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EFFECT OF DIETARY PHYTOEXTRACTS SUPPLEMENTATION ON GROWTH PERFORMANCE AND PRODUCTION EFFICIENCY OF COMMON CARP (*CYPRINUS CARPIO* L.), CULTIVATED IN RECIRCULATION SYSTEM

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Abstract

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The present study aimed to evaluate the effect of dietary phytoextract supplementation on growth performance and production efficiency of common carp (*Cyprinus carpio* L.), cultivated in a recirculaiton system. The following spices were tested: curcuma, pepper, thyme, oregano and garlic. The fish were divided into six groups: one control (C) and five experimental groups whose feed was supplemented with curcuma (EC), pepper (EP), thyme (ET), oregano (EO) and garlic (EG).

The highest values of the final live weight were established in fish, fed with extruded pellets, supplemented with curcuma (EC) which exceeded control and other experimental groups' performance by 3.37% (C), 5.73% (EP), 2.06% (ET) 1.60% (EO) and 5.83% (EG). The differences were insignificant both among the groups and between replications within groups ($P>0.05$).

The weight gain of common carp from experimental groups EC and EO was statistically significantly higher than C ($P<0.05$). The analysis of results confirmed the better growth performance in fish from EC, EP, ET and EO compared to common carp from control group. Relatively lower growth was demonstrated in fish from the EG.

Consumption data showed that feed conversion ratio (FCR) of carps, fed with extruded pellets, supplemented with oregano extract (EO) was 1.47. It is lower than respective FCR of other groups by 19.72 % (C), 4.08 % (EC), 14.97 % (EP), 8.16 % (ET) and 38.10 % (EG). Statistically significantly lower feed consumption per unit weight gain was established for carps from a group EO than C ($P<0.05$).

The survival rate of all fish from control and experimental groups was 100%.

Economic conversion ratio of phytoextracts supplementation to the feed of common carp (*Cyprinus carpio* L.), was lower in EO. It was lower than ECR values of fish from control and other groups.

Key words: common carp; phytoextracts; growth performance; feed conversion ratio; economic efficiency

Introduction

Common carp is a species widely used for human consumption as it has a broad geographical spread and is acclimated worldwide. It is indigenous in Eastern Europe and Western Asia and among most important aquaculture species from economic point of view. As carps survive even in most polluted water ponds, they are considered an appropriate bio-indicator for water environment (Snyder et al., 2004; Reynders et al., 2008).

Phytoextracts are nutritional supplements produced from oil crops or other plants (e.g. garlic, oregano, pepper, thyme, curcuma, ginger etc.). They are widely used as food by both human and animals, including fish. The main advantage from their use is that they are natural substances, safe for the or-

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ganisms and for the environment (Gabor et al., 2010; Gabor et al., 2011). Phytosupplements are alternatives to antibiotics in aquaculture systems. The available literature reports are devoted mainly to their influence on the survival of fish and on their resistance against infectious and parasitic diseases. Relatively few studies were aimed at evaluating the effects of phytosupplements on growth performance and feed conversion in different fish species. In experiments with feeding various vegetable oils to carp and rainbow trout in recirculation systems, higher weight gain and lower feed conversion ratio were found out in groups supplemented with flaxseed and sunflower oil (Zhelyazkov, 2014; Zhelyazkov et al., 2014; Zhelyazkov, 2015). Similar results were demonstrated with betaine supplementation of carp diet (Zhelyazkov et al., 2015).

A number of researchers reported higher weight gain and lower feed conversion ratio in different fish species supplemented with curcuma, pepper, thyme, oregano and garlic (Sahu et al., 2008; Aly & Mohamed, 2009; Gabor et al., 2011; Yılmaz et al., 2012; Antache et al., 2013; Yılmaz et al., 2013; Mehrim et al., 2014; Saleh et al., 2015; Stoyanova et al., 2015; Xia et al., 2015). In carrying out such studies, the influence of the speed of movement of the fish in the tubs of the recirculating system is also important as it influences the heat inputs, the energy recovery and the hydrochemical parameters (Peychev et al., 2015; Georgiev and Peychev, 2002).

