THE EFFECTS OF DIFFERENT DIETARY PROTEIN AND LIPID LEVELS AND OIL SOURCES ON THE GROWTH PERFORMANCE AND BODY COMPOSITION OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*, W.)

Murat Bilguven
Mersin University, Aquaculture and Fisheries Faculty, Aquaculture Department, Turkey

Ibrahim AK
Uludag University, Faculty of Agriculture, Department of Animal Science, Bursa, TURKEY

Abstract:
In this research, the effects of different dietary protein and fat level, and various oil sources on the fattening performance and body carcass composition of rainbow trout (*Oncorynchus mykiss*) was investigated during 14 weeks.
Throughout the feeding period, it was found that dietary protein and fat level had affected the average live weight, live weight gain, feed conversion ratio, protein efficiency ratio (PER), specific growth rate (SGR) and carcass composition significantly (P < 0,01), although they had not effected the condition factor and the ratio of internal organs weight to total body weight.
Throughout the feeding period, it was determined that oil kinds had also affected the average live weight, live weight gain, feed conversion ratio, protein efficiency ratio (PER), specific growth rate (SGR) significantly (P < 0,01), while they hadn't effected the carcass composition, condition factor and the ratio of internal organs weight to total body weight.

Key Words: Rainbow trout (*Oncorynchus mykiss*), dietary protein level, dietary fat level, oils, growth performance, carcass composition

Introduction

The biggest problem that the world will be facing in the future is going to be the ever increasing human population and the hunger or malnutrition that comes with it. Therefore, every nation on earth has to investigate and utilize its natural sources wisely and obtain the maximum yield per cultivated land or animal production unit. This necessity has consequently directed most of the research conducted in agriculture for finding new resources or developing and efficient use of existing ones.

It is obvious that food shortage caused by ever increasing human population on earth will only be alleviated by agriculture ventures that produce cost effectively. Aquaculture industry is no different than any other agriculture ventures and it will only be a part of sustainable food production if it maintains cost effectiveness and quality assured production. In parallel to the increment of intensive aquaculture production, aqua feed use in farms increased significantly in the last two decades. However, aqua feeds are expensive compared to the feeds of other farm animals and feed cost comprises of nearly 2/3 of the operating cost of any aquaculture farm during the whole production cycle.

Farmed fish require high protein diets with an optimum amount of non-nitrogenous energy sources (mainly lipid and digestible carbohydrates) in order to grow rapidly to market size in an intensive fish farm (Lovell, 1988). Fish feeds generally contain 25 to 50 % of crude protein. Salmonid feeds, however, contain crude protein between 40 to 50 % in their diets. In order to maintain these high protein levels in aqua feeds, ingredients that contain high amount of crude protein levels are extensively used in feeds and comprised of almost 50 to 75 % of the ingredients in commercial aqua feeds. Of the ingredients that are classified as high protein ingredient, fish meal is the most important one and it generally comprises of between 25 and 65 % of the ingredients used in salmonid diets (Akiyama, 1988; Akyurt and Erdogan, 1994).

Protein is the most effectively used nutrient among other energetic nutrients in fish. Lipids and carbohydrates are used as an energy source on a lesser extent in fish. Therefore, It is required from aqua feeds that amino acids used in diets are mostly spent for depositing new proteins rather than used as an energy source to maintain basal metabolism in farmed aquatic animals. To achieve this, crude protein levels in diets are reduced and lipids and digestible carbohydrates are added to the diets to provide energy lost by reducing protein. However, It should be kept in mind that carnivourus fish species do not utilize complex carbohydrates well. Therefore, lipids remain as the only option to be considered to provide energy needs of these fish. In fact It was demonstrated that lipids as an energy source resulted in utilization of feed protein better for growth compared to carbohydrates (α-starch and dextrose) in rainbow trout (Ogino *et al.,* 1976). Similarly De la Higuera *et al.,* (1977) investigated the effects of crude lipid levels in diets on protein and lipid apparent digestibilities in the rainbow trout. Authors found that crude lipid apparent digestibility were not correlated with the crude lipid levels in diets. Dietary crude lipid levels were also found not to influence the apparent protein digestibility in the trout. They also concluded that protein use for growth had significantly increased in relation to the increment in dietary crude levels.

