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Effects of extrusion of diet on growth parameters of rainbow trout (*Oncorhynchus mykiss*)

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Abstract. In order to study the effects of extrusion on growth parameters of rainbow trout (*Oncorhynchus mykiss)*, an experimental test was conducted in a fish farm. A total of 360 fish were randomly assigned amongst 12 tanks, three treatments, with each treatment having four replicates. Fish were fed manually three times daily for 70 days. The treatments were fed by pressed, floating and sinking extruded feed, respectively. The diets contained the same level of protein, carbohydrate and fat as formulation and ingredients of the experimental diets were the same. The results showed that the studied parameters varied significantly ($P<0.05$) between the treatments. Within a 70 day-experiment, the final average weight of the pressed, floating and sinking extruded feed group was 45.7, 47.6 and 51.06g, respectively showing a significant difference ($P<0.05$). Feed Conversion Ratio (FCR) and Specific Growth Rate (SGR) also showed a significant difference in fish fed floating feed compared to other two groups ($P<0.05$). The results show that the manufacturing and processing technique has significant influence on the growth parameters of rainbow trout.
Keywords: rainbow trout, floating pellet, sinking pellet, growth performance.

Introduction. In recent years, processing techniques used to produce commercial diets for use in aquaculture have widely increased. This increase has been driven by the fast global development of aquaculture, which has resulted in an increased demand for high quality diets designed to meet nutritional requirements of fish (Hilton et al 1981; Lovell 1992; Cheng & Hardy 2003; Bud et al 2009; Jafaryan et al 2011).

The processing techniques including grinding, steam conditioning and extrusion are common in the production of pellet diets in aquaculture and their use often facilitates improvement in the raw products.

Nowadays most trout diets are produced by extrusion which is a process where the feed is subject to mixing, shearing and heating under high pressure before the product is forced through a die. The feed may undergo reactions during processing that could be beneficial for example anti-nutrients such as protease inhibitors and lectins which may be found in vegetable protein sources are inactivated during heat treatment (Van der Poel et al 1990).

On the other hand, secondary, tertiary or quaternary structure of some proteins may be changed during the heating process while the primary structure remains intact. Moderate heating of feed ingredients may be beneficial for the nutritional value of the feed proteins, since it leads to better protein digestion (Camire & King 1991). It is also proved that extrusion process is effective on starch chemistry compared to other feed processing techniques such as steam-pelleting and screw-press technologies. The gelatinization and expansion of the feed starch also increases its nutritional value through an increase in the digestibility of the starch to most fish species (Jeong et al 1991; Glencross 2011). Many other advantages to extruding some raw materials, with improvements in dry matter and energy digestibility, accompanying with more growth rate in fish population has been reported in previous studies (Kaushik et al 1995; Carter & Hauler 2000; Burel et al 2000; Glencross et al 2010). In recent years, rainbow trout culture industry has been widely developed in Iran especially in Chaharmahal va Bakhtiari

Province as the production rate reached to 16200 and 18000 tons in 2011 and 2012, respectively (Raissy & Ansari 2011; Ansari et al 2012). Despite the development of fish farms, new food processing technologies are less studied.

The aim of this study was to compare the effects of extruded and pellet foods on growth parameters of rainbow trout fish.

Material and Method

Experimental design. The experiment was conducted between October 2012 and December 2012 at the fish farm located in Golestan province (Iran). This test was conducted in 12 tanks containing 500 L water at a constant temperature of 13 °C and The average dissolved oxygen 7ppm, pH=7.8 respectively.

Growth trial. Randomly selected rainbow trout (n=360) from the same batch of eggs were transferred from grow-out ponds to experimental tanks. Each of the tanks was stocked with 30 trout of 32.8±1.5g. Fish were randomly assigned amongst 12 tanks, with each treatment having four replicates.

Fish were fed manually three times daily during a period of 70 days. The treatments were fed by pressed, floating and sinking extruded feed, respectively 5% of body weight. Formulation and chemical analysis of the experimental diets were the same in treatments (Table 1).

Table 1

Formulation and chemical analysis of the experimental diet

Proximate composition (%)	Levels (%)
Moisture	9.68
Crude protein	41.40
Lipid	11.93
Ash	9.48
* NFE	27.49
Gross energy (MJ/kg)	19.09
** P/E ratio	21.68

* Nitrogen-free extract (NFE) = 1000 – (protein + lipid + moisture + ash).