The present study aimed to evaluate the effect of dietary phytoextract supplementation on growth performance and production efficiency of common carp (*Cyprinus carpio* L.), cultivated in a recirculaiton system.

Material and Methods

Common carp for the experiment were provided by the Institute of Fisheries and Aquaculture – Plovdiv in the Experimental base of the Faculty of Agriculture, Trakia University, Stara Zagora. Extracts from the following spices were tested as a feed supplementation: curcuma, pepper, thyme, oregano and garlic. After 7-day adaptation period, fish were divided into six groups of 10 fish each: one control (C) and five experimental groups whose feed was supplemented with curcuma (EC), pepper (EP), thyme (ET), oregano (EO) and garlic (EG). Each experimental variant was run in two replications: C_1, C_2, EC_1, EC_2, EP_1, EP_2, ET_1, ET_2, EO_1, EO_2, EG_1, EG_2. All carps were raised in concrete tanks with efficient water volume 0.8 m^3, part of a recirculation system. The live weight (g) and linear growth (mm) were individually measured and determined.

The initial body weight of fish from the experimental variants and their replications was similar without significant differences:

- EC_1 – 745.80±116.02 g, EC_2 - 767.60±132.93g;
- EP_1 - 731.20±100.37, EP_2 - 712.90±130.34 g;
- ET_1 - 691.90±103.35 g, ET_2 – 797.40±88.86g;
- EO_1 - 779.30±91.14 g, EO_2 - 725.20±141.07 g;
- EG_1 - 780.50±118.37 g, EG_2 - 719.20±151.90 g
- C_1 - 807.50±172.43g, C_2 - 656.20±141.84g.

Carp were fed with extruded pellets produced by Aqua garant Co, with pellet size 6 mm. One gram dry extract of the different spices – curcuma (EC), pepper (EP), thyme (ET), oregano (EO) and garlic (EG) was dissolved in 9 ml distilled water and sprayed onto 100 g feed one hour before being given to the experimental groups. Control carps received feed without phytoextracts. The nutritional content of extruded feed for the different groups is presented in Table 1. The duration of the experiment was 60 days.

Water chemical parameters in the recirculation system for cultivated common carp (*Cyprinus carpio* L.) were determined daily as followed:

- Dissolved oxygen, mg/l – MultiLine P4;
- Water pH – MultiLine P4;
- Electric conductivity of water – MultiLine P4 and BSS EN 27888;
- Water nitrate content, mg/l – BSS 17.1.4.12:1979;
- Water nitrite content, mg/l – BSS ISO 26777:1997.

The effect of used phytoextracts as a supplement to feed on weight gain of fish was determined by control catches in the beginning, middle and end of the experimental period. Live body weight (W, g) was determined with precision of 0.1 g, and linear measurements e.g. total body length (longitudo totum corporis-L, mm), standard body length (longitudo corporis-l, mm), body height (altitudo corporis maxima-H, mm) and body width (latitudo corporis-D, mm) – with precision of 1,0 mm**.** Body measurements were performed by the protocol of Pravdin (1966) for measurement of cyprinids. Individual linear measurements were done with a measuring board and triangle, and weight measurements – on electronic balance. At the end of the trial, weight gain (g), survival rate (%) and feed conversion ratio of the different feeds were determined.

Economic efficiency of carp feed supplementation with phytoextracts in the recirculation system was calculated on the basis of data about feed conversion ratio-(FCR), weight gain and survival rate of fish. All parameters were compared among experimental groups and replicates and extruded feed expenditures were determined. The cost of 1 kg weight gain in the recirculation system was calculated.

Economic conversion ratio (ECR) was determined as ECR = feed cost × FCR (Piedecausa et al., 2007).