Luquet (1971) who investigated 4 diets containing 30, 40, 50, and 60 % crude protein and 2297, 2530, 2652 and 2839 kcal ME (Metabolizable Energy)/kg diet respectively for 36 week-grow out period in the rainbow trout found that decrement in dietary crude protein level from 60 % to 30 % increased the feed efficiency ratio from 0.98 to 1.97 whereas trout fed diets in rich of protein and energy were found to have more body crude lipid levels.

Takeuchi *et al.,* (1978a) have employed feed with a protein level of 35% and oil with a level between 5-25% in their study for the determination of optimal energy / protein ratio in the feeds of rainbow trout. Growth and feed efficiency have increased in line with the increase in the oil content of the feeds and reached the maximum level when the oil ratio was 18%. The value of PER has also increased with the increase in feed fat and it has been reported that DE/protein ratio that must be obtained should be 130 in feed in order to ensure an optimal growth of rainbow trout.

Takeuchi *et al.,* (1978b) in a study where they examined the impact of oil (5-20%) added to high-protein rainbow trout feed (54%) -casein was employed as the protein source- have found that there is not a significant difference in terms of growth rate between the groups however they have found that feed containing 20% oil has led to better results compared to the experimental feed containing 5% oil in terms of both growth rate and feed efficiency.

Reinitz *et al.,* (1978) have examined the effect of various fat levels at two different protein levels in rainbow trout diets. In this study, it was determined feed fat achieve saving of protein. Growth has been associated with feed efficiency while increase in length has been associated with energy content of the feed. High fat containing fish feed has resulted in the accumulation of higher levels of fat in carcass and accumulation of lower levels of protein in these fish compared to the control group.

Akiyama *et al.,* (1981) in an experiment made with *Oncorynchus Keta,*have examined the relation between the need for protein in 9 and 12 °C water temperature and protein-fat requirement in ration. Researchers have reported that at both temperatures the feed containing 5% fat and 43% protein will require 38% protein when the level of oil is increased to 10%.

Kim *et al.,* (1988) have applied feed containing 9.14%, and 21.0% fat and 31.0%, 38.0 % and 44.0 % protein for 12 weeks to 10 different groups of rainbow trout the initial weight which were 46 g ad libitum. The results have revealed that the feed where fish oil is used as feed oil in feeds with low protein (38%) and high fat (21%) and has the effect of achieving saving in terms of protein.

Martins *et al.,* (2006) have also used soybean oil replacing fish oil in trout diets as much as 50% and reported that trout demonstrated better growth than that of fish in the control group. Yu and Sinnhuber (1981) Mugrditchian *et al.,* (1981), Hartfiel *et al.,* (1982), De La Hoz *et al.,* 1987, Hardy *et al.,* (1987) and Arzel *et al.,* (1993) have reported similar results to our findings obtained in this study using trout and salmon. They also found that oil sources used in their diets have not a significant effect on the feeding performance and body composition.

For all these reasons, it has been sought in this study to identify more appropriate protein and fat levels through employment of two different proteins and vegetable oils (soybean and linseed oil) and animal fats (tallow and fish oil) in trout rations and the impact ratio of fat and protein levels and fat varieties on the composition of carcass has also been researched by conducting the nutrient analysis of the carcasses of fish at the end of the experiment.

Material and method

Fish and feeds

Juvenile rainbow trout used in this study were obtained from Istanbul University, Sapanca Freshwater Fishery Research Institute. The experiment was performed in a commercial trout farm with a total of 4800 randomly selected rainbow trout (*Oncorhyncus mykiss*, W.) (initial mean body weight, 17,3-17,7 g). Fish were stocked into 48 tanks at a rate of 100 fish per tank with 3 replication for each dietary treatment after they were counted.

Experimental diets were basically formulated to contain two protein levels at 45 and 35 CP% and two fat levels at 10 and 20 CF % on a dry matter basis. Four types of oils (soybean oil-SO, linseed oil-LO, tallow- T and fish oil-FO) were included in each of the CP and CF combination diets. Therefore a total 16 feeds were investigated in this research (Table 1). Dietary treatments were also formulated to contain between 3200 and 3750 kcal/kg DE (Digestible Energy) depending on the crude fat (CF) level of the diets (10 % vs 20 %, Table 2). Before adding to the diet mixtures, feedstuffs were ground to medium fine size (0.3 mm) and pelleted using a meat grinder. Pellet sizes were adjusted to have 3 mm diameter and 6 mm in length.

