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Effects of dietary energy levels on growth performance, feed utilization and body composition of Rainbow trout

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ABSTRACT:

In order to compare the growth performance of trout with two extruded foods and their impact on body composition, an experimental test was conducted from June 1 to October 5, 2010 at National Center of Hydrobiology and Fish Culture. The comparison of the two foods with different formulation and different energy is perfomed in isoenergetic conditions. Following this study, two diets were formulated : the extruded diet A with 41% crude protein, 27% fat and 20% carbohydrates and the extruded food B with 39.7% CP, 24% fat and 15,7 carbohydrates, with digestible energy respectively of 21.32 Mj and 19.32 Mj. The initial average weight of the trouts was 100 g from the same batch of eggs. They were divided randomly into six fiberglass conical tanks at open circuit . The diet was assigned to six tanks for 50 fish each with three replicates for each diet and the experiment was conducted for 127 days.

The ratio DP/DE of diet influenced feed conversion ratio and specific growth rate ($p<0.05$) . The best FCR was obtained with the extruded food A with 1.18 v.s 1.26. The higher IV was obtained with the low DP/DE ($p<0.05$). Final whole-body lipid content was positively related to dietary lipid levels and to digestible energy. Better retention of protein was obtained by the diet A.

This study is consistent with current trends in the nutrition of fish and salmonids especially designed to reduce the ratio of DP/DE in order to have better perfomances of growth and a better quality of the fish.

Keywords:
growth, feed efficiency, energy ,body composition, rainbow trout.

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INTRODUCTION

The success of the aquaculture is based on the provision of food containing the highest level of energy and nutrients for growth. Food is the major cost for aquaculture (Kaushik, 2000). The food depends mainly on fish meal which is usually the major component of food in aquaculture, and its nutritional quality since it is rich in essential amino acids (Medale, 2009) and the effective use of these proteins are closely related to their concentration in the diet and the availability of food with other non-protein sources, such as lipids and carbohydrates (Kaushik and Medale, 1994;. Watanabe, 2002; Chaiyapechara *et al*., 2003., Morrow *et al*., 2004; Azevedo *et al*., 2004 ; Eliason 2007).

To optimize the performance of growth and control releases fish in fish farming, there is involvement of two key factors, feed formulation and manufacturing method (Hardy and Barrows, 2002). During the 15 recent years, the aquaculture feed manufacturing has seen a great evolution which allowed food to be pressed with a high rate of protein, low fat and high carbohydrate to extrusion processing (Medale and Kaushik, 2008) with which we obtain extruded fish feed, wich are characterized by high energy and are a significant substitution of fish meal with fats and carbohydrates (starch mainly).

Energy and nutrient requirements are affected by several factors and they may vary in different stages of the life cycle of the animal. Several authors have described optimal dietary P/E ratios in some rearing species such as rainbow trout, Oncorhynchus mykiss (Kim and Kaushik, 1992; Lanari *et al*., 1995).

But the success of the Fish culture is based on the provision of rations containing optimal levels of energy and nutrients for growth (Hardy and Barrows, 2002). The optimization of the ratio protein / energy (P: E) has been therefore having an important role in protein and energy utilization (Kaushik and Medale, 1994)

So, one of the factors affecting the optimization of the efficiency of the food is the balance between digestible protein (availability of amino acids) and energy in non-protein food. This balance is represented by the ratio of digestible protein (DP) and digestible energy (DE) of the food (DP / DE). To get a better optimization of the ratio DP / DE, the rate of this ratio can be reduced if an additional power source (fat or digestible carbohydrates) is provided to save protein. (Boujard, 2004). Many studies have shown that increasing dietary DE by increased non-protein energy food resulted in better retention of protein with a decrease in the excretion of ammonia nitrogen, (Dias *et al.,* 1999, Watanabe, 2002; Bureau, 2006, Aba *et al*., 2011b).

In aquaculture, using appropriate feeding management is necessary, to gain an economic advantage and to maximize growth and feed conversion efficiency And the objective of this study was to evaluate the effects of different levels of dietary protein,fat, carbohydrate and energy on growth, feed utilization and body composition of juvenile rainbow trout and to determine the optimal diet for fish.

