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Effect of garlic (*Allium sativum*) - supplemented diet on growth performance, body composition and fatty acid profile of rainbow trout (*Oncorhynchus mykiss*)

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ABSTRACT

In this study, rainbow trout were fed for a total of 90 days with different feed mixes containing 0.00%, 1.00%, 1.50% and 2.00% garlic (*Allium sativum*). The effect of garlic on the growth performance, body composition and fatty acid profile of rainbow trout was researched. The starting weight of fish in the experimental group was approximately 64.12±0.29 gr, which increased to 234.12±3.54gr, 246.31±4.41gr, 258.74±4.42gr, and 268.79±4.79gr, while the difference in growth between the groups was observed to be statistically significant ($p<0.05$). At the end of the feeding period, the specific growth rate (SGR), the economic conversion ratio (ECR), the feed conversion ratio (FCR), the economic profit index (EPI) and the protein efficiency ratio (PER) were checked. In this study, the nutritional composition and fatty acid profiles of fish after 90 days of feeding were examined. As a result of this study, the supplementation of garlic to the diet given to rainbow trout caused an increase in their protein ratio and a decrease in their moisture content and fat ratio. Additionally, it led to a decrease in fatty acid and monounsaturated fatty acid levels and an increase in polyunsaturated fatty acids.

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Introduction

Rainbow trout belonging to the Salmonidae family is a freshwater fish species that is widely grown and consumed in many countries; thus, its breeding has recently increased. One of the most important goals in breeding is to obtain the highest yield with unit feed per unit time. Several researchers are currently focusing on reaching this goal and increasing breeding efficiency. Owing to the use of harmful chemicals in fish farming, which threatened human health, several studies are attempting the introduction of vegetable supplements in fish feeds. Garlic, which has been widely used in traditional medicine since ancient times, is one such example of a vegetable plant supplement (1-3).

Many reports have documented that garlic can effectively eliminate principal pathogenic bacteria in freshwater fish, including *Pseudomonas fluorescens*, *Myxococcus piscicola*, *Vibrio anguillarum*, *Edwardsiella tarda*, *Aeromonas punctata f. intestinalis* and *Yersinia ruckeri* (1). Garlic, used as a feed additive in fish breeding, is also used to raise meat quality. Garlic reportedly protects fish from heavy metal effects and causes changes in the lipid profile (2). Many studies have investigated the effects of garlic on fish but have mainly focused upon the influence of garlic on blood parameters and immunity of fish; however, research regarding the effects on fatty acids content in and body composition of fish remain limited. The most important criterion in fish feed development is the achievement of rapid growth at low feed cost. However, it is necessary to determine the likely influence on fish nutrient and fatty acid profiles caused by differences among feeds administered to fish (1,2).

Most fish are deficient in amino acids (histidine, leucine, aspartic acid and valine) that form the food, flavour and taste. Biochemical analysis indicates that the garlic contains various alkyl sulphide compounds and a C3H6S (O)-base group related to the meat flavour. For this reason, garlic supplementation in the diet administered to fish can compensate for the lack of these meat flavor-producing amino acids and can improve meat quality (1).

Fish meat is an important source of nutrients for

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humans because of its high content of proteins with high biological value as well as its high content of beneficial fatty acids, minerals and vitamins; lack of connective tissue and easy digestibility. Fish oils are particularly rich in terms of unsaturated fatty acids (omega-3 and omega-6) and are important for human health. However, long-chain omega-3 fatty acids cannot be synthesised by the human body and are often taken with foods (3).

Fish are important because they contain fatty acids essential to human health such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In this study, the effects of the garlic used to increase growth and meat quality in aquaculture in terms of body composition and fatty acid profile of rainbow trout were investigated.

Materials and methods

Experimental fish and handling

The feeding activities were performed for 90 days in a commercial rainbow trout fish (*Oncorhynchus mykiss*) farm in Pozantı-Adana, Turkey. In total, 240 rainbow trout were used in the study. Each treatment and control consisted of three equal replicates (20 fish per replicate); the fish in each replicate were randomly assigned to 12 net cages of 1 m^3 each (10 mm mesh size). At the beginning of the experiment, the average live weight of all experimental fish was 64.12±0.29 g. The water temperature and oxygen content of the pools in the experiment were checked twice daily using an OxyGuard oxygen meter (Oxyguard, Birkerød, Denmark). The water temperature was 12 °C, and the oxygen contents were 8.4-12.2 mg/L during the experimental period.

