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# The sustainable aquaculture in morocco by optimization of the energy of the feed of rainbow trout

**Aba Mustapha[1*], Belghyti Driss[1], Benabid Mohammed[2] , Maychal aziz[3]**

[1]*Biology and Health Laboratory, Environmental and Parasitology Team/UFR Doctoral, Sciences Faculty, Ibn Tofail University, Kenitra, Morocco*

[2]*National Center of Hydrobiology and Pisciculture (NCHP) Azrou, Morocco*

[3] *Domaines agricoles. Truites de l'Atlas Azrou. Morocco*

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## Abstract

This research is an update in fish nutrition research in Morocco, and provides insight on the progression and evolution of this field in order to meet the needs of the aquaculture with the purpose to achieve a balance in fish nutrition and aquaculture sustainability. In order to compare the effects of varying dietary digestible protein (DP) and digestible energy (DE) content of two extruded foods on environment, an experimental test was conducted at National Center of Hydrobiology and Fish Culture in city Azrou Morocco. 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% carbohydrate while the extruted 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 were divided randomly into six fiberglass conical tanks at open circuit. The diet was assigned to 6 tanks for 50 fish each with three replicates for each diet. The extruded diet A by low ratio digestible protein/ digestible energy, 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, there by contributing to sustainable aquaculture.

* **Corresponding Author:** Aba Mustapha ✉ aba.mustapha@gmail.com

**Introduction**

This research is an update in fish nutrition research in Morocco, and provides insight on the progression and evolution of this field in order to meet the needs of the aquaculture with the purpose to achieve a balance in fish nutrition and aquaculture sustainability. In order to compare the effects of varying dietary digestible protein (DP) and digestible energy (DE) content of two extruded foods on environment, an experimental test was conducted at National Center of Hydrobiology and Fish Culture in city Azrou Morocco. 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% carbohydrate while the extruted 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 were divided randomly into six fiberglass conical tanks at open circuit. The diet was assigned to 6 tanks for 50 fish each with three replicates for each diet. The extruded diet A by low ratio digestible protein/ digestible energy, 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, there by contributing to sustainable aquaculture.

The success of aquaculture faces a double challenge, the provision of food covering the nutritional needs for better growth and ensure good quality of the flesh and the limitation on fish discards. The largest part of these costs comes for feed in which protein is the most expensive ingredient (Watanabe *et al.*, 2002). The required protein content of the feed varies depending on the species and size of the cultured fish (NRC, 1993, Craig and Helfrich, 2002), which, in turn, strongly impacts the fish growth performance and thus production efficiency. Fish meal, which is the best source of protein and oil due to its high biological values in terms of essential amino acid, unsaturated fatty acids, minerals, and phospholipids for fish metabolism, (Cheng and Hardy, 2004).

The effective use of these proteins are very related to their concentration in the diet and food availability in other non-protein sources, such as lipids and carbohydrates (Watanabe, 2002; Chaiyapechara *et al.*, 2003; Morrow *et al*, 2004; Azevedo 2004; Eliason 2007). Needs energy and nutrients are affected by many factors and may vary in different stages of the life cycle of fish. Several authors have described the optimal values of food protein / energy ratios in some livestock species such as rainbow trout (*Oncorhynchus mykiss*) (Kim and Kaushik ,1992; Lanari *et al*, 1995), but breeding success fish is based on the provision of rations containing optimal levels of energy and nutrients for growth (Hardy and Barrows, 2002).

The optimization of protein/energy ratio (P/E) has an important role in protein utilization and energy. Thus, one of the factors affecting the optimization of the efficiency of the food is the balance between the digestible protein and non-protein energy food. This balance is represented by the ratio of digestible protein (dp) and digestible energy (de) of the food (dp/de). For better optimization ratio pd/ed by reducing its rate, this ratio can be reduced if an additional power source is provided to enable savings of proteins, (Boujard, 2004).

In fish farming, the food is the ultimate source for the production of nitrogen and phosphorus wast, these discharges have a close relationship with the feed conversion ratio (Quellet , 1999). Protein catabolism resulting from deamination leads essentially to the formation of total ammonia nitrogen in both forms respectively ionized and non-ionized (Pagand, 1999), expelled to the outside environment by simple diffusion through the gill epithelium and is an indicator of pollution of aquatic environments (Belghyti *et al.*, 2007) and the increase in temperature and pH implies a greater nitrogen excretion in many species fish including rainbow trout (Quellet, 1999).

However, the composition of the diet in terms of quantity of protein is a factor that affects the nitrogen excretion ( Kaushik and Cowey 1991 ; Hardy 2002), but also affects the retention and excretion of phosphorus ( Green *et al.* , 2002) which causes eutrophication of aquatic environments receptors fish effluents ( Aubin *et al.*, 2009; Boujard, 2004).The nutrient management through the feed formulation is considered the most effective approach to reduce the production of these releases that lead to the degradation of the environment (Bureau,2004) and degradation of the health of fish invasions pathogenic species (Thompson *et al.* , 2002 ; and Crab , 2007).