Table 1. Proximate composition of experimental diets

	Extruded diet A	Extruded diet B
Dry matter	94.4 %	96.1 %
Protéins	41.1%	39.7 %
Lipids	27.4%	24.4 %
carbohydrates	20.4%	15.7 %
Moisture	5.6 %	3.9 %
Gross Energy (GE, Mj Kg^{-1})	23.73	21.70
Digestible energy (DE, MJ Kg^{-1})	21.32	19.32
DP / DE (g MJ^{-1}) (DP:Digestible Prtoein)	17.35	18.48
Ratio P /L	41/27	40/24

MATERIALS AND METHODS

Experimental design:

The experiment was conducted between June 1, 2010 and October 5, 2010 at National Center of Hydrobiology and Fish Culture (NCHP) in Azrou (Morocco).

This test was conducted in fiberglass conical tanks of 0.8 m^3 of volume at open circuit with an initial load of 5 kg fed by spring water at a constant temperature of around 14°C ± 0.2 and a flow rate of 1.6 m^3/h, with a time of renewal of water 2 times per hour with oxygen levels above 80% saturation. The average content of dissolved oxygen in the outlet of the ponds was 7.1 ppm, and pH around 7.

Biological materials:

300 juvenile trout females triploid of average weight of 100g ± 3g from the same batch of eggs were divided randomly into six fiberglass conical tanks.

The test was conducted in triplicate culture, fish were fed manually and the daily ration was split into two meals distributed at 09 am and 03 pm, seven days a week for 127 days, according to the feeding table provided by the supplier of food (LeGouessant). Every two weeks 8 fish of each batch have been anaesthetized after 24 h of fasting in order to measure the size and the weight of each fish for measurements of size and weight. The quantities of food distributed were weighed to estimate the consumption by the fish between two weighings.

Experimental foods

Proximate composition of experimental diets are shown in Table 1.

The rate of feeding:

The experimental test was aimed at comparing two non-isoenergetic foods of different formulations on their growth performance of fish and their flesh quality in isoenergetic condition. The amount of food distributed is consistent with the feeding tables of two extruded foods (ExA, ExB) that have different digestible energy 21.32 Mj, 19.32 Mj, respectively. These rates of rationing depends on the temperature of the water close to the site. We have set the rates according to the temperature of the site which is about 14°C so that the quantitative ratio for the same food energy intake is: amount of food extruded (ExA) 1.10 = amount of extruded (ExB) food .

Gross energy was calculated using the following values: crude protein = 23.7 kJ/g, crude lipids = 39.5 kJ/g and carbohydrate = 17.2 kJ/g as proposed by Brett and Groves (1979). The calculation of digestible energy is obtained by the coefficient of digestibility of protein, fat and carbohydrates gelatinized or raw (Guillaume and Medale, 2001).

Body measurements:

Body mass, length and organ mass were recorded to evaluate the Condition Factor (CF) = ([total body weight (g)] / [total body length (cm)]^3, viscerosomatic index (VSI) = ([viscera weight (g)] / [total body weight (g)] x 100) (Ricker, 1979).

Zootechnical parameters:

Calculations: The following variables were calculated: Daily Weight gain (g/fish /day = (final body weight – initial body weight) / initial body weight.

Survival (%) = 100 x (final amount of fish / initial amount of fish) Average daily growth (g) = (final wt - initial wt) / no. Of days

Specific growth rate (SGR) = [In final mean body wt. (g)] -[In initial mean body wt. (g)]/days x100

Feed conversion ratio (FCR) = g feed consumption / g(final biomass - initial biomass).

BioChemical analysis:

Crude protein, crude fat and ash, at the ventral muscle was determined, according to AOAC, (1990).

Eight fillets of final fish were sampled and stored at -25°C for proximate analyses, which were performed according to AOAC. Dry matter was determined after drying at 105°C until a constant weight was obtained. Ash content was measured by incineration in a muffle furnace at 525°C for 12 h. Crude protein was analyzed by the Kjeldahl method after acid digestion using the Gerhardt system. Lipid was determined by folch method (1957).

Statistical studies:

Results are expressed as mean (± SD). Our results are compared statistically (R Development Core Team, 2011). All parameters of growth and yield were subjected to Analysis of Variance test (ANOVA). Tukey's multiple procedure was used to compare the differences among mean values. Differences were regarded as significant when P<0.05.