Diet preparation

During the experiment and for 2 weeks prior to the beginning of the experiment, the fish were fed a commercial trout feed produced by Skretting (Stavanger, Norway), of which nutritional values are listed in (Table 1).

Garlic powder was purchased from a local market. The powdered garlic that was purchased from the market was again ground and allowed to separate smaller pieces, mixed with 300 ml distilled water, and sprayed on the commercial pellets. The pellets with different garlic concentrations were air-dried at room temperature. The sunflower oil (1.00% ratio) was sprayed on the feed after the drying process was completed and kept in plastic bags at 4 °C until use. The oil spray was applied to all groups, including the control group.

Table 1. Nutritional values of the trout feed used in the study.

Diet Composition	Average of total feed (%)
Crude protein	45
Lipid	20
Crude cellulose	2.0
Crude ash	10
Macro Elements	
Phosphorus	1.10
Calcium	1.90
Sodium	0.30

Proximate analysis

The fish samples were analysed in triplicates for proximate composition as follows: lipid content of rainbow trout was measured using the method proposed by Bligh and Dyer (4), moisture and the ash content of fish was measured using AOAC (5) method and the total crude protein content was measured using Kjeldahl method (6).

FAME analyses

Lipid extraction was conducted according to the method proposed by Bligh and Dyer (4). Methyl esters were prepared by transmethylation using 2 M KOH in methanol and *n*-heptane according to the method proposed by Ichibara, Shibahara, Yamamoto and Nakayama (7) with minor modifications. Extracted oil (10 mg) was dissolved in 2 ml *n*-heptane followed by 4 ml of 2 M methanolic KOH. The tube was then vortexed for 2 min at room temperature. After centrifugation at 4000 rpm for 10 min, the hexane layer was used for analyses using gas chromatography (GC).

Gas chromatographic condition

The fatty acid composition was analysed using GC Clarus 500 with an autosampler (Perkin Elmer, USA) equipped with a flame ionisation detector and a fused silica capillary SGE column (30 m × 0.32 mm ID × 0.25 μm BP20 0.25 UM, USA). The oven temperature was 140 ºC for 5 min, which was then raised to 200 ºC at a rate of 4 ºC/min and held at 220 ºC at a rate of 1 ºC/min; meanwhile, the injector and the detector temperature were set at 220 ºC and 280 ºC, respectively. The sample size was 1 μl and the carrier gas was controlled at 16 ps. The split ratio used was 1:50. Fatty acids were identified by comparing the retention times of FAME with the standard 37-component FAME mixture. Two replicate GC analyses were performed, and the results were expressed as the mean percentage of GC area ± standard deviation.

Growth Performance Calculations and Statistical Analysis

The specific growth rate (SGR, % day^{-1}) is: 100 X (ln wt - ln w0) / t, where w1 and w0 are the wet weights at times t1 and t0. The economic conversion ratio (ECR, US. $ kg^{-1}) is: (feed cost (US. $$^{-1}$) + garlic cost (US. $kg^{-1})) x feed conversion ratio (kg diet kg-1fish). The feed conversion ratio (FCR) is: (Wfinal-Winitial)/consumed feed, where Wfinal and Winitial are the live weights (g) of the fish on the initial (t) and final (T) days, respectively. The economic profit index [EPI (US. $ fish^{-1}) is: final weight (kg fish^{-1}) x fish sale price (US. $ kg^{-1})-ECR (US. $ kg^{-1}) x weight increase (kg)], which was developed by Martinez-Llorens et al. (8). The protein efficiency ratio (PER) is: Weight gain (g) / protein intake (g), (9). The Condition Factor (CF) is calculated as CF= (Body weight (gr) / [Fish size (cm)]^3 x 100) (10).

The mean values and standard deviations of each growth parameter were calculated from the data of the three replicates for each treatment. The growth parameters were statistically tested by ANOVA using SPSS 15.0 for Windows. When only two groups were compared, the differences between the groups were tested using post-hoc Tukey's HSD tests. The effects with a probability P<0.05 were considered significant.

