The effect of dietary lipids on reproductive performance in rainbow trout (*Oncorhynchus mykiss)*

Kohsari H.[1*]

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Abstract

The present study evaluated the effect of different dietary lipids on the reproductive performance of rainbow trout (*Oncorhynchus mykiss).* Brood fish (≈ 920 g, n=80) were fed four different diets with the same amount of protein and lipid. The lipids used in the diet were fish oil (FO), linseed oil (LO), soybean oil (SO), and a commercial trout diet (CTD), which were fed seven weeks before spawning. The growth rate of the fish in different treatment groups was not different during the experimental period. The mean diameter, volume, and weight of the eggs did not differ among different treatment groups. Absolute fecundity, relative fecundity, and gonadosomatic index were not affected by the diet. The results showed that LO and SO can be used as a source of lipid in the diet of the rainbow trout brood fish without reducing the quality of the eggs and reproductive performance.

Keywords: Lipids, Reproduction, Rainbow trout, Dietary.

1- Department of Veterinary, Agriculture Faculty, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran.

*Corresponding autor's Email: kohsari.hesam@yahoo.com

Introduction

The nutrition of brood fish is the main factor that affects the quality of eggs and the subsequent development of larvae (Turkmen *et. al*., 2017). Lipids are one of the basic nutrients in the diet of brood fish. Lipids of the diet affect the quality of eggs and larvae and are the most important source of energy used by the embryo of the trout during its development (Tocher, 2010). It has been demonstrated that the lipid content of eggs is influenced by the lipid content of the diet in fish (Huang *et al*., 2010). It has been shown that the type of essential fatty acids in the diet affects yolk sac development, oocyte maturation, ovulation, fertility rate, spawning, hatching rate, and embryo quality in fish (Furuita *et. al*., 2007; Masoudi Asil *et. al*., 2017).

Conventionally, FO is used as the most important source of lipid in brood fish diet (Torsabo et. al., 2022., Cashion et. al., 2017., Sprague et. al., 2016., Enes and Peres., 2015., Ospina-Alvarez et. al., 2013., Cho and Kim, 2011). With the expansion of the aquaculture industry and the limitation of the FO resources, it is valuable to replace FO with other lipids, especially lipids of plant origin. The results of a study showed that it is possible to replace the FO of the salmonids diet with lipids of plant origin without having a negative effect on their growth (Katan *et. al*., 2019). It has been shown that female trout fed a plant-based diet for a three-year period produced normal numbers of viable offspring (Lazzarotto *et. al*., 2015).

The hypothesis of the recent study was that it is possible to replace the FO in the diet of the brood fish trout with LO or SO without having a negative effect on their reproductive performance. The aim of the recent study was to evaluate the effect of replacing FO with LO or SO in the diet on the egg quality and reproductive performance of brood fish trout.

Materials and methods

The research was conducted in accordance with the principles of local Bioethics Committee of Veterinary Faculty of Kermanshah University. Three diets were prepared with similar amounts of crude protein (≈48%) and crude lipid (≈21%), but their lipids were different. The lipids used were FO, LO, and SO. Food pellets were stored in plastic bags at -20°C until use. Triplicate groups of 2-year-old female (783.3±57.1 g) and male (892.2±73.2 g) rainbow trout brood fish were placed at 20 fish per tank (one male: one female) in $2m^3$ tanks. Freshwater was poured into the tanks and the temperature of the water was kept constant at around 10 °C. The water flow rate was 1.5 lit/min. Brood fish were reared under natural photoperiod conditions during the experiment. Then the brood fish were randomly placed in one of the following experimental groups: 1) Brood fish whose dietary lipid was sourced from FO, 2) Brood fish whose dietary lipid was sourced from LO, 3) Brood fish whose dietary lipid was sourced from SO, and 4) Brood fish that fed a commercial trout broodstock diet (Le

Gouessant, Lamballe, France) as the control group. Composition of the diet was similar in treatment groups (fish meal 350 g/kg, soy meal 100 g/kg, wheat meal 50 g/kg, wheat gluten 190 g/kg, corn gluten 100 g/kg, gelatin 30 g/kg, vitamin premix 15 g/kg, and mineral premix 15 g/kg) and 150 g/kg FO, LO, or SO was added to the diet dependent on the treatment group. Such a diet contained about 48% crude protein, 22% crude lipid, 92% dry matter, 9% ash, and 1.9% cellulose. Growth rate of the fish was evaluated during the experiment. The reproductive performance of ten female brood fish in each tank was investigated during the experiment. Sixty days after beginning the experiment, female brood fish were evaluated every three days for spawning by slowly pressing the abdomen and seeing the eggs. To determine the average weight of an egg in a female brood fish, 200 eggs were weighed. Absolute and relative fecundities were calculated for the fish. The diameter of the eggs was measured to obtain the volume of the eggs. Three hundred eggs from each female fish in each treatment group were fertilized with the semen of males that had received the same diet to determine the reproductive performance of female brood fish by evaluating the percentage of fertilization, eggs reaching the eyeing stage, and hatching. Data analysis was done using a SAS (SAS Institute Inc. 2014. SAS® On Demand for Academics: User's Guide. Cary, NC: SAS Institute Inc.) statistical software.