Statistical analysis of data was performed with statistical software STATISTICA 6.0 (StatSoft Inc., 2002).

Table 1
Nutritional composition of extruded feed for common carp (*Cyprinus carpio L.*), cultivated in a recirculation system

№	Parameters	Experimental groups					
		C	EC	EP	ET	EP	EG
1	Crude protein, %	30.00	30.00	30.00	30.00	30.00	30.00
2	Crude fat, %	8.00	8.00	8.00	8.00	8.00	8.00
3	Crude fibre, %	5.00	5.00	5.00	5.00	5.00	5.00
4	Crude ash, %	8.50	8.50	8.50	8.50	8.50	8.50
5	Calcium, %	1.40	1.40	1.40	1.40	1.40	1.40
6	Phosphorus, %	1.10	1.10	1.10	1.10	1.10	1.10
7	Sodium, %	0.20	0.20	0.20	0.20	0.20	0.20
8	Curcumin, %	-	1.00	-	-	-	-
9	Paprika, %	-	-	1.00	-	-	-
10	Thyme, %	-	-	-	1.00	-	-
11	Oregano, %	-	-	-	-	1.00	-
12	Garlic, %	-	-	-	-	-	1.00
13	Metabolisable energy, MJ/kg	16.60	16.60	16.60	16.60	16.60	16.60

* 1 kg compound feed contains: vitamin A – 10000 IU; vitamin D_3 – 1750 IU; vitamin E – 175 mg; vitamin C - 100 mg.
** 1 kg compound feed contains: Fe – 80 mg; Mn – 35 mg; Cu – 10 mg; Zn – 107 mg; J – 2.3 mg; Se – 0.4 mg.

Results

Water chemical parameters during the experiment are presented in Table 2. Water temperature for the six experimental groups was 23.40±1.42° C, and dissolved oxygen content was 5.89±0.23 mg/l. Water pH in the recirculation system in the different tanks was 7.30±0.06. Nitrate content was 0.57±0.03 mg/l, and nitrites - 0.029±0.004 mg/l. Electric conductivity of water during the experiments was 671.00±2.15 μS/cm.

The data for water chemical parameters demonstrated that during the trial, they were optimum for the cultivated fish species. This resulted in good survival rate, weight gain and feed conversion ratio of common carp in experimental groups.

Survival rates of cultivated fish are presented on Fig. 1. Both in experimental groups supplemented with curcuma, pepper, oregano and garlic as well as in control fish, survival rate was 100%.

Linear measurements and live body weight at the beginning of the trial are shown in Table 3. Average total body length from all replicates of control (C) and experimental groups (EC, EP, ET, EO and EG) were 365.50±35.35 mm, 346.20±75.17 mm, 360.50±17.69 mm, 372.00±21.58 mm, 368.65±23.10 mm and 366.75±26.02 mm, respectively. A similar tendency was observed for average values of the other linear parameters from control and experimental fish. Differences in this parameter between experimental and control fish were insignificant (P>0.05). Average initial live weight in the groups were 731.85±172.15 g (C), 756.70±121.95 g (EC), 722.05±113.61 g (EP), 744.65±108.30 g (ET), 752.25±118.88 g (EO) and 749.85±136.22 g (EG), with statistically insignificant differences (P>0.05) (Table 3).

Mean total body lengths in fish at the end of the 60-day experimental period were as followed: C - 383.50±22.48 mm, EC - 379.50±20.89 mm, EP - 375.25±20.10 mm, ET - 385.00±28.56 mm, EO - 388.00±28.07 mm and EG - 380.75±25.97 mm, with irrelevant differences (P>0.05) (Table 4). A similar tendency was observed for average values of the other linear parameters from control and experimental fish. The final body live weight of control and experimental fish were as followed: C - 928.85±131.95 g, EC - 960.20±150.82 g, EP - 908.10±122.90 g, ET – 940.80±132.76g, EO – 945.00±202.97 g, and EG - 907.25±159.73 g but differences among groups were insignificant (P>0.05) (Table 4).