Feeding trial

The research was conducted in plastic tanks sized 200 L×50 W×60 H cm. Water was distributed with PVC pipes for each tank. The water flow rate was fixed at 2 L/min for all treatments, therefore almost 5 times of total water volume was changed with fresh water daily. Values of pH (D-51 Horiba), dissolved oxygen and water temperature (OM-51 Portble *Dissolved Oxygen meter*) measured periodically and detected as 7.5; 16.3-16.7; 7.9-8.2 respectively.

Fish were fed twice a day, morning (9 AM to 10 AM) and evening (5 PM to 6 PM) to apparent satiation. Utmost care was given that all the feed was consumed by the fish each feeding period. The daily feed intake was recorded throughout the experimentation. Fish were starved for 24 h before bi-weekly weigh gain measurements and batch measurements were performed for each tank in dietary treatments.

Chemical analysis and calculations

At the end of the experiment, fish weight gain, FCR, PER[8], SGR[9], CF [10] and survival rate were calculated as given in the end note. Just before the start of the experiment, 5 fish were randomly collected and killed for the initial proximate carcass analysis. 5 fish from each treatment were also randomly selected and sacrificed and pooled for total body and carcass chemical composition analyses at the end of experiment. The chemical compositions of carcass, complete feeds and feedstuffs were measured following standard AOAC methods (AOAC, 1995). Feed, whole fish and fillet proximate composition analysis are given in Table 2 and 4.

Statistical analyses

16 combinations composed of three factors (dietary protein levels, dietary fat levels and oil types) were used in each application with three replicates of factorial experimental design. The mean final body weights in each treatment were subjected to statistical comparisons using ANOVA. All statistical analyses were carried out using the Minitab (v12) program. Results and Mean differences between treatments were tested for significance (P<0.01 and P<0.05) by Tukey's multiple range test. Results presented in Table 3 and 6 are reported as means ± SD (n=3, 5 and 5 respectively).

[8] $PER = \frac{Live\ weight\ gain\ in\ an\ identified\ period, g}{consumed\ protein\ wit\ the\ diet\ in\ the\ same\ period, g}$ (Hepher, 1988)

[9] $SGR = \left[\frac{\ln W_t - \ln W_0}{t - t_0}\right] \times 100$ (Hepher, 1988)

[10] $CF = \frac{BW}{L^3}$ (Brown, 1957)

Table 1. Biochemical Composition of Experimental Fish Diets, %.

Feed Ingredients	Feeds including 45% CP								Feeds including 35% CP							
	Feeds including 10 % CF				Feeds including 20 % CF				Feeds including 10 % CF				Feeds including 20 % CF			
	SO	LO	T	FO	SO	LO	T	FO	SO	LO	T	FO	SO	LO	T	FO
Fish Meal	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11	31.11
Meat-Bone Meat	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Soybeaan meal	28.22	28.22	28.22	28.22	30.00	30.00	30.00	30.00	5.88	5.88	5.88	5.88	5.00	5.00	5.00	5.00
Corn Gluten	6.22	6.22	6.22	6.22	6.69	6.69	6.69	6.69	1.89	1.89	1.89	1.89	4.16	4.16	4.16	4.16
Wheat Gluten	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
wheat midds	16.55	16.55	16.55	16.55	3.90	3.90	3.90	3.90	42.75	42.75	42.75	42.75	31.02	31.02	31.02	31.02
Soybean Oil	4.68	-	-	-	15.00	-	-	-	4.41	-	-	-	14.71	-	-	-
Linseed Oil	-	4.68	-	-	-	15.00	-	-	-	4.41	-	-	-	14.71	-	-
Tallow	-	-	4.68	-	-	-	15.00	-	-	-	4.41	-	-	-	14.71	-
Fish Meal	-	-	-	4.68	-	-	-	15.00	-	-	-	4.41	-	-	-	14.71
D. C. P.	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Mineral Mix.[a]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin Mix.[b]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Vitamin C	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Dl-Methionine	0.52	0.52	0.52	0.52	0.60	0.60	0.60	0.60	0.76	0.76	0.76	0.76	0.80	0.80	0.80	0.80
L- Lysine	-	-	-	-	-	-	-	-	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Lignobond[c]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Oxigard[d]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] M-1 (g/kg of DM): 80.000 mg Mn, 35.000 mg Fe, 50.000 mg Zn, 5.000 mg Cu, 2.000 mg I, 400 mg Co, 150 mg Se.

