

Growth and survival of fingerlings rainbow trout (*Oncorhynchus mykiss*) using three different diets enriched with essential oils

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Abstract. This study is focused to evaluate the effect on growth and survival of rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792) fingerlings fed with diets that include separately three essential oils (0.2% w/w) of turmeric - *Curcuma longa*, lemongrass - *Cymbopogon citratus*, and ginger - *Zingiber officinale* in an 8 weeks trial. The results for average weight gain describe that final weight obtained with the essential oil treatments is significantly different between all groups ($p < 0.05$); the final weight of the fingerlings fed with turmeric essential oil diet was significantly different from the control treatment. The average values of final length of treatments are not significantly different ($p > 0.05$). The four treatments produce a negative allometric growth with values of 2.59 to 2.73 ($p < 0.05$). After the experiment was determined that variation in the diet had a significant effect on fingerlings mortality ($p < 0.05$)

Key Words: essential oils, growth, survival, rainbow trout, natural additives.

Introduction. Several studies corroborate a positive effect of essential oils applied to aquaculture production process to treat diseases and such as nutritional additives (Harikrishnan et al 2009; Pavaraj et al 2011). There is a very important need to replace chemicals, antibiotics and artificial substances (Mirand & Zemelman 2002) with natural products in various areas of food production for human and animal consumption (Ashley 2007) and develop environmentally clean and economically sustainable processes (Reverter et al 2014). The production of fish for human consumption is an important economic worldwide sector (FAO 2012) and the development of new innovative technologies to promote the production of fish free of artificial additives is highly required (Citarasu 2010). The aim of this study was to evaluate the effect on growth and survival of rainbow trout, *Oncorhynchus mykiss* fingerlings including in the diet 0.2% (by weight) of three essential oils: turmeric, *Curcuma longa*; lemongrass, *Cymbopogon citratus* and ginger, *Zingiber officinale* in a diet for 8 weeks.

Material and Method. The experiment was conducted at the fish farm "Rio de la Plata" in the province of Carchi, Ecuador, between April and July, 2014. A total of 9,400 rainbow trout fingerlings were distributed proportionally in four concrete tanks of 4 cubic meters, each one with a constant exchange of water from the Plata River (Carchi, Ecuador). The physicochemical parameters of water (temperature, dissolved oxygen, nitrite, general hardness and conductivity) were periodically monitored in the four culture tanks with standard methods. Diets were prepared using a commercial pellet food designed for growing trout fry. Four diets were formulated; one control and the other three were prepared individually including each essential oil. These essential oils were provided by local producers of the Ecuadorian Amazon and analyzed by GC-MS (Varian Saturn 2100D) to verify its chromatographic profile and purity. In each diet was included 5.0% (by weight) of fish oil used as vehicle for dissolving the essential oils at 0.2% (by weight). The mixture of fish oil with essential oils was incorporated like thin spray on pellet food using a spray gun. The prepared diets were kept refrigerated in sealed jars. The fry were

fed by hand three times daily with equal portions of food according to the instructions given by the food manufacturer and for equal periods of time.

Data analysis. During the eight weeks, every seven days were taken randomly 50 fishes in each experimental unit for control of total weight and randomly 10 fishes for determining the individual length. The physicochemical water parameters were statistically equal in all experimental units. The weight was determined in grams with a OHAUS Adventurer Pro digital scale (0.1 g) and the fork length was determined in centimeters with a caliper. The initial total weight in average of the fry was 1.49 ± 0.06 g and the average individual length was 4.51 ± 0.02 cm; the fishes were not anesthetized. Every day the existence of dead specimens were verified. The results were statistically analyzed (T test, two-way ANOVA, Tukey and Pearson correlation) with significance level of $p < 0.05$ using R version 3.1.3 i386 environment.

Results and Discussion

Survival. After the experiment, was determined that variation in the diet has a significant effect on fingerlings mortality ($p < 0.05$) (Figure 1). The control diet and treatment of essential oil of ginger were those with lowest survival rate compared to treatment with essential oil of turmeric and lemongrass.