At the end of the trial, individual weight gain of control fish was 176.60 g on the average, while in experimental groups it was: EC – 203.50 g, EP – 186.05 g, ET – 196.15 g,

Table 2
Water chemical parameters in the carp recirculation system

Parameter	n	$\bar{x}$ ± SD	Optimum values (Regulation № 4/2000)
Temperature, ºC	60	23.40±1.42	22.00-26.00
Dissolved oxygen, mg/l	60	5.89±0.23	no less than 5
Ph	60	7.30±0.06	6.50-8.50
Nitrates, mg/l	60	0.57±0.03	up to 2.00
Nitrites, mg/l	60	0.029±0.004	up to 0.05
Electric conductivity, µS/cm	60	671.00±2.15	-

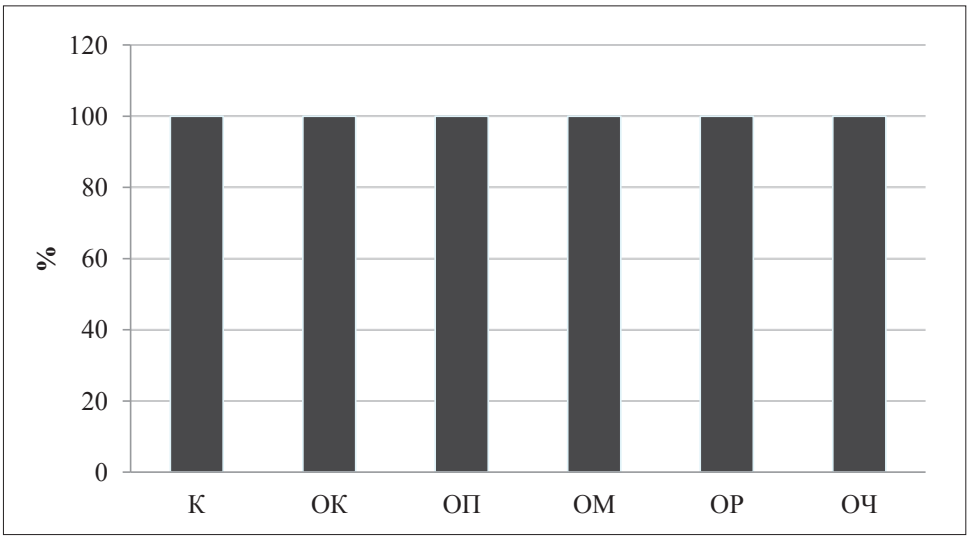

Fig. 1. Survival rate of common carp, cultivated in a recirculation system

Table 3
Linear and weight measurements of carp cultivated in a recirculation system at the beginning of the experiment

Parameter	n	C	EC	EP	ET	EO	EG
		$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Total body length, mm	20	365.50±35.35	346.20±75.17	360.50±17.69	372. 00±21.58	368.65±23.10	366.75±26.02
Standard body length, mm	20	299.25±26.57	299.00±15.78	293.25±13.79	315.00±24.22	310.20±19.91	301.50±24.28
Body height, mm	20	98.35±11.33	93.40±16.45	92.15±14.64	93.55±12.35	86.35±10.81	90.75±8.95
Body width, mm	20	55.50±8.87	56.20±5.65	56.50±5.87	58.00±5.23	54.00±6.81	54.50±6.86
Live body weight, g	20	731.85±172.15	756.70±121.95	722.05±113.61	744.65±108.30	752.25±118.88	749.85±136.22

EO – 213.15 g, EG – 157.40 g. There were substantial differences between weight gain of carps from groups EC and EO than control group ($P<0.05$) (Fig 2).

During the experiment carps were fed three times a day. Daily amount of consumed feed were analysed in control and experimental replications and feed conversion ratio are presented in Fig. 3. FCR values of fish from groups C, EC, EP, ET, EO and EG were 1.76, 1.53, 1.69, 1.59, 1.47 and 2.03, respectively.

