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Optimization and Efficiency in Rainbow Trout Fed Diets for Reduce the Environment Impact in Morocco

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Abstract:
A 60 days field trial was conducted in a private fish farm. The trial was conducted at two circular tanks , in order to investigate the effect of extruded and pelleted fish diet on the growth performance and their impacts on environment of rainbow trout (Oncorhynchus mykiss) . The groups of rainbow trout at average initial weights of 474 g . Following this study, two diets were formulated: the extruded food with 42% crude protein, 28% fat and 17% carbohydrate while the pressed food with 44.7% Crude Protein, 15% fat and 28.6 carbohydrates with digestible energy of 20.9 Mj and 16.48 Mj.Within a 60 day-experiment, significant variation in weight gain and SGR are recorded between the extruded and the pelleted diet. . The best conversion rate was obtained with the extruded food with 1.17 v.s 1.56. The extruded feed emits less nitrogen by the effect of the protein-sparing as we also note this food contains less phosphate that releases phosphate discharges decreased by fish.

Keywords: Environment, extruded, nitrogen, nutrition, pelleted, phosphorus.

1.0 Introduction:
According to FAO (2010), the aquaculture sector is the production of food of animal origin and the most dynamic among the main factors that have contributed to the expansion of this sector is the use of artificial feeds, Kolditz (2008). Recognition of the importance of expanding aquaculture has stimulated the development of new production strategies. They aim to achieve a balance between production costs and the environment, largely due to the excessive dependence of aquaculture resources fish as a food source in order to preserve the natural stocks, and the quality of aquaculture effluents for to contribute at the development of a sustainable global aquaculture (Tacon, 1997 Chevassus, 2009). Food composition, digestibility , manufacturing and feed conversion rates largely determine the level of discharges from fish farming, and thus the release into the environment of organic matter and nutrients (phosphorus , nitrogen and TSS) (Ackefors and Enell, 1994; Kaushik, 2000; Cho and Bureau, 2001 ; Sindilariu, 2007). Yet the composition of the diet by the amount of protein is a factor that affects nitrogen excretion (Kaushik and Cowey, 1991; Hardy, 2002), but also affects the retention and excretion of phosphorus (Green et al., 2002) which leads to eutrophication of aquatic receptors fish effluents (Aubin et al., 2009; Boujard, 2004). Nutrient management through the formulation and manufacturing of foods is considered the best approach effective in reducing the production of these emissions that lead to environmental degradation (Bureau, 2004) and degradation of fish health by invasion of pathogenic species (Thompson et al., 2002; Crab et al., 2007).

Dietary phosphorus (P) is essential for optimum growth and metabolism of fish. It is the most important mineral needed by fish, since its requirement and functions are superior to that of any other mineral element (NCR 1993; Satoh *et al*. 2002). Fishmeal is the source of most dietary P in fish diets and feed quality improvement involving ways to retain dietary P is one of the main strategies to reduce environmental impact of aquaculture, There is a certain amount released into the environment. Phosphorus is an element, when present in excessive amounts, leads to eutrophication of aquatic (Lall, 1991; Sugiura and Hardy, 2000).

Total suspended solids (TSS) are rejected by the fish, they are directly related to the composition of the food. TSS are rejected by the fish, They are Directly related to the composition of the food. They have two origins, fecal or food refusal(Cho and Bureau, 1997). There are two basic strategies for the reduction of this waste, namely: (I) reducing the amount of waste produced in the first place (by optimizing the feed conversion) (Cho and Bureau, 1997) and (II) treating effluent to remove waste before it is discharged into the environment (particle removal) (Bergheim and Brinker, 2003; Boyd, 2003). In order to minimize the impact of these problems, producers should have minimum protocol to assure , improving feed management techniques, minimizing waste by using good quality, highly digestible feed (Rosenthal, 1994; Bureau and Cho, 2001), with lower concentrations of nitrogen, phosphorus and TSS, without reducing its nutritive value (Boyd, 1999; Hardy , 2002). Thus the aim of this study is to compare the emissions from both pressed and extruded foods to determine which of two foods is less polluting so to ensure the sustainability of the sector and allow the passage of aquaculture quality to the quality of the environment

2.0 Materials and Methods:

2.1. Experimental design

The experiment was conducted at the private fish farm located about 70 km from Azrou (Morocco). This test was conducted in two circular tanks of 22 m3 volume at open circuit with an initial load of 14 kg fed by spring water at a flow rate of 30 m^3 h^{-1}, with a time of renewal of water 1.4 times per hour.

