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Effects of Different Feed and Temperature Conditions on Growth, Meat Yield, Survival Rate, Feed Conversion Ratio and Condition Factor in Rainbow Trout (*Oncorhynchus mykiss*) Fingerlings

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Abstract: In this study, we investigated effects of different feeds (live food (*Artemia*+*Drosophila* sp.), wet feed (Spleen+Liver) and commercial feed) and different water temperatures (9.10±0.85 and 15.00±0.50°C) on meat yield, Survival Rate (SR), Feed Conversion Ratio (FCR), Condition Factor (CF) and growth in Rainbow trout, *Oncorhynchus mykiss* (Walbaum) fingerlings. The fingerlings had 0.23±0.04 g mean initial weight. The study lasted a total of 16 weeks and carried out according to completely randomized factorial experimental design (3×3×2). At the end of the experimental period, final weights of fish having about the same initial weights showed big differences. The highest final weight was 13.05±0.21 g from the higher temperature and commercial feed group. The differences between the groups were found statistically significant ($p<0.05$). In terms of feed conversion ratio, very different values were observed among the groups and their differences were also statistically significant ($p<0.01$). At the end of research, carcass weights differences between the results of the commercial feed, wet feed and live food groups were statistically significant ($p<0.05$). In terms of condition factor values, the differences between the groups were insignificant. In terms of Hepatosomatic (HSI) and Viscerasomatic (VSI) indices the differences between the results of the groups were found statistically significant ($p<0.05$).

Key words: Feed, temperature, growth, survival rate, feed conversion ratio, condition factor

INTRODUCTION

Fish farming (aquaculture) has two main ground rules. First is to provide the conditions similar to natural environment of the fish and the second is well-balanced feeding (Hossu *et al*., 2003).

In trout farming, a carnivore species feed of animal origin is required in the ration as well as the feed with high protein content (Aras *et al*., 2000; Bilguven, 2002). High protein content of the ration (40-45%) is one of the important factors that increase the feeding cost of the trout farming because feed containing high quantity and high quality proteins are expensive. This cost could cover 60-70% of the total expense of the trout farming (Kim, 1997; Stickney, 2000; Akyurt, 2004). For this reason, feeding is an important problem in trout farming and requires special attention.

Various studies have been done to reduce feeding cost using available waste and superfluous matters and this kind of studies are still being done. Considering the magnitude and the potential of the sector, it could be understood that this kind of studies will continue in future. In addition to economic dimension of the subject, scarcity and increasing prices of the raw materials of the feed indicate that the major problem of the trout farming is feed input in ready feed technology.

To overcome this problem, alternative feed sources should be considered (Spinelli, 1985; Steffens, 1994; Ariman and Aras, 2004; Shamsaie *et al*., 2007; Abdolbaghian *et al*., 2010).

Wet and live feed are used as supplements for commercial feed to save from feed cost and also to improve the survival rate and meat quality of fish. Even in the brood fish, survival rate and fecundity are improved with the use of flesh and live feed (Mathias *et al*., 1982; Szlaminska and Przybyl, 1986; Kocaman, 1994). Improvement of fish culture is closely dependent on feed. Without solving feed problem, it would be impossible to produce and consume fish at low expense. Therefore, every possible way should be tried to make use of any kind of feed source (Akyurt, 1989).

Water temperature is another important factor affecting growth and feed conversion ratio of trout. Water temperature should be below 20°C for trout farming. If the temperature increases above 20°C, some precautions are implemented. Even in the days when the temperature is

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around 18-20°C, daily feed amount is reduced. Just like high temperature, cold water is also not desired. Due to the close relation between water temperature and metabolism, development of both larvae and juvenile gets slower in cold water.

Optimal water temperature is very important for better feed conversion ratio and growth (Celikkale, 2002; Alpbaz, 2005; Pillay and Kutty, 2005).

In this study, it is aimed to determine the effects of different feed (dry, wet and live) and different water temperatures on the growth, meat yield, survival rate, feed conversion ratio and condition factor of rainbow trout fingerling (*Oncorhynchus mykiss*).

MATERIALS AND METHODS

The study was done in the Trout Juvenile Production and Research Center of Department of Fishery, Faculty of Agriculture, Ataturk University. Chlorinated city water was used in this study after removing chlorine with active carbon filter. Filtered water was distributed to water tanks in amounts of at least 0.5 L/dk/k fish (Schmidtke and Carson, 1999). During the study, mean normal water temperature was 9.10±0.85°C and heated water temperature was measured as 15.00±0.50°C. Thermostat heater (10-80°C) was used to keep water temperatures almost constant throughout the experiment. Portable circular fiberglass tanks of 75 L volume were used in the study.