Economic efficiency of dietary supplementation in extruded pellets with phytoextracts is shown in Table 5. The calculated economic conversion ratio of fish in the control and experimental groups was 3.08 (C), 3.67 (EC), 3.09 (EP), 2.96 (ET), 2.72 (EO) and 3.69 (EG).

Discussion

The analysis of data from water chemical parameters (temperature, dissolved oxygen, pH and electrical conductivity) showed that during the experimental period they were in the optimum ranges for the cultivated species. This was also valid for maximum allowances of water nitrates and nitrites which, for carp farms, should not exceed 2 mg/l and 0.05 mg/l respectively (as per Regulation 4/2000 on water quality for

Table 4
Linear and weight measurements of common carp, cultivated in a recirculation system at the end of the experiment

Parameter	n	C	EC	EP	ET	EO	EG
		$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD	$\bar{x}$ ± SD
Total body length, mm	20	383.50±22.48	379.50±20.89	375.25±20.10	385.00±28.56	388.00±28.07	380.75±25.97
Standard body length, mm	20	327.50±23.81	313.00±16.58	314.50±17.01	322.00±19.36	324.00±21.86	319.50±23.05
Body height, mm	20	101.65±9.69	101.75±11.15	93.50±10.53	98.95±8.26	91.15±9.66	100.75±8.05
Body width, mm	20	59.50±8.87	60.50±8.87	59.50±13.17	60.00±7.95	59.00±7.18	57.50±5.50
Live body weight, g	20	928.85±131.95	960.20±150.82	908.10±122.90	940.80±132.76	945.00±202.97	907.25±159.73

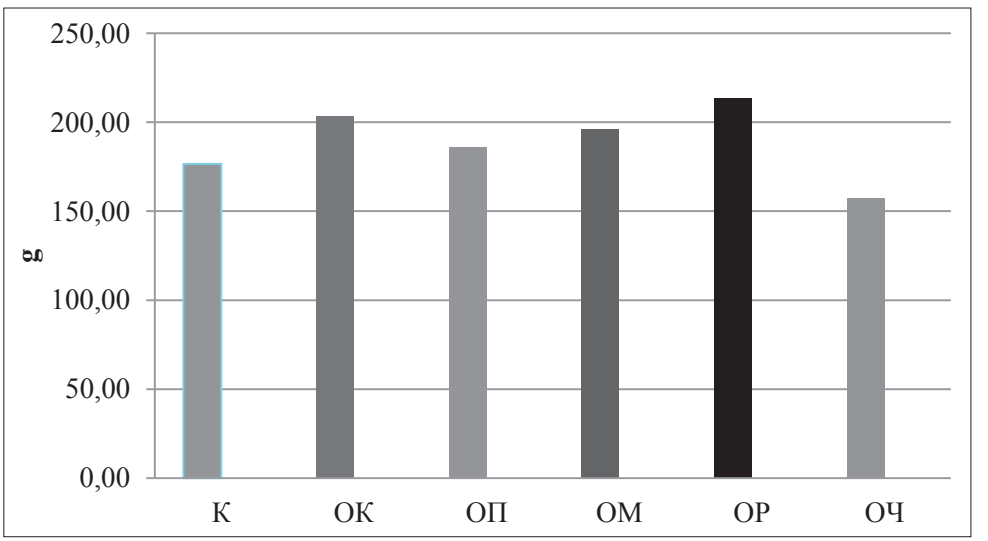

Fig. 2. Average individual weight gain of common carp, cultivated in a recirculation system