Results

The growth rate and reproductive performance of female trout brood fish that were fed diets with different lipid sources are shown in the Table 1.

Table 1: Growth rate and reproductive performance (mean±SD) of female brood fish fed different diets.

Parameters	Experimental diets			
	FO	LO	SO	CD
Initial weight (g)	900±69.3	910.4±93.2	904.2±83.2	899.8±77.8
Final weight (g)	2600.7±223.4	2434.3±242.7	2528.2±220.3	2488.1±212.5
Weight gain (g)	1700.7±113.7	1523.9±123.3	1624.2±112.1	1588.3±108.2
Survival (%)	100±0.00	100±0.00	100±0.00	100±0.00
Spawning (days)	147±17.2	160±11.3	161±12.3	149±16.3
Spawning females (%)	88.7±14.7	84.7±13.7	83.9±9.3	89.9±8.7
Absolute fecundity	3762±13	3799±32	3629±53	3734±72
Relative fecundity	1393.2±4.5	1412.2±18.3	1399.5±22.8	1401.8±33.1
Egg diameter (mm)	5.3±0.1	5.3±0.1	5.2±0.1	5.3±0.1
Egg volume (cm^3)	80.3±1.3	81.1±2.8	82.7±2.3	80.2±3.2
Egg weight (mg)	75.3±2.9	77.8±1.8	74.8±1.8	76.5±1.5
Fertilization rate (%)	87.2±0.3	85.5±0.4	86.3±0.2	84.9±0.3
Eying rate (%)	84.3±0.2	82.9±0.3	81.8±0.3	80.9±0.2
Hatching rate (%)	80.9±0.2	79.3±0.2	78.3±0.3	76.8±0.2

Pairwise comparison of the groups did not show statistically significant differences in any of the parameters. FO: fish oil in the diet as lipid source; LO: linseed in the diet as lipid source; SO: soybean in the diet as lipid source; CD: commercial diet; Absolute fecundity: Average number of eggs per fish; Relative fecundity: The average number of eggs per kg of fish body weight; Egg diameter: long axis length+short axis length; Egg volume: π/6× (long axis+short axis). There were 10 fish in each group.

Discussion

It was demonstrated in the recent study that complete replacement of FO, as the source of lipid in the diet, with LO or SO did not have a negative effect on the growth rate and reproductive performance of female trout brood fish. The results of two studies showed that replacement of FO in the diet of trout brood fish with LO or sesame oil did not reduce the reproductive performance of the fish (Lazzarotto *et. al*., 2015; Yildiz *et al*., 2020).

It was found in the recent study that feeding brood fish trout with LO or SO diet can delay spawning compared to the control group. The results of a study showed that trout brood fish that received a diet containing LO or sesame oil as the source of lipid in the diet had a delay in spawning compared to the brood fish that received FO as the source of lipid in their diet (Yildiz *et. al*., 2020). In the recent study, it was found that delay in spawning did not have a negative effect on the reproductive performance of trout brood fish.

In the recent study, there was no difference in the average diameter and weight of the eggs of the fish among different groups, and this result shows that the complete replacement of FO with LO or SO in the diet does not reduce the reproductive performance of trout brood fish. Replacing FO with plant origin lipids decreases omega-3 and 6 fatty acids in the diet, but this decrease did not have a negative effect on the reproductive performance of trout brood fish in the recent study, because fertilization, eyeing, and hatching rates were not different between different groups. In the recent study, all diets contained 350 g/kg of fish meal and it seems that this amount of fish meal is enough to meet the needs of female brood fish for essential fatty acids to produce high-quality eggs. The results of the recent study showed that egg indices did not differ between different groups.

In conclusion, it is possible to completely replace the FO in the diet of trout brood fish, as the source of dietary lipid, with LO or SO without having a negative effect on their growth rate and reproductive performance.