To prevent juvenile fish from jumping, water level was adjusted to 15 cm below surface using level pipes and top of the tanks are covered with a fine net. Fingerling trout (*O. mykiss)* of 0.23±0.04 g produced in the same center was used in the experiment. As commercial feed, we used starter feed 0.005 mm at the beginning and later depending on growth, 0.7, 1 and 1.5 mm granules and 2 numbered extruded pellets were used. As wet feed, we used cattle liver and spleen obtained from slaughter houses.

Liver and spleen were broken into pieces, cleaned from fat and nerve tissues and very finely ground. Then wet feed is prepared as a 50% spleen and 50% liver mixture. As live feed, we used salt water crabs (Artemia) larvae and fruit fly larvae *(Drosophila* sp.). Feed properties were shown in Table 1. After obtaining them, 50% artemia larvae and 50% fruit fly larvae are mixed to obtain live feed.

Artemia eggs used as live feed in the experiment were obtained from market. Artemia eggs were put in 24-28°C aquariums with heater in 2 L containers at a density of 1g L^{-1} and 2% saltiness, stirred and ventilated and 22-24 h later they were harvested. Fruit fly larvae was obtained by letting some of the spleen and liver to get wormed. Liver and spleen were kept in a warm place in open containers. In 4-5 days, fruit fly eggs and about one week later fruit fly larvae appeared. Growth of fruit fly larvae (*Drosophila* sp.) changes based on the ambient temperature. Egg-larva period of *Drosophila melanogoster* is around 8 days at 20°C and 5 days at 25°C. Hatching larvae molt twice during this period. At the end of the third molt, larvae reach 4.5 mm of length (Alemdar, 1980; Demirsoy, 2003).

Table 1: Proximate analysis results of the feeds (Kocaman *et al.*, 1997)

Feeds (as %)	Crude protein	Crude fat	Water	Crude cellulose	Crude ash
Dry feed	52.25	17.700	10.00	3.30	9.84
Liver	20.10	2.500	70.40	-	16.60
Spleen	18.60	2.200	75.00	-	12.20
*Artemia**	52.20	18.900	-	-	10.10
Drosophila sp.	16.50	10.000	80.20	-	10.70

*(Alpbaz *et al.*, 1989)

Study was planned as 3×2×3 factorial type randomized design in accordance with Yildiz and Ve Bircan (1991). Experiment was implemented in 18 tanks. In this method, groups were planned with 3 replicates. About 900 fingerling fish of 0.23±0.04 g mean weight were put in the tanks after getting accustomed to feed following incubation period. About 50 fingerling were put to each one of 18 tanks.

Fish were weighted every 14 days with ±0.01 g sensitive scale. After fish were weighted, feed amounts that would be given to each group were calculated. Commercial diets (dry feed) were calculated from the existing tables which are based on percentage of live fish weight and water temperature (Celikkale, 2002; Halver and Hardy, 2002).

Wet and live feeds were given to fish as three times heavier than dry feed because the calories of dry feed is about three times more than wet or live feed. Wet and live feed has about 1000 kcal kg^{-1} and dry feed has about 3000 kcal kg^{-1}. This is because dry feed is almost all dry matter with little water in it whereas most of the wet and live feed is water. By giving wet and live feed three times more we equalized caloric content of the different feed approximately (Cetinkaya, 1989). At the end of the experiment, six fishes randomly taken from each one of 18 units were weighted and head, fin, carcass weight, hepatosomatic and viscerasomatic indices were determined, respectively according to Ronsholdtand and McLean (2004) to determine effects of different feed on fish meat. Experiment lasted for 16 weeks. Data obtained in the experiment were subjected to variance analysis and Duncan's Multiple Range test at 0.05 significance level using Statistica for Windows statistical packet program (Duncan, 1971). We also used SAS packet program for some of the statistical analysis (Hellwig, 1981). Results of the analysis were evaluated based on the formulae (Flower, 1991; Celikkale, 2002):

$$\text{Specfic Growth Rate (SGR)(\%)} = \frac{\text{In last weight (g)} - \text{In first weight (g)}}{\text{Cultivation period (day)}} \times 100$$

$$\text{Feed Conversion Ratio (FCR)} = \frac{F}{(A_2 + D - A_1)}$$

F = Feed amount of one period (g)
A_1 = Weight at the beginning of period (g)
A_2 = Weight at the end of period (g)
D = Weight of fish died in period (g)

$$\text{Survival Rate(SR) (\%)} = \frac{\text{Fish quantity at the end of period}}{\text{Fish quantity at the beginning of period}} \times 100 \text{(Fowler, 1991)}$$

$$\text{Condition Factor (CF)(\%)} = \frac{W}{L^3)} \times 100 \text{(Avsar, 2005)}$$

