Organic Selenium (Sel-Plex) and its Impact on the Indices of Growth, Consumption and Meat Quality of Carp (Cyprinus Carpio), the Galitian Variety

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Abstract

This study is focused on the impact of organic selenium (Se) (Sel-Plex) on the growth performance, consumption and quality of meat in the case of carp (Cyprinus carpio), Galitian variety. The experiment was conducted over two years and had the following structure: (1) growth stage juveniles (159 days, year 2008); the period of hibernation; and (2) the status of fish for consumption (200 days, year 2009). Fish growth was conducted at Mărtineşti fish farm, Romania. The total number of specimens was 200, organized in two equal groups: experimental group and control group. Average weight of individuals at the beginning of the experiment was 1.5 g/individual. Growth conditions were identical for the two groups, except food. The experimental group received 0.03 mg organic Se/kg food. At the end of the experiment the individual average weight of the experimental group was 1191±014.21g/individual, with a food conversion rate of 1.79:1:1 kg foodd/kg body weight; compared to the control group with a mean weight of 908.67±17.78g/individual and a food conversion rate of 1.88:1 kg foodd/kg body weight. Regarding these indices significant differences resulted between two groups when analyzing experiment results; while, regarding meat quality in terms of protein content, dry matter, water and fat there were no significant differences between the two groups. Analysis was done using ANOVA program.

Keywords: carp Galitian variety, consumption, growth, organic Se, meat quality.

1. Introduction

In our country a viable way to increase production of fish and other aquatic organisms is to widely develop intensive farming systems, technique confirmed with high performances in Western Europe [1]. In these systems the role of additional food is crucial for achieving good performance in economic, quantitative and qualitative, in order to solve one of the biggest problems in the fish diet: anti-oxidation. A solution is to use organic selenium (Se).

In nature Se can be found in two forms: inorganic and organic [2, 3] and as a part of multiple components. It is generally accepted that Se in biological system is part of the amino constituent of proteins: cysteine, methionine and derivatives, seleno-cysteine (seleno-methionine) [4]. When juvenile trout (Salmo salar) was given seleno-methionine, its compounds were present in muscles and all over the body, unlike selenit being treated almost entirely in the liver [10]. Seleno-methionine is assimilated more easily in the body because it is absorbed as amino acid, methionine similar [9]. Some is used immediately for synthesis of seleno-methionine and another part of organic Se is incorporated into newly synthesized proteins. Dissimilar, the selenit is passively absorbed in the intestine as mineral used for the synthesis of seleno-protein and the remainder is excreted in faeces and urine [11]. Se stored during the process of protein turnover is recovered from tissues.

Amino acids are also termed liquid protein or prediger. A protein is of good quality when its

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chain is complete: incorporates in its constitution the nine amino acids. These nine amino acids are called essential because they can not be synthesized (produced). But they are of insufficient quantities in the fish body. Unlike protein amino acids can not be stored in the fish body, and when there is a need for a certain amino acid first this is consumed from blood, but after that proteins are destroyed in order to deliver amino acids [9]. Consequently, amino acids supplementation is needed. In the present research methionine supplementation was made trough the management of organic Se, improving the fodder with Sel-Plex. Se binds methionine and fish treats the body as amino acid resulting in a better assimilation.

The most important peroxidases (important enzymes for living organisms) also depend on Se [5]. Therefore peroxidases have to be present in fish food in an amount of 0.1-0.5 mg/g food, as it is an extremely important enzyme [2, 6, 7] found in all tissues where oxidative processes occur. Peroxidase it is also considered the ''emergency enzyme'' responsible for preventing oxidative stress [8]. The elimination of oxidative stress trough the administration of organic Se was also among the concerns of this research: the organic Se will keep the balance of oxidative stress. Symptoms in case of Se deficiency in fish are multiple: reduced growth, anemia, muscular dystrophy and even mortality [12].

Se is provided in the human diet trough bread, cereals, fish, etc. Research result recommended a daily dose of 55µg for 60 kg adults [14] and 60µg Se for 75 kg adults [15]. Dietary intake varies considerably from country to country, but the overall intake of Se is low. This led to establishing a standard of reference for Se daily intake (RDI) in different countries [13]. A study was conducted on 11 species of fish in Turkey and the amount of Se in fish flesh ranged between 1.32-4,6µg 100µg.