2. 2. Biological materials

1400 juveniles trout females triploid with an average body weight of 474 g the same batch of eggs were divided randomly into two circular tanks at a density of 700 fish per tank, 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 60 days, according to the feeding table provided by the supplier of food (71 Ecolife of Biomar). Every two weeks 30 fish of each batch have been anesthetized after 24 h of fasting in order to measure the size and the weight of each fish. The quantities of food distributed were weighed to estimate the consumption by the fish between two weighing.

2.3. Experimental foods

Formulation and chemical composition of experimental diets are shown in Table 1, 2 and 3.

2.3.1. Food composition

Table 1: Ingredient and proximate compositions (g/100 g dry matter) of the Extruded diets

Ingrédients	Extruded diet
Fish meal	30%
Soybean meal	15%
Rapeseed oil	12%
Fish oil	10%
soy concentrate	8%
wheat	6%
Rapeseed meal	6%
Krill meal	5%
Vitamin A - (UI/kg)	5000
Vitamin D3 – (UI/Kg)	1000
Vitamin E - (mg/kg)	180
Vitamin C - (mg/kg)	100
Astaxanthin	50 ppm
ashes	7%

Table 2: Ingredient and proximate compositions (g/100 g dry matter) of the pelleted diet.

Ingrédients	Pressed diet
Fish meal	41,5%
Fish oil	11,5%
Corn gluten	15%
Wheat Flour	30%
vitamin complex	2%
Cantaxanthin	40 ppm
ashes	6,1%

2.3.2. Table 3: Proximate composition of diets (%)

	Extruded diet	Pelleted diet
Protéins	42%	44.7 %
Lipids	28%	15 %
carbohydrates	17%	28.6 %
Moisture	4 %	6.80 %
phosphorus	1 %	1,15 %
Gross Energy (GE, Mj Kg^{-1})	24,28	21,58
Digestible energy (DE, MJ Kg^{-1})	20,90	16,48
DP / DE (g MJ^{-1}) (DP :Digestible Prtoein)	18,08	24,41
Ratio P/L (Protein/lipid)	42/28	44,7/15

2.4 The rate of feeding

The experimental test was aimed at comparing two non-isoenergetic foods to 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 extruded and pressed foods that have different digestible energy 20.90 Mj ,16.48 Mj, respectively. These rates of rationing depends on the temperature of the water colsely of the site, we have set the rates according to the temperature of the site which is about 14 ° so that the quantitative ratio for the same food energy intake is: amount of food extruded 1.27 = amount of pressed food (or amount of food extruded 0.78 = amount of pelleted food). Gross energy was calculated using the following values: crude protein = 23.7 kJ g-1, crude lipids = 39.5 kJ g-1 and carbohydrate = 17.2 kJ g-1 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 et al., 2001).

2.5. Zootechnical parameters and feed efficiency

Calculations: The following variables were calculated:

Weight gain (WGR, %) =100 x (final body weight - initial body weight) / initial body weight

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

Specific Growth Rate (SGR) = 100 (Ln final weight (g) -Ln initial weight (g)) / time (days).

Condition factor (K) = Condition Factor (K) = 100W/ L3 ; Where, W= weight in grams; L= total length (cm).

2.6 Water sampling

The hydrobiological approach is based on the water flow rates and concentrations measured at the inlet and the outlet of the circular tank if fish farm (Boujard et al., 1999; Roque D'Orbcastel, 2008).

2.7 Water analysis

We performed in situ measurement of water temperature (T),dissolved oxygen (DO) and pH with lots of devices (Orion, model 260, Orion, model 330 Orion, model 130). Total Suspended solids (TSS), were determined according to Mudroch and Macknight (1991). Other variables, Total Nitrogen, Total Phosphorus , ammonia, nitrite, nitrate were analysed in the laboratory of Water Quality, at National Center of Hydrobiology and Fish (CNHP) in the Azrou City (Morocco) with dataloging spectrophotometer (HACH. DR/2010).

2.8 Statistical studies

Our results are compared statistically (R Development Core Team, 2011). All parameters were subjected to analysis of variance test (ANOVA). The results were subjected to analysis of variance and any differences estimated by the Duncan test (1955) at the 0.05 level.