[b] V-221 (mg/kg or IU/ kg of DM): 4.800.000 IU Vitamin A, 800.000 IU Vitamin D_3, 12.000 mg Vitamin E, 1.200 mg Vitamin K_3, 1.200 mg thiamine, 2.400 mg riboflavine, 2.000 mg Vitamin B_6, 6 mg Vitamin B_{12}, 10.000 mg niacine, 16 mg biotin, 3.200 mg Calcium pantothenat, 400 mg folic acide, 120 mg Cholin chlorid, 20.000 mg Vitamin C.

[c] This commercial product is used as pellet binder.

[d] Antioxidant powder.

Table 2. Nutritional Composition of Experimental Feeds, %.

Feeds	Dry Matter	Organic Matter	Crude Protein	Crude Oil	Crude Cellulose	Nitrogene Free Matter	Crude Ash	Ca	P	Lysine[a]	Met.+ Cys.[a]	DE, KJ/kg
45CP10SO	91.10	83.21	44.98	9.98	2.68	25.57	7.89	2.96	1.96	2.29	1.50	13.39
45CP10LO	91.14	82.93	45.01	9.87	2.65	25.40	8.21	2.81	2.01	2.29	1.50	13.39
45CP10T	90.89	83.28	44.86	10.03	2.96	25.43	7.61	2.88	1.93	2.29	1.50	13.39
45CP10FO	90.13	82.57	44.91	10.03	3.01	24.62	7.56	2.91	1.90	2.29	1.50	13.39
45CP20SO	90.89	83.22	44.71	19.84	2.46	16.21	7.76	3.11	1.81	1.84	1.51	15.69
45CP20LO	91.56	84.04	45.01	20.12	2.45	16.46	7.52	3.03	1.78	1.84	1.51	15.69
45CP20T	91.75	84.22	44.96	19.96	2.61	16.69	7.53	2.98	1.76	1.84	1.51	15.69
45CP20FO	90.86	83.45	45.01	20.03	2.40	15.94	7.41	3.20	1.75	1.84	1.51	15.69
35CP10SO	91.55	84.59	34.34	9.97	1.70	38.58	6.96	2.95	2.04	2.08	1.50	13.39
35CP10LO	91.80	84.54	34.83	10.26	1.58	37.87	7.26	2.94	2.01	2.08	1.50	13.39
35CP10T	90.76	83.63	35.01	9.96	1.61	37.05	7.13	2.87	1.96	2.08	1.50	13.39
35CP10FO	90.29	83.40	35.02	9.98	1.55	36.85	6.89	2.88	1.97	2.08	1.50	13.39
35CP20SO	91.01	84.23	34.95	20.16	1.34	27.78	6.78	2.93	1.96	2.00	1.50	15.69
35CP20LO	91.08	83.99	35.03	19.89	1.43	27.64	7.09	2.97	1.94	2.00	1.50	15.69
35CP20T	90.16	83.61	34.77	20.04	1.37	27.43	6.55	3.01	1.93	2.00	1.50	15.69
35CP20FO	90.41	83.50	35.12	20.13	1.29	26.96	6.91	2.94	1.94	2.00	1.50	15.69

[a] As a rate of dietary protein (N.R.C. 1981).