Se may affect meat quality due to degradation of lipids [2]. The chemical composition of fish meat varies according to age, season, type of food, body region, [16]. Administration of 0.25 ppm Se in the form of Sel-Plex, to Atlantic salmon (Salmo salar) may lower the amount of fat with 6.93%, [17]. Regardless of the accuracy of recommendations, it appears that the RDI is greater than the optimum levels of intake. This means deficiency of Se. Approximately 40 diseases and physiological states have been associated with deficiencies of Se, among which: arthritis, cancer, cardiovascular disease, cataracts, cystic fibrosis, diabetes, [18]. Thus increasing demand for higher quality food provides an excellent opportunity to produce Se enriched functional food.

2. Materials and methods

The experiment took place at Mărtineşti farm, Cluj, Romania, between 09.06.08 - 15.11.08 lasting 159 days in juvenile growth stage and between 17.04.09 - 03.11.09 lasting 100 days while fish was brought up to consumption stage. Hibernation took place between the two periods. Total number of fish was 200 juvenile carp, Galitian variety, with an average weight of 1.5 g/individual, early experiment. They were divided in two equal groups: control group and experimental group. The two groups leaved in separate pools/tanks providing the same growing conditions: water quality, increase density, hours of feeding, amount of food, nursery technology, the quantity and quality of natural food. The tanks beds were having green grass. First tanks were flooded and 4 hours later juveniles were released in water. The tanks were covered with meshes with dense grid in order to avoid entrance of foreign species. Water characteristics were monitored daily and taken into account to calculate food ratio and fish health.

Granulated mixed fodder of 3-5 mm granulation containing 38% protein, 5% fat, 3.5% cellulose, 9% moisture, 1500 IU Vitamin A / kg; was used. The experimental group received 0.03 mg organic Se / kg food. Sel Plex was provided by Alltech Inc. in powder form.

Same food was maintained throughout the experiment and feeding was done manually. No feeding was carried out in the first week of both experimental periods. Food was first given all over the tanks and then the area decreased gradually to clearly delimit the table food at one side of each tanks. The amount of food varied as a function of comments made on daily meals, water temperature, body weight of fish, water quality and fish health. At the beginning of 2008 (09.06.08 - 15.07.08) feeding was done 3 times daily at fixed hours and after this period twice daily. Table 1 and Table 2 present feeding program for both groups of juvenile carp in 2008 and Table 3 and Table 4 present feeding program during summer II (2009).

The following indices of consumption were investigated:

1. Rate of food conversion (FCR) at the end of each season for each group: FCR = kg food consumed/ kg body weight
2. Weight increase: Sc = final weight of individuals-initial weight of individuals [g]
3. Average growth rate [g]/day was calculated at the end of each season for each group: Rm = average body mass [g]/Experimental days.

Table 1. Feeding program and the amount given based on the time of Feeding in 2008

Period of Feeding	Hours of Feeding	The amount of food [%] of total daily
09.06.08 – 15.07.08	8^{00}	30
	13^{00}	40
	19^{00}	30
16.07.08 – 15.10.08	8^{00}	40
	18^{00}	60
16.10.08 -15.11.08	18^{00}	100

Table 2. Distribution of food consumed per month in 2008

Month	The share of total food [%]	Decade		
		I	II	III
June	3,5	1	1,5	2
July	16,5	3	5	8,5
August	30	9	10	11
September	32	13	11	8
October	15	6	5	4
November	3	2	1	-

Table 3. Feeding program and the amount given based on the time of Feeding the carp summer-II in 2009

Period of Feeding	Hours of Feeding	The amount of food from daily total [%]
17.04.09 – 30.07.09	8^{00}	30
	18^{00}	30
31.07.09 – 15.10.09	8^{00}	40
	18^{00}	60
16.10.09 - 03.11.09	18^{00}	100

Table 4. Distribution of food consumed per month in 2009

Month	The share from total food [%]	Decade		
		I	II	III
April	2	-	0,8	1,2
May	6	1,5	2	2,5
June	8	2,5	2,6	2,9
July	10	3	3,5	3,5
August	30	9	10	11
September	32,9	14	11	6,9
October	11	8	7	3
November	0,1	0,1	-	-

A series of body were done measurements in order to calculate several indices or assets. Somatic measurements (Figure 1) are: total length, great height, small height, head length and length of caudal. During the experiment somatic measurements were done once a month and meristem measurements were done at the end of the experimental period, when the fish has attained the necessary weight for consumption. Meristem measurements mean counting certain biological characters to characterize a group or a species, Figure 2. At the end of the experimental period measurements were made on all survivors. In order to determine the chemical composition of meat samples of 150g muscle/exemplar were taken from 10 individuals of each group, Figure 3. For these specimens we determined:

- Weight of head and peduncle caudal separation.