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References

Cashion, T., Le Manach, F., Zeller, D., & Pauly, D., 2017. Most fish destined for fishmeal production are food- - grade fish. Fish and Fisheries, 0, 1–8. http://doi.org/10.1111/faf.12209

Cho, J. H., & Kim, I. H., 2011. Fish meal – nutritive value. Journal of Animal Physiology and Animal Nutrition, 95, 685–692. http://doi.org/10.1111/j.1439-0396.2010.01109.x

Enes, P., & Peres, H., 2015. 8 - Replacing fishmeal and fish oil in industrial aqua feeds for carnivorous fish. Feed and Feeding Practices in Aquaculture. Elsevier Ltd. http://doi.org/10.1016/B978-0-08-100506-4.00008-8

Furuita, H., Hori, K., Suzuki, N., Sugita, T. and Yamamoto, T., 2007. Effect of n-3 and n-6 fatty acids in broodstock diet on reproduction and fatty acid composition of broodstock and eggs in the Japanese eel Anguilla japonica. *Aquaculture***,** 267, 55–61. https://doi.org/10.1016/j.aquaculture.2007.01.039

Huang, X., Yin, Y., Shi, Z., Li, W., Zhou, H. and Lv, W., 2010. Lipid content and fatty acid composition in wild-caught silver pomfret (*Pampus argenteus*) broodstocks: effects on gonad development. *Aquaculture*, 310, 192–199. http://doi.org/10.1016/j.aquaculture.2010.10.015

Lazzarotto, V., Corraze, G., Leprevost, A., Quillet, E., Dupont-Nivet, M. and Medale, F., 2015. Three-year breeding cycle of rainbow trout (*Oncorhynchus mykiss*) fed a plant-based diet, totally free of marine resources: consequences for reproduction, fatty acid composition and progeny survival. *PLoS One* 10(**2**), e0117609. http://doi.org/10.1371/journal.pone.0117609

Katan, T., Caballero-Solares, A., Richard, G., Taylor, R. G., Rise, M.L., Parrish, C., 2019. Effect of plant-based diets with varying ratios of ω6 to ω3 fatty acids on growth performance, tissue composition, fatty acid biosynthesis and lipid-related gene expression in Atlantic salmon (Salmo salar). *Comparative Biochemistry and Physiology Part D: Genomics and Proteomics Volume 30, 290-304. https://doi.org/10.1016/j.cbd.2019.03.004*

Masoudi Asil, S., Abedian Kenari, A., Rahimi Miyanji, G. and Van Der Kraak, G., 2017. The influence of dietary arachidonic acid on growth, reproductive performance, and fatty acid composition of ovary, egg and larvae in an anabantid model fish, Blue gourami (*Trichopodus trichopterus*, Pallas, 1770). *Aquaculture*, 476, 8–18. http://doi.org/10.1016/j.aquaculture.2017.03.048

Ospina-Alvarez, A., Bernal, M., Catalan, I. A., Roos, D., Bigot, J., & Palomera, I., 2013. Modeling Fish Egg Production and Spatial Distribution from Acoustic Data: A Step Forward into the Analysis of Recruitment. PLOS One, 8(9), 1–18. http://doi.org/10.1371/journal.pone.0073687

Sprague, M., Dick, J. R., & Tocher, D. R., 2016. Impact of sustainable feeds on omega-3 long-chain fatty acid levels in farmed Atlantic salmon, 2006 – 2015. Nature Publishing Group, (November 2015), 1–9. http://doi.org/10.1038/srep21892

Torsabo. D., Ishak. SD., Noordin, NM., Koh, ICC., Abduh, MY., Iber, BT., Kuah, MK., Abol-Munafi, AB., 2022. Enhancing Reproductive Performance of Freshwater Finfish Species through Dietary Lipids. 1-13. Aquaculture Nutrition. http://doi.org/10.1155/2022/7138012

Tocher, D.R., 2010. Fatty acid requirements in ontogeny of marine and freshwater fish. *Aquaculture*

Research, 41, 717–732. https://doi.org/10.1111/j.1365-2109.2008.02150.x

Turkmen, S., Zamorano, M.J., Fernandez-Palacios, H., Hernández-Cruz, C.M., Montero, D., Robaina, L. and Izquierdo, M., 2017. Parental nutritional programming and a reminder during juvenile stage affect growth, lipid metabolism and utilisation in later developmental stages of a marine teleost, the gilthead sea bream (*Sparus aurata*). *British Journal of Nutrition,* 118, 500–512. https://doi.org/10.1017/S0007114517002434

Yildiz, M., Ofori-Mensah, S., Arslan, M., Ekici, A., Yamaner, G., Baltac, M.A., Tacer, S. and Korkmaz, F., 2020. Effects of different dietary oils on egg quality and reproductive performance in rainbow trout *Oncorhynchus mykiss. Animal Reproduction Science,* 221, 1. https://doi: 10.1016/j.anireprosci.2020.106545