W = weight (g)
L = Total length (cm)

$$\text{Hepatosomatic Index (HSI)(\%)} = \frac{\text{Liver weight (g)}}{\text{Body weight (g)}} \times 100$$

$$\text{Viscerasomatic Index (VSI) (\%)} = \frac{\text{Inner Organ Weight(g)}}{\text{Body weight (g)}} \times 100$$

(Ronsholdtand and McLean, 2004).

RESULTS AND DISCUSSION

In this study, we investigated effects of different feed (dry, wet and live) and temperature (normal 9.10±0.85°C, high 15.00±0.50°C) on growth and body composition of rainbow trout fingerlings. The study lasted 16 weeks and measurement were taken in 14 days periods. Study results were shown in Table 2. The fingerlings had 0.23±0.04 g mean initial weight. At the end of study highest weight 7.05±0.06 g for dry feed group and lowest weight was 5.83±0.12 g for wet feed group in normal water temperatures. For the higher temperature groups all weight increases were higher than normal water temperature groups. In higher temperature groups, the dry feed group had the highest weight gain again with 13.05±0.21 g. Similarly, wet feed group had the lowest weight gain with 7.11±0.04 g. The difference between groups was found statistically important ($p<0.05$).

During the study, the highest Specific Growth Rate (SGR) was found as 3.65±0.62% in the higher water temperature dry feed group and the lowest was found as 2.95±0.56% in the live feed normal water temperature group. Higher temperature increased SGR in all feed groups. For both temperatures dry feed had the highest SGR. With respect to Feed Conversion Ratio (FCR) values, live feed and higher temperature group had highest value 3.99±0.22 and dry feed and normal temperature group had the lowest FCR value 1.51±0.19. Higher temperature groups had higher FCR than normal temperature groups for all feed types. Dry feed had the lowest and live feed had the highest FCR for both temperatures.

Dry feed had the lowest Survival Rate (SR) (92.70±1.20%) for normal temperatures whereas live feed had the highest SR for higher temperature (98.1±0.31%). Live feed groups had higher SR than wet feed groups for both temperatures. Also, higher temperature groups have higher survival rate than normal temperature groups. Carcass weight, Condition Factor (CF), Hepatosomatic (HSI) and Viscerasomatic (VSI) indices at the end of experiment were shown in Table 3.

In this respect, maximum carcass weight was found as 62.40±0.80% in the dry feed normal water temperature group. The best condition factor was found as 1.14±0.03% in the live feed higher temperature group, the highest hepatosomatic index value was found as 1.70±0.44% in live feed normal water temperature group and the highest viscerasomatic index was found as 14.06±1.01% in the same group. Fingerlings weighting 0.23±0.04 g at the beginning of the experiment reached to 7.05±0.06, 5.83±0.12, 6.00±0.09 g values with dry (Commercial pellet),

Table 2: Data obtained in the study

Groups	Normal water temperature (9.10±0.85°C)			High water temperature (15.00±0.50°C)		
	Dry feed	Wet feed	Live feed	Dry feed	Wet feed	Live feed
Initial fish number	150	150	150	150	150	150
Final fish number	139	144	147	146	145	147
Mean initial weight (g)	0.23±0.00	0.23±0.00	0.22±0.00	0.22±0.00	0.23±0.00	0.23±0.00
Mean final weight (g)	7.05±0.06	5.83±0.12	6.00±0.09	13.05±0.21	7.11±0.04	9.06±0.51
Mean weight increase (g)	6.82±0.05	5.60±0.11	5.78±0.41	12.83±0.20	6.88±0.01	8.83±0.62
Specific growth rate (%)	3.06±0.33	2.89±0,51	2.95±0.56	3.65±0.62	3.06±0.40	3.28±0.04
Feed conversion ratio	1.51±0.19	2.55±0.11	3.85±0.16	1.85±0.11	2.73±0.03	3.99±0.22
Survival rate (%)	92.70±1.20	96.00±0.95	98.00±0.16	97.20±0.15	96.70±0.05	98.00±0.31