** Protein/energy ratio (g/MJ).

At the end of each week, four randomly selected fish from each tank were anesthetized in order to measure the length and weight. At the end of the experiment, weight gain, FCR and SGR were determined to compare the obtained results among the treatments.

Statistical analysis. Data were transferred to Microsoft Excel spreadsheet (Microsoft Corp., Redmond, Washington, USA) for analysis. SPSS 18.0 statistical software (SPSS Inc., Chicago, Illinois, USA), was used for Duncan's test; differences were considered significant at values of $P<0.05$.

Results and Discussion. The results of this study showed that the studied parameters varied significantly ($P<0.05$) between the treatments (Table 2). The final weights of the studied fish ranged between 45.7 and 51.06 g for diets pellet and extruded showing a significant difference between the final weights ($P<0.05$). FCR and SGR also showed a significant difference in fish fed floating feed compared to other two groups ($P<0.05$). The results are presented in detail in Table 2.

Table 2

Results of the studied parameters in rainbow trout

Parameter	Pressed feed	Floating extruded	Sinking extruded
Initial weight (g)	32.8±1.5	32.8±1.5	32.8±1.5
Final weight (g)	45.75±2.17 ^{c}	51.06±2.83 ^{a}	47.69±3.28 ^{b}
Weight gain (g)	11.75± 2.09 ^{c}	20±3.97 ^{a}	13.75±2.41 ^{b}
FCR	1.7± 0.23 ^{c}	1.1±0.17 ^{a}	1.35±0.12 ^{b}
SGR	0.9±0.07 ^{c}	1.38±0.07 ^{a}	0.03±0.24 ^{b}

In this study different processing treatments affected weight gain and performance of the studied fish reared under our experimental conditions.

The techniques of processing may have effect on feed consumption as well as digestibility of the feed content. Feed consumption was clearly affected by diet processing as the lowest FCR was found in fish fed the non-extruded pellet. Fish fed the floating extruded diet consumed significantly less on a biomass basis than fish fed the floating and steamed pellet. This difference is attributed to differences in feeding behavior of rainbow trout.

Extruded pellets had a low bulk density ~579.5 g/L and either floated or sank very slowly (≤2.0 cm/s) compared to the steam pellet. Rainbow trout prefer to feed floating pellet than sinking or pressed pellets as the fish feeds at the surface of water consequently the fish needs lower attempt and energy to achieve the pellets. This may account for the lower FCR and better growth rate associated with the floating extruded diet in this study. Unlike rainbow trout, silver perch has been reported to be reluctant to consume floating pellets. Sinking pellets which can be ingested at or near the bottom of the ponds reported to be the best choice for silver perch (Booth et al 2000).

In our study the weak growth performance observed in the fish fed with the pressed food could be related to the manufacturing technology of that food (Aba et al 2011). Despite the composition and formulation of the three diets in this study were the same, the pressed food contains less digestible protein and fat because it's physical structure does not allow incorporation of these fats (Kaushik 2000) and as a consequence the energy of the food is low compared to that of extruded one. In salmonids, the digestive and metabolic utilization of carbohydrates and proteins highly depends on their nature or complexity while the processing technology, such as extrusion, improves the digestibility of proteins and carbohydrates (Spannhof & Plantikow 1983; Bergot & Breque 1983; Kaushik 2000). As a consequence, the extruded diets containing gelatinized starch provide more digestible energy than the pressed diets containing raw starch. The low digestibility of the raw starch is due to the amylase enzyme which is lacking in the rainbow trout (Silas Hung & Trono 1994).

The results found in this study are comparable to those obtained by Pfeffer et al (1991) and Pokniak et al (1999) and these results are in good agreement with those reported by Zoccarato et al (1996) and Aba et al (2011). All of the results represent the advantages of extruded pellet comparing to pressed pellet. Similar results were also observed in other fish species such as silver perch (*Bidyanus bidyanus*) by Booth et al (2000) and in the Nile tilapia (*Oreochromis niloticus*) by Ammar (2008) that show a significant increase of weight gain with the extruded food compared to the pressed food. Guroy (2006) and Chebbaki (2010) in their work on *Dicentrarchus labrax*, even with isoenergetic diets for pressed and extruded diets have observed a better performance in terms of weight when fish were fed extruded diets.

It is concluded that the best growth performance is offered by using floating extruded food so in intensive fish culture using floating extruded pellets is highly recommended despite their high price.

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