RESULTS

During the experiment no mortality and no disease were recorded. The two experimental diets were well accepted by fish throughout the trial, the water temperature varied during the test between 13.8°C and 14.2°C.

During the experimental period, temperatures ranges were 13.8°C and 14.2°C, pH was 6.9 –7.2, and dissolved oxygen was not less than 6,9.0 mg/l. To compare growth performance, all results have been reported in the average weight of individual fish and the parameters are studied from the average of the three tanks assigned to each diet.

In this experimental test, it is seen that the performance of zootechnical parameters vary significantly (p<0.05) between the two dietary treatments (Table 3). The highest values in terms of weight gain were obtained with the extruded diet A and Duncan's test shows a significant difference between the final weights (p<0.05).

The best feed conversion ratio (FCR) was obtained with extruded diet A (1.18). The extruted diet B has the highest FCR, there is a significant difference between the two values of the two dies (p<0.05). The SGR was calculated by 3,35% for fish fed with the diet A and 3,82 for the extruded diet B,and there was a significant difference (p<0.05).

The Viscerosomatic index was 09,11 for the diet A and 10.28 for the extruded food B; The condition factor was 1.18 and 1.26 respectively for the the extruded food A and B. The survival rate was 100% for the two diets, the difference between the two groups was not significant. Dietary energy variation affects significantly the chemical flesh composition of rainbow trout. The rainbow trout fed with extruded feeds B had high levels of lipid and low levels of moisture compared with rainbow trout fed with extruted feeds B (p<0.05), probably due to high fat level in the extruded feed B and with high energy. The crude protein levels of the fish fillet differ (p<0.05) among fish fed with extruded and pelleted feeds.The highest valuesof moisture was obtained with the extruded diet A with a significant difference beween the two diets (p<0.05).

DISCUSSION

Growth and feeding performance are shown in table 2.

Fish meal and fish oil are still considered key ingredients in the formulation of feeds for aquaculture species. Fish meal and fish oil, combined, together currently account for 30 to 80 percent of the weight of

Table 2 : Results of Rainbow trout performances obtained during this experimental test.

Parameters	Extruded diet 1	Extruded diet B
Initial mean weight (g)	100 ± 3	100 ± 3
Final mean weight (g)	526.66^{a} ± 47	586^{b} ± 34
Mean weight gain (g)	426.66^{a} ± 47	486^{b} ± 34
Daily Weight gain (%)	3.35^{a} ± 0.09	3.82^{b} ± 0.11
Specific growth rate (%/day)	1.30^{a} ±0.01	1.40^{b} ± 0.03
FCR	1.26^{b} ± 0.014	1.18^{a} ± 0.017
Condition factor K	1.14^{a} ± 0.02	1.22^{b} ± 0.03
Viscerosomatic index	09.11 ± 0.14	10.28 ± 0.12
Survival rate (%)	100	100

Values are means of three replications. Data are expressed as mean ± SD. Values in a row with different superscripts are significantly different from each other (P<0.05).

most of the salmon, trout, marine fish, and shrimp feeds sold worldwide (Bureau, 2006).

The protein requirement is dependent upon the levels of other non protein energy sources lipids and carbohydrates (Ruohonen and Kettunen, 2004). A recent approach to assessing fish nutrition recognize the importance of a mixture design (Ruohonen and Kettunen, 2004).

The present study has shown that, the growth performance of rainbow trout can be significantly influenced by feeding regimes that strongly affect the feed ingestion and assimilation. Our results revealed that the ration levels had significant effects on growth and conversion efficiencies in fingerling of rainbow trout

Numerous studies have demonstrated the beneficial effect of high energy diets on growth and on feed efficiency and fish protein (Kaushik and Oliva-Teles, 1985; Dias *et al*., 1999; Medale and Kaushik 2008; Aba *et al.,* 2011a).

However, a supplementation of lipid rather than carbohydrate as a non-protein energy source, is generally more effective for increasing energy level because lipid is readily metabolized by fish especially by the carnivorous one (NRC, 1993). The addition of lipids to a diet also contributes to effective utilization of dietary protein through the sparing effect in fish (Watanabe, 1982; De Silva *et al*., 1991; Skalli *et al*., 2004).