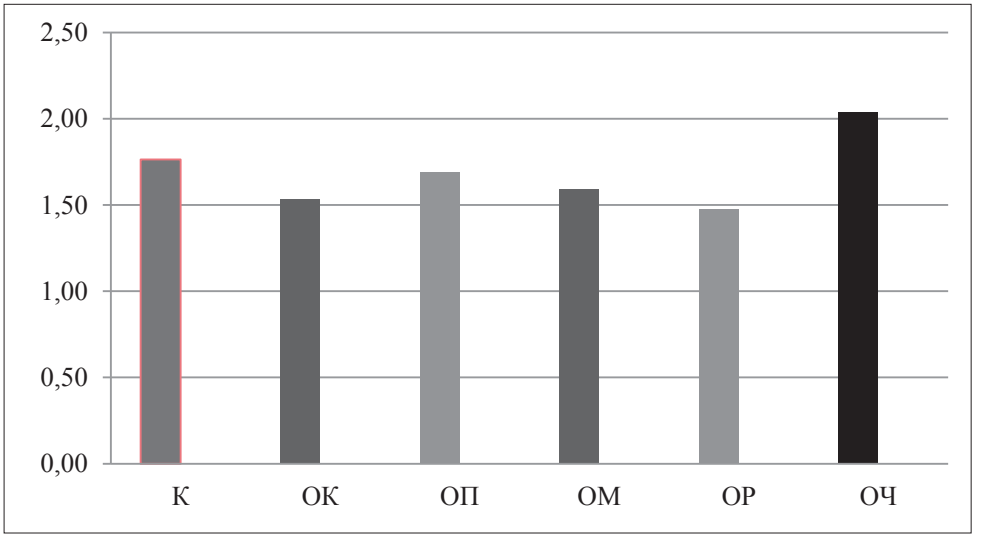

Fig. 3. Feed conversion ratio in carp cultivated in a recirculation system

Table 5
Economic efficiency of dietary phytoextracts supplementation in common carp, cultivated in a recirculation system

Parameters	Experimental variants					
	C	EC	EP	ET	EO	EG
Feed cost, BGN/kg (VAT excluded)	1.75	2.40	1.83	1. 86	1.85	1.82
Feed conversion ratio	1.76	1.53	1.69	1.59	1.47	2.03
Economic conversion ratio	3.08	3.67	3.09	2.96	2.72	3.69

fish and shellfish farming), with reference ranges being significantly higher than those measured in the water during the experiment. The maintenance of these optimum water values was possible by virtue of optimized technical and technological parameters of the production system. The fish tanks were cleaned thrice on a daily basis with addition of fresh water at amount of 10 % of the total recirculation system volume. The mechanical and biological filters played a primary role for maintenance of optimum water chemical parameters in the recirculation system during the experiment.

The addition of 1% extracts from the spices curcuma, pepper, thyme, oregano and garlic to extruded carp pellets did not exert any influence on survival rate of fish in the recirculation system. The data at the end of the 60-day experimental period showed 100% survival in all groups and replicates (Fig 1). This is attributed to maintained optimal technological parameters such as stocking density, daily ration, and feeding frequency.

The analysis of average individual weight gain data showed that in carps from a control group it is lower (176.60±31.47 g) than those in individuals from experimental groups: EC - by 15.20%, EP - by 5.35%, ET - by 11.07% and EO - by 20.70% whereas it was by 12.19% higher as compared to EG carp. The weight gain of fish from experimental groups EC and EO was statistically significantly different vs control fish ($P<0.05$) (Fig 2).

At the end of the trial, the expenditure of extruded feed allowed affirming that the feed conversion ratio in carp cultivated in a recirculation system and supplemented with oregano extract (group EO) in pellets is 1.47. This figure was lower as compared to both control and other experimental groups (EC, EP, ET, EG) by 19.72%, 4.08%, 14.97%, 8.16% and 38.10%, respectively. Statistically significantly lower feed conversion ratio was established in the EO group vs control fish ($P<0.05$) (Fig 3).