- Carcase weight without head, tail (Gccp), internal organs and caudal peduncle, Figure 4.
- Weight of sexual organs for well developed individuals, Figure 4.
- Length of digestive system and intestines, Figure 4.
- Weight of internal organs, Figure 5.

Figure 1. Measuring minimum height and head in carp summer II, Galiţian veriety

Figure 2. Detremination of the number of dorsal and caudal fin radial in carp summer II, Galiţian veriety

Figure 3. Sampling to determine the quality of carp meat

Figure 4. Gccp (A), sexual organs (B) and digestive system and intestines (C).

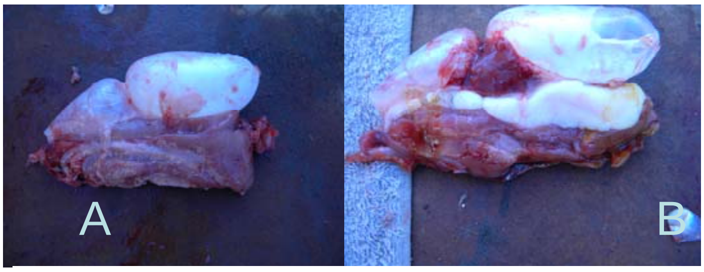

Figure 5. Internal organs of fish without sexual material (A) and sexual material (B)

After sampling meat, chemical components were determined: water, dry matter, crude protein and fat. Further on tests and well known methods were performed in the laboratory [19]. Determination of water and S.U. calculating the percentage of water lost after drying the sample taken in the analysis, and then calculate the percentage content of dry matter percentage of water decreased from 100% [20]. Determination of protein substances in fish was made by the Kjeldahl method and the determination of fish fat was made by hydrolysis and extraction with organic solvents [19]. Se content was determined by AAS method (atomic absorption spectrometry). The ratio of initial and attenuated radiation provides information about the concentration in the test sample item.

The processing was done with program statistical ANOVA test Tukey-Kramer Multiple Comparisons Test and Variability [%] calculation:

$$V = \frac{S}{M} * 100$$

Where: S is the standard deviation of the sample and M is the average group.

3. Results and discussion

1. **Water quality**

Comparing results from 2008 and 2009 we observed very large fluctuations in water temperature; e.g. in the first days of the last decade of July and August (Table 5 and 6). Related physical characteristics of water in 2009 compared with 2008 were no differences in oxygen and organic matter content. The amount of oxygen dissolved in water in 2009 is below the comfort of carp in June, July, August and September [1]. In conclusion sudden temperature changes and the small amount of oxygen led to reduced water quality in 2009, and thus influence fish Feeding. All about water quality mention that we had problems with Arguloza (Scale fish), which suck the blood of a fish. In our case we had a number of 1-3 individuals of scale/fish, regardless of age group, which could lead to their death [21].

Table 5. Mean monthly physical characteristics of water in 2008

Indicators moon	Color [mg.Caramel]	Oxygen [mg/l]	pH	Oganic matter [mg KmnO4/l]	Nitrite	Nitrate	Iron	Temperature [ºC]
June	1.9	5.4	7.98	65.65	0	0.02	0.1	25.33
July	0.3	5.3	7.8	78.60	9.8	0.05	0.1	25.13
August	0.4	5.2	7.9	39.2	9.7	0.07	0.15	26.53
September	1.3	6.1	7.63	49.29	0	0	0.17	19.83
October	0.9	7.6	7.95	41.71	10	0	0.1	16.4
November	0.6	7.8	7.85	36.07	0	0	0.1	10.46

