp (2+) meat, as it was confirmed with partial research results (Ligaszewski et al., 2006, 2007). Especially, in PUFA-3 and EPA, important in human diet, level in HFA profile is higher in younger carp meat than in 3 years old carp. That ensures from higher natural food in form of invertebrates in younger carps, while in commercial carp (2+) diet vegetable feed (crop seeds) are greatly used.

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ЗАВИСИМОСТЬ КАЧЕСТВЕННОГО СОСТАВА ВЫСШИХ ЖИРНЫХ КИСЛОТ В МЯСЕ КАРПА ОТ НЕКОТОРЫХ ЭЛЕМЕНТОВ ХИМИЧЕСКОГО СОСТАВА ЗООПЛАНКТОНА И ПРОДУКТИВНОСТИ ПРУДОВ

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Исследовалась связь между содержанием глюкозамина в зоопланктоне и пищевом комке с рыбопродуктивностью прудов. Одним из заданий исследования было изучить использование индексов, связанных с содержанием глюкозамина, для оценки продукции карпа в краткосрочной перспективе. Также исследовались корреляционные связи между содержанием отдельных фракций высших жирных кислот в зоопланктоне и их содержанием в мясе карпа.

Обнаружено, что параметры содержания глюкозамина в пищевом комке значительно коррелировали с рыбопродуктивностью прудов (P<0,05), особенно по сравнению с контролем. Также наблюдалась значительная корреляция (P<0,05) между содержанием PUFA-3, PUFA и совокупностью PUFA-MUFA в профиле высших жирных кислот в мясе товарного карпа и содержанием этих фракций в зоопланктоне.

На основании качественного состава высших жирных кислот и соотношения PUFA-6/3 обнаружено, что при двухгодичном цикле выращивания карпа полученное мясо характеризуется более высокой пищевой ценностью, чем при трехгодичном.

ЗАЛЕЖНІСТЬ ЯКІСНОГО СКЛАДУ ВИЩИХ ЖИРНИХ КИСЛОТ У М'ЯСІ КОРОПА ВІД ДЕЯКИХ ЕЛЕМЕНТІВ ХІМІЧНОГО СКЛАДУ ЗООПЛАНКТОНУ ТА ПРОДУКТИВНОСТІ СТАВІВ

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Досліджувався зв'язок між вмістом глюкозаміну в зоопланктоні та харчовій грудці з рибопродуктивністю ставів. Одним із завдань досліджень було використання індексів, пов'язаних із вмістом глюкозаміну, для оцінки продукції коропа у близькій перспективі. Також досліджувалися кореляційні зв'язки між вмістом окремих фракцій вищих жирних кислот у зоопланктоні та їх вмістом у м'ясі коропа.

Встановлено, що параметри вмісту глюкозаміну у харчовій грудці корелювали із рибопродуктивністю ставів ($P<0,05$), особливо порівняно з контролем. Також спостерігалася кореляція ($P<0,05$) між вмістом PUFA-3, PUFA і PUFA-MUFA в профілі вищих жирних кислот у м'ясі товарного коропа та вмістом цих фракцій у зоопланктоні.

На основі якісного складу вищих жирних кислот та співвідношення PUFA-6/3 виявлено, що при дворічному циклі вирощування коропа отримане м'ясо характеризується вищою харчовою цінністю, аніж при трирічному.

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ПОРІВНЯЛЬНИЙ АНАЛІЗ РОЗМІРНОГО СКЛАДУ ДОСЛІДНИЦЬКИХ І ПРОМИСЛОВИХ УЛОВІВ

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Методами варіаційної статистики проведено порівняльний аналіз розмірного складу уловів риби науково-дослідних і промислових зябрових сіток. Встановлено відсутність статистично значущих розходжень між ними. Зроблено висновок, що немає необхідності змінювати або коригувати загально прийняту методику збору іхтіологічного матеріалу.

Розвиток рибодобувного промислу в сучасний період відбувається з постійним збільшенням інтенсивності вилучення риби з водойм. Пошук шляхів зниження собівартості виловлюваної риби, зумовлює збільшення ефективності знарядь і способів лову. Зміна тих або інших характеристик знарядь лову, зокрема селективній вибірковості зябрових сіток через удосконалення сіткових матеріалів, може спотворювати дані, які дослідники одержують під час проведення рибогосподарських науково-дослідних ловів у переднерестовий період.

Зменшення чисельності промислових видів риб і закономірне розгалуження популяцій на локальні групи може привносити істотні погрішності в наукові дані, особливо якщо їхній обсяг істотно знижується під тиском різного роду адміністративних і господарських причин. Безперечним є факт, що частина генеральної сукупності, яка одержана при проведенні науково-дослідних ловів зі стовідсотковою імовірністю не відображає всі характеристики популяції досліджуваних видів риб. Однак обсяг вибірки покликаний компенсувати випадкові погрішності й відхилення при подальшому аналізі отриманих матеріалів. При цьому питання порівнянності даних науково-дослідних ловів і промислової статистики є постійно актуальним.

Метою роботи було порівняння розмірного складу науково-дослідних уловів зябрових сіток, отриманих у переднерес-