Results and Discussion

The results obtained in this experiment are summarized in Table 3 and 4. The effect of protein level on live weight gain was found significantly (*P* <0.01). Our results are in agreement with Austreng and Refstie (1979), Tabachek (1986) and Heinen and Hankins (1995) findings. These authors have also demonstrated that live weight gain was affected by increasing level of protein in diets. Because fish could use protein both for supplying energy and routine metabolism function of cold water fish like trouts, need high level protein and non-nitrogenous energy sources (mainly fat and carbohydrates) in their feeds. As a matter of fact it can be seen that these carnivorous fish have consumed high level protein foods in the wild life when compared with warm water fish. However, high protein demands of trout can be reduced by addition of oil to feeds and it can be ensured that fish use protein for body mass production. Our study has also revealed that protein levels could be reduced by addition of fat to rations. The results of the experiment have shown that rations containing 35% protein and 20% fat and 45% protein and 10% fat generally leads to similar results in trout diets. As such, it has been determined that increase of the fat level in the ration has led to demonstrated in trout protein sparing effect in juvenile rainbow trout. Overall findings of this study are in line with the findings obtained by Luquet (1971), Reinitz *et al.* (1978) and Akiyama *et al.* (1981). Furthermore, It was found that live weight gain also was increased by the increment of lipid levels in diets throughout the study (*P*<0.01). These results were supported by the findings of Takeuchi *et al.* (1978b), Tabachek (1986), Kim *et al.* (1988) and Heinen and Hankins (1995). Different oil sources than fish oil used in the experiment had no effect on body weight gain of the live fish insignificant. But the small differences observed in live weight gain among treatments could be attributed to the different digestibility of fats or fish oil included diet was more palatable to the trout. Several studies have also revealed that using vegetable oils in fish feed partly or wholly do not have negative effects on the growth performance and body composition (Luzzana *et al.*, 1994; Figueiredo-Silva *et al.,* 2005; Mourente *et al.,* 2006; Güler and Yıldız, 2011; Parpoura *et al.,* 2011).

It was determined in this study that feed intake of fish fed 35% CP and 10% CO was significantly higher than that fish in other dietary treatments (*P* <0.01) and their FCR rates were better (*P* <0.01).This can be explained by the fact of that fish consume more feed to fulfill their energy requirements. Furthermore, when the impact of oil varieties on feed consumption were analyzed it was thought that higher consumption of feed containing animal-derived fats than plant- derived oils is due to the fact that animal-derived fats are more palatable than the latter. The findings obtained in this research is similar to the results obtained by Luquet (1971), Takeuchi *et al.* (1978b), Austreng and Refstie (1979), Heinen and Hankins (1995), De La Hoz *et al.* (1987), Teskeredzic (1990), Akyurt and Erdogan (1993) and Arzel *et al.* (1993).

Increase in the level of oil in the ration has led to increase of PER and therefore better utilization of protein (*P* <0.01). During the feeding period it has been determined that feeds containing fish oil containing diets provided better PER and this ratio is significantly lower in the fish fed tallow, soybean and linseed oil (*P* <0.01). The findings of the experiment are coherent with the results obtained by Takeuchi *et al.* (1978a) De La Higuera *et al.* (1977) and Silver *et al.* (1991).

During the feeding period it has been determined that both protein and fat levels have significant effects on specific growth rate (SGR, *P* <0.01). SGR of fish has increased in parallel with the increase of the level of protein and fat in diets. Silver *et al.* (1991) and Arzel *et al.* (1993) have also obtained similar findings to this study conducted experiments using rainbow trout.

Moreover, It also has been determined that protein level have significant effect on the body composition of fish in this experiment (*P* <0.01). Moisture, crude fat and crude ash contents were all reduced in the carcass in parallel with the increased protein level of feed and accumulation of protein content has increased due to the crude protein levels in diets. These findings were also supported by the findings of Austreng and Refstie (1979) and Heinen and Hankins (1995). Crude oil levels in the body composition have also increased in parallel with the increased fat level of the diets whilst the content of crude protein and moisture have decreased. Findings of Luquet (1970), Reinitz *et al.* (1978), De La Higuera *et al.* (1987), Silver *et al.* (1991), Akyurt and Erdogan (1993), Arzel *et al.* (1993) and Heinen and Hankins (1995) have also supported our findings obtained in this experiment.

Researches have revealed that oil sources of feeds had no significant effect on the body proximate composition of fish. Hıowever, Mugrditchian *et al.* (1981) and Hartfiel *et al.* (1982) have also reported similar results to this experiment.

In coclusion;

*Protein sparing effect can be achieved in fish if the level of proteins in diets is reduced oil is cheaper and protein sources to be used in feed are scarce or expensive;

*By adding cheaper and digestible plant oil or animal originated fats as an energy source in trout diets, soybean oil, linseed oil, and tallow can be partially or completely substituted for the fish oil; and

*Inasmuch as the results of many studies on this subject are different from each other more research needs to be done to classify the optimal replacement levels of fish oil in the rainbow trout for the future development of trout diets.