Results and discussion

Body Composition

The nutrient composition of rainbow trout fed with the garlic-supplemented diet for 90 days was examined and the results are shown in Table 2. In the current study, the crude protein ratios of rainbow trout were 17.97 ± 0.12%, 19.09 ± 1.19%, 19.98 ± 0.11% and 20.27 ± 0.16%, respectively. The addition of garlic to the diet affected the amount of protein in the rainbow trout, and the amounts were significantly different among the groups (p < 0.05). In our study, the highest amount of moisture was found in the control group (75.70 ± 1.27%) and the lowest was found in the 4th group (73.87 ± 0.46%) in which the trout were fed with food supplemented with 2.00% garlic. Total lipid amounts were 4.56 ± 0.97, 4.39 ± 0.52, 4.26 ± 0.59 and 4.17 ± 0.53, respectively, and there was no significant difference among the groups (p > 0.05). Rainbow trout fed with a garlic-supplemented diet had decreased crude ash content as opposed to the controls, and there was a statistically significant difference among the groups (p < 0.05).

Tokur et al. found protein and lipid contents of 22.96% and 2.71%, respectively, in a study conducted on rainbow trout (11). In other studies, the ratio of crude proteins found in raw rainbow trout was 22.33% and in those grown in aquaculture was 19.06% (12), the crude protein content in brown trout was 19.92% (13). In a study by Korkmaz and Kırkağaç, it was reported that the crude protein, fat, crude ash and water content in rainbow trout was 20.33%, 4.1%, 1.22% and 74.18%, respectively (14).

It has been reported that long-term administration of feeds supplemented with garlic reduces the lipid and cholesterol contents in fish, activates allergic intestinal proteases, increases feed utilisation by converting feed protein into body protein content in fish and contributes positively to the flavour of the fish (1). It has been reported that the body composition of fish varies according to the diet fed to fish, feed composition, living area, harvest season, sex, fish size and environmental conditions (15- 18).

Table 2. Body composition of rainbow trout fed with garlic supplemented diet

Proximate Composition	G1 $\bar{X} \pm S_{\bar{X}}$	G2 $\bar{X} \pm S_{\bar{X}}$	G3 $\bar{X} \pm S_{\bar{X}}$	G4 $\bar{X} \pm S_{\bar{X}}$
Protein	17,97± 0,12^{b}	19,09± 1,19^{ab}	19,98± 0,11^{a}	20,27± 0,16^{a}
Lipid	4,56± 0,97^{a}	4,39± 0,52^{a}	4,26± 0,59^{a}	4,17± 0,53^{a}
Moisture	75,70± 1,27^{a}	75,24± 0,56^{a}	74,02± 0,27^{b}	73,87± 0,46^{b}
Ash	1,33± 0,20^{ab}	1,41± 0,07^{a}	1,24± 0,12^{ab}	1,19± 0,14^{b}

$^{a-d}$Indicating significant differences(p<0.05) between groups fed with food containing garlic at different ratios.

Fatty Acid Profile

Table 3 shows the saturated fatty acid (SFA), monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) contents, respectively, in rainbow trout fed with diets supplemented with garlic in varying ratios. At the end of the 90-day feeding period, 23 different fatty acids were detected in all test groups, and the predominant basic fatty acids in all groups were identified and their contents were determined to be as follows: palmitic acid (C16:0, 13.69%–14.16%), palmitoleic acid (C16:1, 2.69%–2.70%), stearic acid (C18:0, 4.49%–5.12%), oleic acid (C18:1 n9, 26.66%–27.88%), linoleic acid (C18:2 n6, 21.82%–22.57%), linolenic acid (C18:3 n3, 2.33%–2.49%), eicosapentaenoic acid (C205 n3, 1.62%–1.83%) and docosahexaenoic acid (C22: 6.82%-9.27%).

At the end of the feeding period, the highest SFA content (21.91%) was observed in the control group and the lowest content was found in the test group fed with a 2.00% garlic-supplemented diet (20.95%). Hence, this indicates that the added garlic reduced the amount of SFA in rainbow trout.

At the end of the feeding period, the difference in the MUFA content among the groups was found to be statistically significant ($P < 0.05$), and the highest MUFA content was in the control group (34.28%) and the lowest content was in the group fed with 2.00% garlic-supplemented diet (32.76%). Hence, the added garlic also reduced the MUFA amount of the rainbow trout.

When the total PUFA values at the end of the feeding period were compared, it was found that it ranged between 37.71% and 40.89%. The lowest total PUFA content was found in the control group and the highest content was present in the 4th group fed with a 2.00% garlic-supplemented diet.