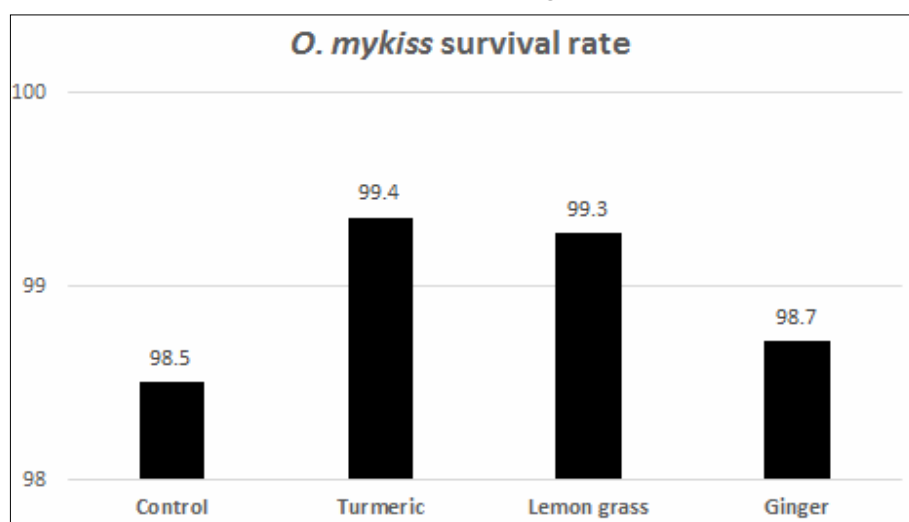


Figure 1. Rainbow trout survival rate (%) under four different diet regimes.

Growth performance. Data on growth of rainbow trout fingerlings after eight weeks of exposed to four different diet regimes are presented in the Table 1.

Table 1
Weekly variation of weight and fork length of *Oncorhynchus mykiss* under four different diet regimes. Values are means \pm SD

Week	Weight (g)			
	Control	<i>C. longa</i>	<i>C. citratus</i>	<i>Z. officinale</i>
1 (initial)	1.48 ± 0.04^a	1.50 ± 0.07^a	1.48 ± 0.09^a	1.50 ± 0.07^a
3	3.22 ± 0.29	3.26 ± 0.24	3.10 ± 0.16	2.92 ± 0.15
6	6.96 ± 0.71	7.74 ± 0.54	7.44 ± 0.50	7.36 ± 0.24
8 (final)	12.22 ± 0.87^a	13.20 ± 1.45^c	12.72 ± 0.45^b	12.96 ± 0.23^b
Week	Fork length (cm)			
	Control	<i>C. longa</i>	<i>C. citratus</i>	<i>Z. officinale</i>
1 (initial)	4.51 ± 0.14^a	4.50 ± 0.16^a	4.52 ± 0.15^a	4.51 ± 0.17^a
3	6.40 ± 0.33	6.15 ± 0.41	6.39 ± 0.52	6.29 ± 0.50
6	8.59 ± 0.41	8.83 ± 0.64	8.97 ± 0.67	8.53 ± 0.39
8 (final)	10.39 ± 0.35^a	10.60 ± 0.48^a	10.62 ± 0.50^a	10.56 ± 0.49^a

Different letters indicate significant differences ($p < 0.05$).

Fork length increase. After eight weeks testing it was determined that fish fed diets incorporating essential oils not produce a significant increase in the length of the fish compared with the control diet. The results of statistical analysis of two-way ANOVA indicate that the average values of final length of treatments are not significantly different ($p > 0.05$).

Weight increase. After 8 weeks of the experiment, the results for weight gain averages describe that final weight obtained with the essential oil treatments is significantly different between all groups ($p < 0.05$). Using the analysis of variance for a linear model ($R^2 = 0.985$) which adds the factor time and treatments related to the final weight variable, indicates that treatment containing turmeric essential oil is very significantly different from the control treatment ($p < 0.01$). The results of the Tukey HSD classify three different groups, one of the turmeric essential oil, other one with the ginger and lemongrass treatments and the third with control treatment.

Length-weight ratio. All of the treatments increases the length and the weight of the fingerlings in negative allometric relationship as shown the value of exponent ($b < 3$) in the potential equation ($R^2 \approx 0.98$) (Figure 2).