Table 6. Mean monthly physical characteristics of water in 2009

Indicators moon	Color [mg.Caramel]	Oxygen [mg/l]	pH	Oganic matter [mg KmnO4/l]	Nitrite	Nitrate	Iron	Temperature [ºC]
June	1.6	5.4	7.99	63.60	0	0.01	0.1	21
July	0.3	5	7.5	78.20	9.5	0.05	0.1	20.09
August	0.5	4.1	7.3	69.2	9.2	0.04	0.15	26.2
September	1.5	4.8	7.2	49.29	0	0	0.1	20.03
October	0.5	7.3	7.97	41.71	0	0	0.1	12.66
November	0.4	7.8	8.05	32.09	0	0	0.1	10.5

2. Indices of consumption and growth

Looking at individual's weight by using ANOVA Tukey-Kramer Multiple Comparisons Test, shows significant differences in average body weight of experimental group compared to control group, Table 7. The average growth at the end of 359 days of grows was 2.526 g/day at the control group and 3.313 g/day at the experimental group, Table 8. In literature carp of Summer II reaches an average weight of 680g [22] and 650-700g/ exemplar [1], while the experimental groups recorded an average weight of 1000g/individ.

Feed conversion rate (FCR), at the end of experiment was 1.88:1 kg food / kg body weight at the control group compared with 0,09 kg food / kg body weight, (1.79:1 kg food / kg body weight) at the experimental group, Table 8.

Table 7. Statistical parameters of mean body weight control group and experimental

[%]/Number of individuals	Control group/90	Experimental group/97
Mean ± e [g]	908.67±17.78	1191±014.21***
Maximum weight [g]	1112	1510
Minimum weight [g]	650	1002
Weight variability [%]	9.3	7.7

P<0.001 – significant

Table 8. Consumer index values at the end of the experiment

Specification	Measurement unit	Control group	Experimental group
Increased growth	g / year	907.17	1189.5
The average growth	g / day (359)	2.526	3.313
Feed conversion rate (FCR)	kg food / kg body weight	1.88:1	1.79:1

3. Somatic measurements

Somatic measurements can be observed in Table 9. Literature [22, 1] head length is 15,7 to 21,4% of body length, and in our experiment is 17.54% to 16.55%, Table 10.

Following somatic variability measurements, we see that it has a coefficient range between 0 and 15%, meaning that data is spreading very little, and the average is representative because the sample measured is homogeneous.

Table 9. Somatic measurements values on carp Summer II

-	Control group	Experimental group
Number of individuals	90	97
Total lenght [cm], Mean ± e / V[%]	38.75±1.124 / 7.09	43±0.948 / 4.93
Great height [cm], Mean ± e / V[%]	13±0.577 / 9.96	12.9±0.367 / 6.36
Small height [cm], Mean ± e / V%[%]	4.72±0.15 / 6.71	4.98±0.115 / 5.18
Head lenght [cm], Mean ± e / V%[%]	8.8±0.24 / 1.23	10.16±0.261 / 5.75
Lenght of caudal [cm], Mean ± e / V[%]	6.85±0.40 / 1.06	7.12±0.174 / 1.91

e- standard error

Table 10. Percentage of body size of the average total length of the four batches of carp consumption

[%] of Total length	Standard length	Head length	Length of caudal	Number of individuals
Control group	65.34	22.70	17.54	90
Experimental group	60.9	23.62	16.55	97

4. Meristem measurements

Variability of measurements is very small the result that average is representative said the number of radiator fins fall in specific species and Galitian variety. What we see is that the number of needles of the dorsal and anal fins is equal for the variety, Table 11.

Table 11. The mean meristem measurements in batches studied

Index meristem	Control group n=90	Experimental group n=97
Number of dorsal fin radiator / V[%]	21±0.1667 / 1.94	21±0.2236 / 2.60
Number of dorsal anal radiator / V[%]	21±0.2582 / 3.01	21±0.000 / 0
Number of tail fin radiator / V[%]	6±0.1667 / 6.80	7±0.000 / 0

5. Meat quality

The head is the highest percentage of body weight of individuals, 24.79% to 23.45%. Then a greater impact on total body weight and bodies has an internal rate of 16.39% for the control group and 17.03% for the experimental group. The lowest percentage of body weight is caudal, Table 12.

Sexual organ weights were determined only in males because only they were sexually developed. Only 2 individuals out of 10 in the control group had developed sexual organs, with an average weight of 50g/individ, and the average weight of individuals was 908.67±17.78g. The experimental group had 3sexually developed males with a mean weight of sexual organs of 74±0.472 g/individual and an average weight of individuals of 1191±14.21g, Table 12. Thus, increasing weight leads to early maturing of sexual organs.