The total SFA content measured at the end of the feeding period ranged between 20.95% and 21.91% in our study. In the study by Haliloğlu et al. (19), it was reported that the total SFA content in rainbow trout was 31.92%; however, Beyter found the content to be ranging between 23.07% and 24.52% (20). Öz and Dikel found that the total SFA content in the rainbow trout grown in the wild was 28.04% and the total SFA content in cultured rainbow trout was 20.74% (12). Haliloğlu et al. (19) reported that MUFA content in rainbow trout was 30.81%, while Beyter reported that the total MUFA content ranged between 33.00% and 36.90% depending on feed content (20)

Beyter fed rainbow trout with three commercial feeds and found that the total PUFA content before feeding was 44.33% and that after feeding was 42.14%, 34.13% and 40.03%, respectively (20). Öz and Dikel found that the total PUFA content in the rainbow trout grown in the wild was 35.07% ± 0.95% and the total PUFA content in the cultured rainbow trout was 51.12% ± 0.97% (12). In another study, fish were fed with black cumin oil-supplemented feed and liver fatty acid content in fish were investigated; it was reported that black cumin oil altered the total content of SFA, MUFA and PUFA in those fish (21).

In our study, EPA content (C20:5 n3) in fish was between 1.62%–1.83% and DHA content (C22:6 n3) ranged between 6.82% and 9.27%. Garlic-supplement feed intake increased the amounts of DHA and EPA in rainbow trout and there was a significant difference among the groups in terms of the total PUFA/SFA, total n-6, total n-3 and DHA/EPA ratios ($P < 0.05$), as shown in Table 3. Omega-3 and omega-6 fatty acids are fatty acids that need to be externally supplemented, as they are not synthesised by the human body. Therefore, these fatty acids should be obtained in sufficient quantities from the diet. Acquiring these fatty acids from foods is thus important for metabolic activities in humans (22). The proportion of total omega-3 and omega-6 fatty acids in rainbow trout fed with garlic-supplemented feed was higher than that in the control group.

The Growth Performance

The growth parameters achieved as a result of the study are shown in Table 4. The starting weight of fish in the experimental group was approximately 64.12±0.29 gr, which increased to 234.12±3.54gr, 246.31±4.41gr, 258.74±4.42gr, and 268.79±4.79gr, while the difference in growth between the groups was observed to be statistically significant ($p<0.05$).

The feed conversion rates for the groups were as follows: 1.14±0.01, 1.09±0.01, 1.03±0.02 and 1.00±0.01.

The addition of garlic into the fish feed increased feed consumption and the daily feed consumed per fish was as follows, respective to each group: 2.16±0.01, 2.20±0.01, 2.23±0.01 and 2.27±0.02. The protein efficiency values were also observed to increase, with values of 1.94±0.01, 1.98±0.01, 2.01±0.01 and 2.05±0.02, respectively. The specific growth rates for the groups of fish receiving feed with garlic additives in the scope of the study were, 1.44±0.02, 1.50±0.02, 1.55±0.03 and 1.59±0.01, respectively.

Table 3. Fatty acid profile of rainbow trout fed with garlic supplemented feed with different amounts