3.0 Results and Discussion:

3.1 Zootechnicals parameters and feed efficiency

Table 4: Zootechnicals parameters and feed efficiency

Parameters	Weight gain	SGR	FCR	Condition factor
Pelleted diet	52,74[a]	0,7[a]	1,56[b]	1,16[a]
Extruded diet	60,12[b]	0,8[b]	1,07[a]	1,24[b]

Table 5: Environmental conditions of fish

Parameters	Temperature (°C)	pH	DO (mg/l)
Pelleted diet	13,8 - 14,2	7,2	8,O5
Extruded diet	13,8 - 14,2	7,2	8,25

Table 6: Water sample analyses data

Parameters	Pelleted diet	Extruded diet
Total Solids Suspension(mg/l)	65,34[b]	30,06[a]
Nitrate (mg/l)	4,12[b]	0,32[a]
Nitrite (mg/l)	<0,01[a]	<0,01[a]
NH_4 (mg/l)	0,72[b]	0,51[a]
Total phosphate (mg/l)	0,18[b]	0,11[a]

The two experimental diets were well accepted by fish throughout the trial. Our experimental test shows that the performance of zootechnical parameters vary significantly ($p < 0.05$) between the two dietary treatments (Table 4). Indeed the final weights of fish are between 724 ± 57 and 759 ± 48 g for extruded and pelleted diets, and Duncan's test shows a significant difference between the final weights ($p<0.05$). The percentage weight gain was 52.74 for the pelleted food, when he was in the extruded feed 60.12. There is a significant difference between the two values of the two systems ($p<0.05$). The SGR is calculated by 0.7 % for fish fed with the diet in a pelleted feed and 0.8 % for the extruded diet, there was a significant difference ($p<0.05$). The condition factor was 1.16 and 1.24 respectively for the pelleted and the extruted food.

3.2 Water quality

3.2.1 Environmental conditions

The results recorded during the experiments (with their tolerable limits) are given in Table 4. During the whole experiment period, the water quality parameters were within tolerable limits. Water temperature ranged from 13,8 to 14,2°C (tolerable limits 10 to 21°C), pH ranged from 7.2 (tolerable limits 6.0 to 8.0), Dissolved oxygen (DO) ranged from 6.5 to 7.0 mg/L (tolerable limits superior to 6 mg/L).

3.2.2 Water quality parameters

For the determination of optimum growth rates of rainbow trout, it is necessary to determine the protein and energy requirement of this fish. Since the protein content in finfish diets usually constitutes the largest single cost factor in feeds (Watanabe, 2002). A significant improvement in growth performance due to the sparing effect of lipid and carbohydrate on dietary protein and the manufacturing technology has been reported for the same fish species (Guroy, 2006; Aba et al., 2012) and in the sea bass (Chebbaki, 2010) and in silver perch (Booth et al., 2002).

The difference performance observed between the tested foods (Pelleted and Extruded) would result from the best degree of convertibility by the fish, the ingredients incorporated into foods. In our study the weak growth performance observed in the batch fed with the pelleted food could be explained by their different levels of protein, fat and carbohydrates and also by the manufacturing technology of that food (Aba et al., 2012). The pelleted food contains significant levels of protein,more raw starch and the salmonids in general are characterized by a low digestibility in raw starch and this results from a failure in specific enzyme (Krogdahl et al.,2005). In salmonids, the digestive and metabolic utilization of carbohydrates depends on their nature or complexity while the technological treatments (extrusion, gelatinization) improve the digestibility of starches (Spannhof and Plantikow, 1983;

Bergot and Breque, 1983; Kaushik, 2000). Therefore, the diets containing gelatinized starch provide more digestible energy than the diets containing raw starch. The low digestibility of the raw starch is due to the amylase (Spannhof and Plantikow, 1983; Silas and Trono, 1994), which is lacking in the rainbow trout (Oncorhynchus mykiss). The pelleted food contains less fat because its physical structure does not allow incorporation of these fats (Kaushik, 2000; Aba el al,2012) and thus the energy of the food is low compared to that of extruded one. This is why the best feed conversion ratio (FCR) obtained with extruded feed, FCR has a major influence on fish discards.

The condition factor (relationship between weight and length of fish) is an index of the health of fish and an indicator of growth (Dutta, 1994). fish fed the extruded feed had a better growth in weight and length while fish fed with the pelleted diet had a performance in size and this can be explained by the richness of the regime of phosphorus where significant development of the skeleton of the fish. (Kaushik 2005). Our results indicate that the K factor trout have good growth in weight rather than size especially for fish fed with diet A, and these results are similar to those of Yildiz (2004). It is now well known that decreasing dietary energy supply reduces supply fish growth, feed efficiency and protein retention by increasing protein catabolism (Medale et al., 1995, Cho and Bureau, 2001, Aba el al, 2012).Reducing the protein content of fish feeds is one strategy to increase the sustainability of trout aquaculture via reducing feed costs as well as reducing the environmental impact (Gaylord, 2009).The amount and quantity of waste depends on production system and feed quality (Cho and Bureau, 1997). First solution to reduce the environmental impacts of aquaculture systems consists in minimizing the Feed Conversion Ratio (Roque d'Orbcastel et al., 2009 ;Martins, et al.2010). Feed impact on the environment may also be reduced by choosing feed ingredients more digestible and with processing and manufacturing by extrusion.