Our results for the FCR are higher than those obtained by Gelineau *et al*., (2001) and can be explained by the richness of our food carbohydrates and trout have a preference for protein and fat instead of carbohydrates. The results of the present study clearly indicate that the growth rate of trout was affected by the dietary levels of non-protein energy ($P<0.05$).

Table 3: Fillet composition (g/100 g DM)

Parameters	Diet A	Diet B
Protein	$19.56^{b} \pm 0.27$	$18.11^{a} \pm 0.17$
Fat	$8.47^{b} \pm 0.32$	$7.03^{a} \pm 0.26$
Moisture	$68.21^{a} \pm 0.24$	$70.01^{a} \pm 0.15$

Means (±SE) with different superscript letters were significantly different (P<0.05).

Several studies (Kaushik and Medale, 1994; Lupatsch *et al.,* 1998) Lupatsch *et al*., (2001) have shown that the optimal DP/DE ratio for rainbow trout may be lowered from the value of 22 to 25 g MJ^{-1} kg DM to 17 to 20 g MJ^{-1} kg DM.

Traditionally, the effect of diet quality on fish growth is assessed using either DP:DE or the dietary protein-to-lipid ratio. However, the sparing effect of lipid and carbohydrate on dietary protein, using the manufacturing technology and high energy have a significant improvement in growth performance of rainbow trout

This study confirms the existence of a positive effect of high dietary energy contents on feed efficiency and protein efficiency ratio as already described in the rainbow trout. The FCR obtained in our test is slightly higher than that obtained in the tests of De Francesco *et al.,* (2004) because the test foods are higher in fat and carbohydrates (Gelineau *et al*., 2001).

The specific growth rate (SGR, 1.30-1.40) values obtained in this study are indicative of good growth in rainbow trout and our results are similar to those reported by Chaiyapechara *et al*., (2003) who found that rainbow trout fed diets containing a low ratio DP/DE had a significantly greater SGR compared to fish fed diets containing high ratio. The same results are obtained by Morrow *et al*., (2004), yildiz (2004), Eliason (2007).

Our results for the condition factor K indicates that the trout have a good growth in weight rather than size especially when fed with diet A and these results are similar with those of Yildiz (2004).

The extruded diet can be to have a greater incorporation of lipids,(Kaushik, 2000; Aba *et al*., 2012) which is probably increased by the IVS and increased visceral fat is seen in the viscera that there are more deposition of fat in the rainbow trout (Richard *et al*., 2006; Medale, 2009) and IV obtained in this study is almost similar with the results of Dias *et al*.,(1999) and

Gelineau *et al*., (2001).

For body composition generally, lipid accumulation in fish increases with higher levels of dietary lipid;(Jobling *et al.,* 1998; Rasmussen *et al*., 2000; Chaiyapechara *et al*., 2003). As reported for several fish species such as rainbow trout (Chaiyapechara *et al.,* 2003), sea bass; Pirini *et al*.,2000) and Atlantic salmon (Hamre *et al*., 1998), .

Lipid concentration in fish body (fillets), reflected dietary lipid concentration (Chaiyapechara *et al*., 2003; Medale, 2009; Aba *et al*., 2012). Increasing the lipid concentration in the feed from 24-27% increased the fillet lipid concentration from 7,03-8.47%. The trout composition at the end of the test shows an increased content of lipids independently of protein levels (Dias *et al*., 1999).

Increasing dietary energy intake leads, in almost all species, to an increase in body. In addition, deposition of lipids is associated with a lower deposition of water (Jobling, *et al*., 1998; Medale, 2010). Moisture content,is inversely correlated to lipid content (Quillet *et al*., 2007). According to studies by De Francesco *et al*., (2004), Quillet *et al*., (2007),Eliason (2007), Aba *et al*., (2012) ,the moisture content increases as the fat content of fillet is low, Similar results were obtained for Sea bass by Yildiz (2004) and these results are consistent with results obtained in this trial.

CONCLUSION

The present study demonstrated that diets containing high energy and low ratio DP/DE affect the growth performance and body composition. The high energy in diet may be an indicator of the good flesh quality. These results suggest that feeding the fish with diets containing more of fat and carbohydrate are the most effective.