X±Sx = Mean value±standard deviation of mean value

Table 3: Results obtained from the properties of fish flesh

Groups	Normal water temperature (9.10±0.85°C) Dry feed (X±Sx) (N = 6)	Wet feed (X±Sx) (N = 6)	Live feed (X±Sx) (N = 6)	Higher water temperature (15.00±0.50°C) Dry feed (X±Sx) (N = 6)	Wet feed (X±Sx) (N = 6)	Live feed (X±Sx) (N = 6)
Head weight (%)	16.13±0.30	15.48±0.13	15.35±0.22	14.62±0.48	15.38±0.30	15.26±0.06
Fin weight (%)	2.50±0.03	2.41±0.04	2.39±0.15	2.29±0.01	2.40±0.08	2.38±0.03
Carcass weight (%)	62.40±0.80	60.01±0.12	59.55±0.35	61.13±0.80	58.02±0.03	56.50±0.53
Condition factor (%)	1.17±0.01	1.16±0.16	1.15±0.21	1.18±0.01	1.17±0.18	1.14±0.03
Hepatosomatic index (%)	1.65±0.07	1.67±0.02	1.70±0.44	1.25±0.01	1.56±0.11	1.63±0.80
Viscerasomatic index (%)	13.77±0.34	13.94±0.19	14.06±1.01	12.37±0.50	13.90±0.90	14.02±1.40

X±Sx = Mean value±standard deviation of mean value

wet (Spleen + Liver) and live (*Artemia* + *Drosophila* sp.) feeds in normal water temperature. Same feed groups with higher temperature yield 13.05±0.21, 7.11±0.04 and 9.06±0.51 g average final weights, respectively. As can be shown in Table 2, temperature difference created significant growth increase. Ideal temperature suggested for larvae and juvenile trout is 8-13°C (Aras *et al*., 2000; Stickney, 2000; Celikkale, 2002; Alpbaz, 2005). In studying growth, one might look at either absolute weight increase or Specific Growth Rate (SGR). SGR is percent weight increase of fish in one day. If fish grows with constant SGR the growth is exponential. However, nothing keeps increasing exponentially in nature forever. So, SGR depends on age (Avsar, 2005). When a SGR is reported for an experiment that lasted for a period, it is actually an average of SGR over the period. For many experiments, change of SGR in the experimental period is small and average SGR and instant SGR does not differ much for the experimental period. We found that Specific Growth Rate (SGR) was statistically significant among groups in the results of variance analysis ($p<0.05$) (Table 2). In general, dry feed groups had highest and wet feed groups had lowest (live feed in between) SGR for both temperatures.

Higher water temperature groups had higher SGR than normal water temperature groups as can be also observed from significant effect of temperature on absolute growths. Here, temperature difference seems to be as important as feed difference.

In this study, we found that different feed types and temperatures strongly affect growth performance. Temperature effect on fish growth is well known. Fish metabolism accelerates with increasing temperature (up to certain limit) and temperature strongly affect growth performance (Celikkale, 2002).

Abdolbaghian *et al*. (2010), studied angel fish fry (*Pterophyllum scalare*) fed with artemia and dry blood worm at temperatures 27, 29, 31°C and they investigated SGR and weight growth. Their study lasted 6 months and they found that both feed type and temperature affects growth. It is interesting that in their study even two degrees temperature difference had significant effects on growth. Shamsaie *et al.* (2007), studied effects of live feed (rotifers), dry feed (commercial) and mixture of them on white fish (*Coregonus lavaretus*) for a three months period. In the first month of the experiment, specific growth rate was highest (5.36%) in the live feed group. They also found that in the last month of the experiment, SGR was highest (3.73%) in the dry feed group. In the study, SGR for dry feed higher temperature group was 3.65% and SGR for live feed higher temperature group was found 3.28% (Table 2).

From the results of Shamsaie *et al.* (2007), it might be inferred that although of live feed might have some advantages in the early period of growth, after some growth stage commercial feed provides higher SGR than live feed. From the interesting results of Shamsaie *et al.* (2007), we might guess that different feed combinations might be better at different stages of growth.