The better conversion of feeds supplemented with 1% curcuma, pepper, thyme and oregano extract had a benefi-

cial effect on the growth of fish cultivated in the recirculation system. The group supplemented with garlic extract however showed the opposite tendency e.g. higher FCR than control group. In the beginning of the trial, the live weight and linear measurements of carp were similar (P>0.05). By the end of the experiment, fish supplemented with curcuma, pepper, thyme and oregano tended to grow more intensively than these from control group and growth performance was the lowest in experimental carp supplemented with garlic extract. The average live weight of experimental carp fed with curcuma (EC) was 960.20 g which was superior to EP, ET, EO, EG and control group by 5.74%, 2.06%, 1.61%, 5.84% and 3.38% respectively (P>0.05) (Table 4). These results confirmed earlier reports from feeding various fish species with spice extracts (Gabor et al., 2011; Yılmaz et al., 2012; Antache et al., 2013; Xia et al., 2015).

The cost of used extruded carp pellets was 1.75 BGN/kg, VAT included. The cost of used spices was: curcuma – 64.80 BGN/kg, pepper – 7.56 BGN/kg, thyme – 11.28 BGN/kg, garlic – 10.2 BGN/kg. In this experiment in a recirculation system, 1% extract from these spices was sprayed onto feeds of respective groups. Hence, the higher production costs for the different groups were as followed: EC – 0.648 BGN/kg, EP – 0.0756 BGN/kg, ET – 0.1128 BGN/kg, EO – 0.102 BGN/kg, EG – 0.065 BGN/kg. The lowest economic conversion ratio was that of the EO group. It was lower compared to control and other experimental groups by 13.23% (C); 34.92% (EC); 13.60% (EP), 8.82 % (ET) and 35.66 % (EG) (Table 5).

The analysis of experimental data from the present investigation showed higher weight gain at common carp in all experimental groups supplemented with curcuma compared to control, as well as lower feed conversion ratio. Similar results were reported by Sahu et al., (2008) with different dietary curcuma levels in the feed of rehu, *Labeo rohita* (Ham.). Xia et al., (2015) also established increased live weight of juvenile *Megalobrama amblycephala* than that of fish fed non-supplemented feed.

The experiment showed higher live body weight in the group by supplemented feed with thyme than in fish from a control. Phytosupplements thyme, fenugreek and neem added to the feed of Nile tilapia (*Oreochromis niloticus*), reared in a recirculation system also had a positive effect on its growth performance (Yılmaz et al., 2012; Antache et al., 2013).

According to Yılmaz et al. (2013) the addition of pepper to the daily ratios of Mozambique tilapia (*Oreochromis mossambicus)* increased significantly its live weight.

In the present study the inclusion of oregano in the diet of a common carp showed higher weight gain compared to control group and lower feed conversion ratio. This was also confirmed by Gabor et al., (2011). According to the experimental data from the present study dietary garlic did not exert any influence on the growth performance of common carp compared to that of non-supplemented fish. This was confirmed by the results of Nwabueze (2012) and Thanikachalam et al. (2010) who studied the influence of garlic added in the diet of African catfish (*Clarias gariepinus*). For the same results also reported Metwally (2009) for Nile tilapia (*Tilapia nilotica*). On the contrary, other authors having fed garlic to European bass *(Dicentrarcus labrax),* African catfish (*Clarias gariepinus*) and Zilli's tilapia (*Tilapia zillii*) affirmed its positive effect on weight gain and feed conversion (Saleh et al., 2015; Mehrim et al., 2014; Aly & Mohamed, 2009; Agbebi et al., 2013; Jegede, 2012). The results of present research with a common carp however disagreed with them.

Conclusions

Throughout the experiment, growth performance of common carp whose diet was supplemented with curcuma, pepper, thyme and oregano phytoextracts was superior compared to fish from control group. Relatively lower growth performance was exhibited by experimental fish supplemented with garlic extract. The feed conversion ratio of carp cultivated in a recirculation system was the lowest in the experimental group supplemented with oregano both compared to control and to the other supplemented groups. Economic conversion ratio was the lowest in oregano-fed group of carp.

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