The protein sparing effect of lipid and to a lesser extent carbohydrates have been studied by numerous researchers. In salmonids, up to 30% lipid diets have been shown to improve feed and protein utilization efficiencies and to reduce N excretion.

This study is consistent with current trends in the nutrition of fish and salmonids and especially designed to reduce the ratio DP / ED in order to have better perfomances of growth and a better quality of flesh fish.

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REFERENCES

Aba M, Belghyti D, Elkharrim K, Benabid M, Elguamri Y and Maychal A. 2011a. Effects of two pressed and extruded foods on growth performance and flesh quality of rainbow trout (*Oncorhynchus mykiss*). Sciencelib Editions Mersenne, 3, N°111004.

Aba M, Belghyti D, Benabid M. 2011b. Effects of two pressed and extruded foods on growth performance of rainbow trout (*Oncorhynchus mykiss*) and their environmental impacts. Sciencelib Editions Mersenne Volume 3, N ° 111205.

Aba M, Belghyti D, Elkharrim K, Benabid M and Maychal A. 2012. Effects of Pressed and Extruded Foods on Growth Performance and Body Composition of Rainbow Trout (*Oncorhynchus mykiss*). Pakistan Journal of Nutrition 11(2):104-109.

AOAC (Association of Official Analytical Chemists). 1990. Official methods of analysis of the Association of Official Analytical Chemists, 15th edition. AOAC, Arlington, Virgina, USA.

Azevedo PA, Leeson S, Cho CY, Bureau DP. 2004. Growth and feed utilization of large size rainbow trout (*Oncorhynchus mykiss*) and Atlantic salmon (Salmo salar) reared in freshwater: diet and species effects, and responses over time. Aquac.

Nutr., 10:401-411.

Boujard T. 2004. Aquaculture Environnement. Les dossiers de l'environnement de l'INRA n°26, Paris, 110.

Brett JR. et Groves TDD. 1979. Physiological energetics. *Fish Physiology* , Vol. VIII (eds W.S. Hoar, D.J. Randall & J.R. Brett), 279-352. Academic Press, New York.

Bureau D. 2006. Rendered Products In Fish Aquaculture Feeds, In Essential Rendering All About The Animal By-Products Industry. 179-194.

Chaiyapechara S, Casten MT, Hardy RW and Dong FM. 2003. Fish performance, fillet characteristics, and health assessment index of rainbow trout (*Oncorhynchus mykiss*) fed diets containing adequate and high concentration of lipid and vitamin E. Aquaculture, 219:715-738.

De Francesco, Giuliana Parisi, Françoise Medale and Paola Lupi. 2004. Effect of long-term feeding with a plant protein mixture based diet on growth and body/fillet quality traits of large rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 236:413-429.

De Silva SS, Gunasekera RM, Shim KF. 1991. Interactions of varying dietary protein and lipid levels in young red tilapia: evidence of protein sparing. Aquaculture 95:305-318.

Dias J, Corraze G. Arzel J, Alvarez MJ, Bautista JM, Lopez-Bote C and Kaushik SJ. 1999. Nutritional control of lipid deposition in rainbow trout and European seabass: Effect of dietary protein/energy ratio. Cybium, 23:127-137.

Eliason EJ, Higgs DA, Farrell AP. 2007. Effect of isoenergetic diets with different protein and lipid content on the growth performance and heat increment of rainbow trout. Aquaculture, 272:723–736.

Folch : Folch J, Lees M and Sloane-Stanley GHS. 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem., 226:497-509.

Gelineau A, Corraze G, Boujard T, Larroquet L and Kaushik S. 2001. Relation between dietary lipid level and voluntary feed intake, growth, nutrient gain, lipid deposition and hepatic lipogenesis in rainbow trout. Reproduction, Nutrition, Development, 41:487-503.

Hardy RW and Barrows FT. 2002. Diet formulation and manufacture. In: *Fish Nutrition.* J.E. Halver and R.W. Hardy (eds.),3rd edition. London:Academic Press. 505-600.

Jobling M, Koskela J and Salvolainen R. 1998. Influence of dietary fat level and increased adiposity on growth and fat deposition in rainbow trout, *Oncorhynchus mykiss* (Walbaum). Aquaculture Research, 29:601-607.