Wet and live feed generally, meet most of the nutritional needs of trout. What is important is to obtain these feed stuff in required amounts and in time. Wet and live feed should be used when the fish amount and size are small (larvae period). As a matter of fact, all feed requirements of the intensive fish farming can not be supplied with these feed. However, during certain time of the fish production, wet and live feeds help both to save from feed cost and to improve meat quality (Akyurt, 1989; Stickney, 2000).

In the study, all groups except dry feed normal temperature group had survival rates between 96 and 98%. The differences in the number of deaths between groups are only a few (2-3) fishes and they could be due to various reasons other than feed or water temperature differences. Effect of the feed groups on survival rate of fish was found statistically insignificant in the results of variance analysis (Table 2).

There are reports of significant effects of different feed on survival rates of rainbow trout in the literature however. Especially in the juvenile period, death rate decreased significantly in the enterprises using natural feeds. For instance, Mathias *et al.* (1982) determined the death rate of juvenile rainbow trout as 2.23% for the group fed on commercial feeds and 0.93% for the group fed on live feeds. Kocaman *et al.* (1997) gave wet and live feeds to juvenile rainbow trout in their study and determined the highest survival rate as 97.5% in the groups fed on *Artemia*+dry feeds and spleen+dry feeds, however the lowest survival rate as 85% in the group fed on spleen. Feed conversion ratio was found statistically highly significant among the groups fed on dry, wet and live feeds in normal water and higher temperature groups ($p<0.01$) (Table 2). As can be shown in Table 1, high level of water contents of live and wet feed (80.20% fruit fly larvae, 75.00% spleen, 70.40% liver) created big difference in Feed Conversion Ratio (FCR).

Similarly, Aras (1993) determined the feed conversion ratio value 2.40-2.78 for the brood rainbow trout fed on cattle liver as wet feed. As in the production of fish meal, feeds could be turned into meal after applying some process to decrease water content of the feed (Sener and Ve Senel, 1987). For instance, Spinelli (1985)'s study in which he used *Musca domestica* (domestic fly) larvae meal in rainbow trout ration instead of fish meal, found the feed conversion ratio value as 1.55 and there was statistically no significant difference in the comparison with control groups. Therefore, a comparison of FCR can be more meaningful after eliminating water content in the wet or live feed.

It is reasonable to assume that if the fish receives same amount of required feed contents (protein, fat, vitamin etc.) it would grow the same amount regardless of the source (liver, spleen, *drosophila*, dry feed ect.) as long as they are all digested. Therefore by choosing different feed, we are changing relative ratios of these basic feed components. One issue of aquaculture studies is to provide these feed components as cheap as possible and same quality protein or fat can be cheaper from one source than another. This point is one of the reasons why feed studies is necessary.

Percentages of carcass weight was high in the dry feed and normal temperature group (Table 3). The differences are a few percent and relatively small however, live feed and higher temperature group had the lowest carcass percentage.

Generally, wet and live feed are easily digested thus, relaxing metabolism (Aras *et al*., 2000). Therefore, they are given as substitutions to fish fed on commercial feeds. Low quality feed with high carbohydrate content exhaust digestion system and cause liver growth. For this reason, hepatosomatic index should be 3 or below in fish feeding. Table 3 and above values indicate low quality of feed and therefore, high level of carbohydrate (Cetinkaya, 1989). In this study, hepatosomatic index values were all <3. In the results of analysis made among feed groups, carcass weight was found statistically significant, condition factor was insignificant and hepatosomatic and viscerasomatic indices were found significant ($p<0.05$) (Table 3). Condition factor of <0.1 indicates weak condition of fish which means long and thin fish. If the condition factor is equal to 1, fish is said to have good condition. However if the condition index is >1, fish is said to be fleshy (Avsar, 2005). Conditions of the fish fed on wet and live feed were found to be slightly better (closer to 1) than dry feed groups but the difference is small (Table 3).

CONCLUSION

In this study, feed conversion ratio was found to be better in the dry feed with normal temperature group than other groups. This was an expected result considering the previous studies. Low values of specific growth rate, high feed conversion ratio values and low carcass weight of the groups fed on wet and live feeds were attributed to high water content of these feeds.

The use of dry feed is very important for intensive aquaculture. It is important to pay attention to the content of feed components, the amount of feed additives and the amount of residuals in fish meat before harvesting. Organic aquaculture is gaining popularity in recent years. Different feed types such as live and wet feed and organic dry feed are being considered (Korkut, 2009) for different growth periods of cultured fish. Results of research on live and wet feed could be useful for organic aquaculture projects too.

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