Regarding total solids suspensions (TSS) the results obtained during experimental testing shows that the pelleted diet releases more TSS, because of its physical quality and its high raw starch content less digestible by rainbow trout (Kaushik, 2000; Aba et al.,2012). A high concentration of TSS has a negative influence on nitrification, water quality (Eding et al., 2006) and fish growth (Davidson et al., 2009). Total suspended solid in effluent water from the circular tank trout fed with the pelleted diet of was more than the extruded diet, the TSS are derived mainly faeces, and the food not consumed. TSS more than 80 - 100 mg/L will cause injure fish gills (Teodorowicz et al., 2006). TSS, recorded in this experimental test , was less than 30 mg/L which does not have undesirable effect on fish farming. These results are similar to those of pokniak and Zoccarato (1999). These results are consistent with those of Baccarin and Camargo (2005), on the release of tilapia fed with the pelleted and extruded diets. The high levels of TSS of the pelleted diet, can be explained by the richness of this food by starch less digestible believed by trout. Spannhof and Plantikow (1983) Silas (1994) have suggested that the raw starch accelerated the passage of chyme in the intestine and reduces the time available for digestion is what explains the emission of large quantities of suspended solids by trout fed with pelleted diet , this diet is subjected to low buoyancy crumbles easily with water and generates large amounts of dust (Kaushik, 2000), which is consistent with the results of the pelleted food.

The excretion of nitrogen waste from the fish is mainly dependent on protein intake and metabolic efficiency of fish, which is species-specific and is affected by the levels of dietary protein (Dosdat et al ., 2003). It is well known that an excess of amino acids in the diet will result in the catabolism of amino acids with ammonia excretion associated with a loss of energy, the importance the balance between the digestible protein and digestible energy in the diet (Lazzari and Baldisserotto, 2008). So, the dietary protein to energy ratio, in fish diets, is of great importance. Levels of dietary protein and energy, not only influence the growth and body composition, but metabolites excretions in various fishes (McGoogan and Gatlin , 2000), and the ratio Protein /Lipid has a major of nitrogen excretion of rainbow trout, this is what explains the high excretion of nitrites, nitrates, ammonia and total nitrogen in fish fed with pelleted diet , due to a strong protein catabolism at the expense of lipid and carbohydrate(Cho and Bureau, 2001; Green ,2002). This sparing effect by supplementation of fat (and carbohydrates) has been well demonstrated for salmonids and catfish (Dias et al., 1999; Torstensen et al., 2001; Aba et al., 2011), perch Scortum barcoo (Song et al., 2009). Our results are similar to the results obtained by (Medale (1995); Boaventura et al., (1997), Zoccarato et al, (1999); Pulatsu et al.,(2004), Maillard et al., (2005),Sindilariu (2007) and Tekinay(2009).

The optimization of digestible phosphorus content of the diet should meet the requirements of fish (Cho and Bureau 2001), hence the need for better management of food through their formulation considered the most effective approach and possible to reduce the production of phosphorus in the environment. Phosphate excretion is proportional to the level of P in the food, where the concordance with those of our réultats Hernandez (2004) and are also similar to those of Boaventura (1997), Sugiura et al. (2000) Roy and Lall (2003); Pulatsu (2004); Maillard (2005), Sindilariu (2007), Tekinay (2009) andour results were observed also with those of Vandenberg (2010).

4.0 Conclusion:

The results of this study show that the extruded food is characterized by its energy content buoyancy, its digestibility and performance ratio better digestible protein / digestible energy and non-protein energy level determinant, is the food that provides the trout the best growth performance. Considering food as the main production cost intensive farming using extruded diets despite their price can be justified by the savings resulting from efficiency through better food conversion and contribution to sustainable aquaculture by substitution of fishery products by carbohydrates (mainly starch) and also reduce discards and fish by controlling the feed formulation. These practices of environmental friendly aquaculture which will ultimately leads to sustainable fish farming with less negative impact on the environment, of the sector and allow the passage of aquaculture quality to the quality of the environment.

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