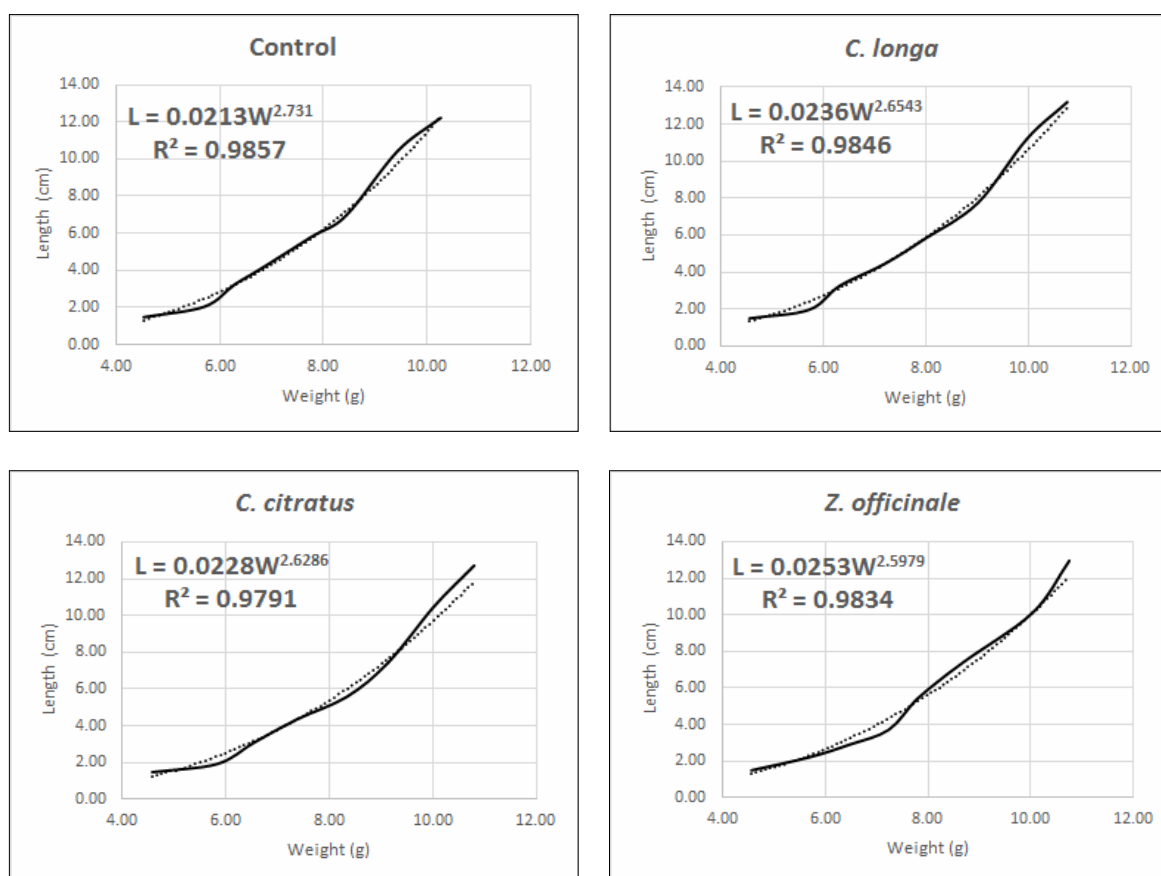


Figure 2. Negative allometric growth of fingerlings *O. mykiss*. Solid line length-weight curve; dotted line regression curve.

Conclusions. This study shows that the addition of essential oils of turmeric, lemongrass, and ginger in a diet for 8 weeks of rainbow trout, clearly influences in the weight gain of fingerlings. The fish were fed diets that included turmeric essential oil showed the best rates of weight gain. None of the tested essential oils significantly influences the final length of the fish. Weight-length curves denote isometric growth of the fingerlings, however, in all cases the slopes are significantly different between treatments and control. The survival rates of juveniles during the time of experimentation

improve with the use lemongrass or turmeric compared to the control diet and ginger essential oil.

Overall we think the alternative use of bio-based medicinal herbs, like the essential oils, promotes best features growth by acting as stimulating and improve overall health for its proven capabilities like as antimicrobial agents and immune stimulants.

The use of these and other natural products may be the best way for the production of fishes without any environmental and hazardous problems in aquaculture industry.

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