Fatty Acids	Groups			
	1	2	3	4
C12:0	0.04±0.00^{a}	0.04±0.00^{a}	0.03±0.00^{a}	0.04±0.00^{a}
C14:0	1.95±0.01^{a}	1.89±0.03^{a}	1.74±0.04^{b}	1.91±0.02^{a}
C15:0	0.24±0.00^{a}	0.23±0.00^{ab}	0.22±0.01^{b}	0.23±0.00^{ab}
C16:0	14.16±0.04^{a}	14.00±0.01^{a}	13.88±0.26^{a}	13.69±0.24^{a}
C17:0	0.15±0.11^{a}	0.22±0.01^{a}	0.22±0.01^{a}	0.23±0.00^{a}
C18:0	5.12±0.02^{a}	4.90±0.15^{ab}	4.71±0.07^{bc}	4.49±0.16^{c}
C20:0	0.28±0.00^{a}	0.27±0.00^{a}	0.27±0.00^{a}	0.27±0.00^{a}
C24:0	0.13±0.01^{c}	0.19±0.00^{b}	0.20±0.01^{b}	0.24±0.01^{a}
∑SFA	21.96±0.10^{a}	21.64±0.16^{a}	21.19±0.15^{b}	20.99±0.06^{b}
C14:1	0.08±0.00^{a}	0.08±0.00^{a}	0.07±0.00^{a}	0.08±0.00^{a}
C16:1	2.69±0.02^{a}	2.70±0.03^{a}	2.69±0.09^{a}	2.69±0.10^{a}
C17:1	0.19±0.01^{a}	0.17±0.00^{a}	0.16±0.01^{a}	0.15±0.02^{a}
C18:1n9	27.88±0.06^{a}	27.58±0.45^{a}	27.12±0.00^{ab}	26.66±0.43^{b}
C18:1n7	2.38±0.01^{a}	2.28±0.01^{a}	2.28±0.01^{a}	1.98±0.07^{b}
C20:1n9	0.49±0.02^{b}	0.52±0.01^{ab}	0.56±0.01^{a}	0.56±0.02^{a}
C22:1n9	0.56±0.00^{c}	0.59±0.00^{b}	0.61±0.00^{ab}	0.62±0.02^{a}
∑MUFA	34.29±0.01^{a}	33.93±0.40^{ab}	33.50±0.12^{b}	32.76±0.25^{c}
C18:2n6	21.82±0.04^{c}	22.20±0.10^{b}	22.44±0.10^{a}	22.57±0.02^{a}
C18:3n3	2.49±0.04^{a}	2.45±0.08^{a}	2.42±0.01^{a}	2.33±0.16^{a}
C20:2cis	2.45±0.05^{a}	2.17±0.01^{b}	2.12±0.02^{bc}	2.05±0.01^{c}
C20:3n6	1.15±0.01^{a}	1.17±0.02^{a}	1.15±0.04^{a}	1.18±0.01^{a}
C20:4n6	1.34±0.00^{c}	1.43±0.01^{bc}	1.50±0.05^{b}	1.62±0.04^{a}
C20:5n3	1.62±0.01^{c}	1.67±0.01^{c}	1.73±0.02^{b}	1.83±0.01^{a}
C22:2cis	0.01±0.00^{a}	0.01±0.00^{a}	0.02±0.01^{a}	0.01±0.00^{a}
C22:6n3	6.82±0.05^{d}	7.20±0.01^{c}	8.47±0.02^{b}	9.27±0.02^{a}
∑PUFA	37.71±0.04^{d}	38.31±0.21^{c}	39.86±0.04^{b}	40.90±0.06^{a}
∑PUFA/SFA	1.72±0.01^{d}	1.77±0.01^{c}	1.88±0.02^{b}	1.95±0.00^{a}
∑n-6	24.31±0.03^{d}	24.80±0.12^{c}	25.09±0.01^{b}	25.38±0.07^{a}
∑n-3	10.93±0.02^{d}	11.32±0.08^{c}	12.62±0.04^{b}	13.44±0.14^{a}
∑n-6/n-3	2.22±0.01^{a}	2.19±0.01^{a}	1.98±0.01^{b}	1.89±0.02^{c}
DHA/EPA	4.20±0.01^{c}	4.31±0.04^{c}	4.89±0.06^{b}	5.05±0.03^{a}

$^{a-d}$ Indicating significant differences($p<0.05$) between groups fed with food containing garlic at different ratios.

Growth parameters in the present work indicate an enhancement in growth and feed utilisation for all fish groups fed garlic powder at all inclusion levels compared to the control fish group.

Many authors reported that the administration of garlic in diets has important effects on growth parameters and feed utilisation of many fishes including Rainbow trout, *Oncorhynchus mykiss* (23, 24), Nile tilapia, *Oreochromis niloticus* (25-27), African catfish, *Clarias gariepinus* (28) and *Xiphophorus helleri* (29).

The ratio of feed conversion decreased with increasing *Allium sativum* levels. These results are also in agreement with those obtained by Saleh et al., Khattab et al. and Farahi et al. (30-32).

One of the indicators allowing the parametric evaluation of growth is the Economic Conversion Rate (ECR), which is calculated as a multiple of feed prices and feed benefit rates and shows the economic reflection of feed benefit. Groups 4 had the best economic conversion rates (1.72 $/Kg), while the control group had an economic conversion rate of 1.83 $/Kg. A higher economic conversion rate indicates higher costs.