Length of digestive organs (86.77±0.532cm) is 2.23 times the average total length of individuals (38.75±1.124cm) in the control group. For the experimental group (103.14±0.524cm) they are 2.39 times the average total length of individuals (43±0.948 cm), Table 12, as distinct digestive and bowel length is directly proportional to the weight of individuals [1, 22].

Table 12. The amount and proportion of body parts in lots of crap summer II

The plots studied /	Control group	Experimental group n
Average weight of individuals	908.67±17.78	1191±14.21
The average weight of the intestines [g], Media ±e	148.98±0.421	202.83±0.205
[%] of body weight / V[%]	16.39 / 9.61	17.03 / 10.46
The average weight of the head[g], Media ±e	225.27±0.441	279.29±0.412
[%] of body weight / V[%]	24.79 / 11.95	23.45 / 6.87
The average weight of the swimmers tail [g], Media ±e	23±0.01	23±0.0655
[%] of body weight / V[%]	2.53 / 0.08	1.93 / 2.21
The average weight of the sexual organs [g], Media ±e	50	74±0.472
[%] of body weight / V[%]	5.50 / 0	6.21 / 21.01
The length of the digestive system and bowels [cm] Media ±e	86.77±0.532	103.14±0.524
[%] of body weight / V[%]	2.23 / 6.89	2.39 / 14.27

Yield of carp sacrifice is 64 % for three summers, [23]. In our experiment, the carp has a second summer slaughter yield (fish without head and caudal fin) of 72.68 % in control group and 73.11 % in experimental group, Table 13. A better yield of sacrifice recovery in May is leading to increased amount of meat.

Table 13. Weight of fish carcasses in batches studied

The plots studied/ Number of individuals =10	Control group	Experimental group
Media ±e [g]	908.67±17.78	1191±014.21
Carcase weight without head and tail, Gccp [g]	248.27±0.671	320.29±0.321
[%] Gccp	27.32	26.89
Return to slaughter [%]	72.68	73.11

Table 14. The chemical composition of carp meat, variety Galician Summer II [%]

The plots studied / Number of individuals =10	Control group	Experimental group
Substance dry [%], Media± e / V[%]	22.068±0.126 / 4.53	21.579±0.2358 / 3.45
Protein [%], Media±e / V[%]	17.954±0.02 / 0.044	18.728±0.1273 / 2.15
Fat [%], Media± e / V[%]	8.002±0.5473 / 12.22	7.716±0.1780 / 7.29
Water [%], Media ±e / V[%]	77.932±0.1267 / 0.51	78.421±0.2358 / 0.95
Se [µg / kg carp meat], Media ±e / V[%]	109.52±5.694 /11.62	174.68±12.256 / 15.68

There were small variations in protein content between groups. Values are higher for the experimental group 18,728 ± 0.1273% and lower for the control group 17,954 ± 0.02%, Table 14. Compared with literature [1, 22] the amount of protein is 5% higher for Mărtinești species, where the amount of fat drops by 3.57%. Experimental group has 8.002±0.5473 % and control value is 7.716±0.1780% higher. Atlantic salmon has decreased fat with 6.93% [17]. Analyzing Se values in carp meat shows an increase of 59,49 % meat content is in response to food supplementation with organic Se as Sel – Plex. This means the present research made a first step in testing functional food [14, 15].

4. Conclusions

The present research confirms some of the positive effects of organic Se on the carp. The employed methodology is original and custom tailored for the environment and parameters Romania offers for fish growing. Moreover, similar studies were not applied to this carp species, even if this is one of the most consumed fish species. The research is valuable from both technological and economical point of view, because: (1) allows an inside view on the influence of organic Se on the fish body: (2) helped to test Sel-Plex on carp; and (3) demonstrates that organic Se enriched fodder leads to higher fish production and economical effectiveness (functional food, a food conversion rate lower, increasing body mass in less time and better quality at lower costs).

Thus increasing demand from consumers for higher quality foods provides an excellent opportunity to produce functional foods rich in Se. Functional foods will give the most benefits because they can be adapted to the needs and lifestyle of each country. Modernization and intensification in fisheries production lead to the need to focused attention to use with maximum efficiency the production capacity, to adopt new technologies for mining, scientific organization of production and labour in order to increase their productivity while lowering cost price.

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