Table 3. Average initial weight (WG), final weight, weight gain, feed intake (FI), FCR, SGR, PER and survival rate for rainbow trout fed different diets for 84 days.[a]

	Protein Ratio		**Lipid Ratio**		**Oil Sources**			
Item	**35 %**	**45 %**	**10 %**	**20 %**	**SO**	**LO**	**T**	**FO**
	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$
Trial Period, day	84	84	84	84	84	84	84	84
Total Fish Num.	2400	2400	2400	2400	1200	1200	1200	1200
Survival Rate, %	94	96	92	94	92	93	93	95
Initial Weight, g	17.54 ± 0.014	17.53 ± 0.014	17.53 ± 0.014	17.54 ± 0.014	17.57 ± 0.021	17.51 ± 0.021	17.56 ± 0.021	17.50 ± 0.021
Final Weight, g	178.15 ± 0.750^{b}	196.77 ± 0.750^{a}	179.41 ± 0.750^{b}	195.51 ± 0.750^{a}	187.65 ± 1.061^{b}	185.35 ± 1.061^{b}	184.24 ± 1.061^{b}	192.60 ± 1.061^{a}
AWG, g	160.61 ± 0.717^{b}	179.24 ± 0.717^{a}	161.88 ± 0.717^{b}	177.97 ± 0.717^{a}	170.08 ± 1.014^{b}	167.84 ± 1.014^{b}	166.68 ± 1.014^{b}	175.10 ± 1.014^{a}
FI, g	238.81 ± 1.012^{a}	214.66 ± 1.012^{b}	237.63 ± 1.012^{a}	215.84 ± 1.012^{b}	226.19 ± 1.431^{b}	226.06 ± 1.431^{b}	232.20 ± 1.431^{a}	232.20 ± 1.431^{a}
FCR	1.49 ± 0.005^{b}	1.21 ± 0.005^{a}	1.48 ± 0.005^{b}	1.22 ± 0.005^{a}	1.34 ± 0.007^{b}	1.37 ± 0.007^{b}	1.41 ± 0.007^{a}	1.28 ± 0.007^{c}
PER	1.94 ± 0.007^{a}	1.86 ± 0.007^{b}	1.72 ± 0.007^{b}	2.08 ± 0.007^{a}	1.90 ± 0.010^{b}	1.87 ± 0.010^{b}	1.82 ± 0.010^{c}	2.00 ± 0.010^{a}
SGR	2.758 ± 0.0050^{b}	2.877 ± 0.0050^{a}	2.76 7± 0.0050^{b}	2.867 ± 0.0050^{a}	2.817 ± 0.0050^{b}	2.805 ± 0.0050^{b}	2.796 ± 0.0050^{b}	2.851 ± 0.0050^{a}

Table 4. Nutritional composition of carcass in initial and final of the trial.[a]

		Protein Ratio		**Lipid Ratio**		**Oil Sources**			
Item		**35 %**	**45 %**	**10 %**	**20 %**	**Soybean Oil**	**Linseed Oil**	**Tallow**	**Fish Oil**
		$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$	$X \pm S_{\bar{X}}$
Initial	Moisture	79.41 ± 0,09							
	Crude Protein	17.36 ± 0.43							
	Crude Oil	1.95 ± 0.037							
	Ash	1.28 ± 0.011							
Final	Moisture	72.25 ± 0.092^{a}	71.74 ± 0.092^{b}	72.93 ± 0.092^{a}	71.07 ± 0.092^{b}	72.11 ± 0.130	71.85 ± 0.130	71.88 ± 0.130	72.16 ± 0.130
	Crude Protein	18.75 ± 0.054^{b}	19.84 ± 0.054^{a}	19.78 ± 0.054^{a}	18.81 ± 0.054^{b}	19.24 ± 0.077	19.44 ± 0.077	19.11 ± 0.077	19.39 ± 0.077
	Crude Oil	4.54 ± 0.015^{a}	3.68 ± 0.015^{b}	3.48 ± 0.015^{b}	4.74 ± 0.015^{a}	4.12 ± 0.021	4.11 ± 0.021	4.15 ± 0.021	4.06 ± 0.021
	Ash	1.35 ± 0.004^{a}	1.30 ± 0.004^{b}	1.33 ± 0.004	1.32 ± 0.004	1.33 ± 0.006	1.32 ± 0.006	1.33 ± 0.006	1.33 ± 0.006

[a] Results are means ± SD (n=3; n=5). Averages followed by different letters in the same parameter column are significantly different (P <0.01) by Tukey's test.

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