Therefore, Group 4 had the lowest costs and was the most profitable among the different groups. Furthermore, the Economic Profit Index (EPI) was calculated to show the level of benefits achieved by the addition of garlic into fish feed, and it was observed that an addition of 2% garlic into the feed, as given to Group 4, yields an EPI of 0.51. An examination of these results shows that the addition of 2% garlic into trout feed increases the EPI. Öz et. al. reported that rainbow trout the economic conversion rates of the fish ($/Kg) were between 1.58 and 1.67, while the economic profit index was between 0.60 and 0.72 (33). These findings have also been supported by Dikel et al. who showed that a lower conversion rate (2.21 $/Kg) and higher profit index (0.464) were obtained for rainbow trout (34).

Lee et. al. reported that the addition of 0.5% garlic extract to the commercial diet was optimal for the growth performance of sterlet sturgeon (35). In agreement with the present results, Shalaby et al. reported a significant increase in weight gain, feed efficiency, the protein efficiency ratio (PER) and specific growth rate (SGR) in Nile tilapia which were fed diets containing 30.0 g/kg diet of garlic powder (25). Similarly, Diab et al. mentioned that a diet with 2.5% garlic/kg diet resulted in the highest growth performance in *O. niloticus* (36). In the same species, Abou-Zeid found a positive improvement in biomass and specific growth rate with garlic supplementation (37). It was also reported that the best performance was obtained in Nile tilapia fed a diet with 32 g/kg diet of garlic powder (26). A significant increase in growth performance, feed conversion ratio and protein efficiency ratio was shown in rainbow trout fed a diet with 1.0% garlic (24).

Table 4. Growth parameters of trout after 90 days of feeding

	1. Group	2. Group	3. Group	4. Group
IFW (gr)	64.12±0.29	64.12±0.29	64.12±0.29	64.12±0.29
FW (gr)	234.12±1.82	246.31±2.44	258.74±1.98	268.79±2.61
WG (gr)	170	182.19	194.62	204.67
SGR (%)	1.44±0.02	1.50±0.02	1.55±0.03	1.59±0.01
FI (gr)	194.18±0.27	198.24±0.48	201.02±0.35	204.64±0.34
DFI(gr)	2.16±0.01	2.20±0,01	2.23±0,01	2.27±0.02
FCR	1.14±0.01	1.09±0.01	1.03±0.02	1.00±0.01
PER	1.94±0.01	1.98±0.01	2.01±0.01	2.05±0.02
SUR(%)	100	100	100	100
ECR($/Kg)	1.83±0.01	1.81±0.01	1.75±0.02	1.72±0.01
EPI	0.44±0.01	0.46±0.00	0.49±0.01	0.51±0.02

In recent years, a lot of research has been carried out in the field of Aquaculture and these studies are tested on herbal and chemical feed additives. In these studies, it has been reported that the additives added to fish feeds affect the nutrient content of fish (38; 39; 40), sperm quality (41), growth parameters (38; 39; 40, 41), muscle fatty acid profile (40; 42), liver fatty acid (21, 40, 42) and the shelf pattern of the fish (43-45). Similar to the results of this study, garlic added to fish feed affected the nutrient content, fatty acid profile and growth parameters of rainbow trout in my research.

As a result of this study, the growth of rainbow trout fed a diet containing powdered garlic was positively affected. The best growth performance was observed in the group given a diet supplemented with 2.00% garlic. It also reduced the feed conversation ratio and increased the economic profit index. Moreover, garlic added to the diet fed to fish raised the meat quality of rainbow trout. The total amount of omega-3 and omega-6 fatty acids, DHA, EPA and PUFA also increased in rainbow trout fed with garlic-supplemented feed. In addition, the supplementation of garlic led to an increase in the body protein content in rainbow trout. It will thus be beneficial to add garlic to fish feeds as it increases the nutritional content of fish, facilitating better human health.

Each value indicates the average ± standard deviation. The averages expressed using different letters in each row are significantly different ($p<0.05$). IFW: Initial fish weight, FW: Final weight, WG: Weight gain, SGR: Specific growth rate, FI: Feed intake, DFI; Daily feed intake, FCR: Feed conversion rates, PER: Protein efficiency ratio, SUR: Survival, ECR: Economic Conversion Rate, EPI: Economic profit index. Group 1: 0.00% garlic in fish feed, Group 2: 1.00% garlic in fish feed, Group 3: 1.50% garlic in fish feed, Group 4: 2.00% garlic in fish feed.

It is recommended that similar research be done on other oilseeds (46-51), especially those whose oil is similar to fish oil, such as camellia (52-57).

Authors' Contributions

All responsibilities and contributions of every author are equal.

Conflict of Interest Disclosure

There is no conflict of interest among the authors of this manuscript.

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