Kaushik SJ, Medale F. 1994. Energy requirements,utilization and dietary supply to salmonids. Aquaculture. 124:81-97.

Kaushik SJ. 2000. Feed formulation, diet development and feed technology CIHEAM, 43-51.

Kim JD and Kaushik SJ. 1992. Contribution of digestible energy from carbohydrates and estimation of protein/energy requirements for growth of rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 106:161-169.

Lanari D, D'Agaro E and Ballestrazzi R. 1995. Effect of dietary DP/DE ratio on apparent digestibility, growth and nitrogen and phosphorus retention in rainbow trout, *Oncorhynchus mykiss* (Walbaum). Aquaculture Nutrition, 1:105-110.

Lupatsch I, Kissil GWM, Sklan D, Pfeffer E. 1998. Energy and protein requirements for maintenance and growth in gilthead seabream (*Sparus aurata* L.). Aquacult. Nutr., 4:165-173.

Lupatsch I, Kissil Gwm, Sklan D, Pfeffer E. 2001. Effects of varying dietary protein and energy supply on growth, body composition and protein utilization in gilthead seabream (Sparus aurata L.). Aquacult. Nutr.

7:71-80.

Médale F, Brauge C, Vallée F and Kaushik SJ. 1995. Effects of dietary protein/energy ratio, ration size,dietary energy source and water temperature on nitrogen excretion in rainbow trout. Water Science and Technology, 31:185-194.

Medale F. 2009. Protein sources in feed for farmed fish. Agricultures, 18:103-111.

Medale F. 2010. Nutritional quality of fish flesh lipids as affected by farming practices. Cahiers de Nutrition et de Diététique, 45:267-273.

Morrow MD, Higgs D, Kennedy CJ. 2004. The effects of diet composition and ration on biotransformation enzymes and stress parameters in rainbow trout, *Oncorhynchus mykiss*. Comp.Biochem. Physiol., Part C 137:143-154.

National Research Council (NRC). 1993. Nutrient Requirements of Fish. Washington, DC: National Academy Press.

Pirini M, Gatta PP, Testi S, Trigari G and Monetti PG. 2000. Effect of refrigerated storage on muscle lipid quality of sea bass (*Dicentrarchus labrax*) fed on diets containing different levels of vitamin E. Food Chemistry, 68:289-293.

R. Development Core Team. 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing

Richard N, Kaushik SJ, Larroquet L, Panserat an S, Corraze G. 2006. Replacing dietary fish oil vegetable oils has little effect on lipogenesis, lipid transport and tissue lipid uptake in rainbow trout (*Oncorhynchus mykiss*). Br. J. Nutr., 96:200-309.

Ricker WE. 1979. Growth rates and models. In: W.S. Hoar, D.J. Randall and J.R. Brett (Eds.), Fish Physiology Vol. VIII: Bioenergetics and Growth.Academic Press, New York: 677-743.

Ruohonen K and Kettunen J. 2004. Effective experimental designs for optimizing fish feeds. Aquaculture Nutrition 10:145-151.

Skalli A, Hidalgo MC, Abellan E, Arizcun M, Cardenete G. 2004. Effects of the dietary protein/lipid ratio on growth and nutrient utilization in common dentex (*Dentex dentex* L.) at different growth stages. Aquaculture 235:1-11.

Quillet E, Guillou S, Aubin J, Labbé L. Fauconneau B and Médale F. 2007. Response of a lean muscle and a fat muscle rainbow trout (*Oncorhynchus mykiss*) line on growth, nutrient utilization, body composition and carcass traits when fed two different diets. Aquaculture, 269:220-231.

Watanabe T. 1982. Lipid nutrition in fish. Comparative Biochemistry and Physiology.73:3-15.

Watanabe T. 2002. Strategies for further development of aquatic feeds. Fish Sci., 68:242-52.

Yildiz M. 2004. The Study of Fillet Quality and the Growth Performance of Rainbow Trout (*Oncorhynchus mykiss*) Fed with Diets Containing Different Amounts of Vitamin E. *Turkish Journal of Fisheries and Aquatic Sciences* 4:81-86 (2004).

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