Mitigation of negative impacts by made through the development of more environmentally friendly aquaculture diets food is considered a major challenge , given that the food provided to farmed fish marine or freshwater ( Aba *et al.* , 2011) in Morocco was pelleted food, kind which caused more pollution of aquatic and had a negative impact on fish health and the environment, and the use more energy and digestible extruded feeds by improving the power quality of the best ways of involving retention of P and N food is one of the main strategies to reduce the environmental impact ( Lall, 1991; Sugiura *et al.*, 2000; Aba *et al.*, 2011) , and the balance and better optimization between digestible protein and digestible energy in the diet. ( Lazzari , 2008).

The aim of this study was to evaluate the effects of different levels of protein, fats, carbohydrates and energy on impact environmental of two extruded feeds of rainbow trout, through better use of the food, and the development of cleaner forms and contribute to respect for the environment and ensure sustainability of aquaculture in Morocco.

**Materials and methods**

*Experimental design*

The experiment was conducted at National Center of Hydrobiology and Fish Culture (NCHP) in Azrou (Morocco). This test was conducted in fiberglass conical tanks of 0,8m$^3$ of volume at open circuit with an initial load of 5kg fed by spring water.

*Biological materials*

300 juveniles trout females triploid of average weight of 100 g ± 3 g 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. Every two weeks 8 fish of each batch have been anesthetized after 24 h of fasting in order to measure the size and the weight of each fish for measurements of weight and size. The quantities of food distributed were weighed to estimate the consumption by the fish between two weighings.

*Experimental foods*

Proximate composition of experimentals diets are shown in table 1.

*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 tow extruded foods (A,B) that have different digestible energy 21.32 Mj, 19.32 Mj, respectively. These rates of rationing depends on the temperature of the water closely of 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 (Ex A) 1.10 = amount of extruded (Ex B) 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 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).

*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, 2009).

*Water analysis*

We it 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).

*Statistical studies*

The 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 were estimated by the Duncan test (1955) at the 0.05 level.

**Results**

*Water quality*

*Environmental conditions*

The results recorded during the experiments are given in Table 4. During the whole experiment period, the water quality parameters were within tolerable limits. Water temperature ranged from 13,80 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 8.35 to 8.28 mg/L (tolerable limits superior to 6 mg/L), ( Wedemeyer, 1996).

**Table 1.**Proximate composition of experimentals diets.

| Composition | Extruded diet A | Extruded diet B |
|---|---|---|
| Proteins | 41,1% | 39,7% |
| Lipids | 27,4% | 24,4% |
| Carbohydrates | 20,4% | 15,7% |
| Moisture | 5,6% | 3,9% |
| Phosphorus | 0,9 | 1,2 |
| Gross Energy Mj | 23,73 | 21,70 |
| Digestible Energy | 21,32 | 19,32 |
| DP/DE | 17,35 | 18,48 |
| Ratio P/L | 41,1/27,4 | 39,7/24,4 |

DP : Digestible Protein ; DE : Digestible Energy ; P : Protein ; L : Lipids.

*Water quality parameters*

Regarding releases of trouts, it appears from the results of Table IV that fish fed the extruded food B emit more $NH_4$ $NO_3$ and total Phosphate with a significant difference (P <0 05), while $NO_2$ is noted that the two releases are similar foods.

The energy content, with a low ratio between digestible protein and digestible energy (dp/de) could explain the improved performance of the extruded diet B (Guillaume and Medale, 2001) as a result of better utilization of food, while contributing to better growth and better use of proteins, which saves the proteins as indicated in numerous studies (Kaushik *et al.*, 1991; Cho, 1992; Aba *et al.*, 2013).

**Discussion**

Dietary pd/ed is an important criterion in fish feed formulation. Optimum dietary DP/ED ratios for rainbow trout at temperature between 15° and 18° were investigated and the estimated ratios range from 17 to 19 Mj/kg (Medale, 2010).

Numerous studies have shown that increasing the power of the non digestible protein food by incorporation in feed energy as carbohydrate and lipid forms ( Medale , 1999) leads to a better retention of the protein and a decrease excretion of ammonia nitrogen ( Dias *et al* 1999 ; Watanabe *et al.,* ; 2001; Bureau *et al.*, 2002 ; Aba *et al.*, 2011 ).

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 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 by reducing its rate of this ratio can be reduced if an additional power source (fat or digestible carbohydrates) is provided to allow saving protein( Aba *et al.*, 2012) . Many studies have shown that increasing dietary (de) by increased non-protein energy food resulted in better retention of protein and a decrease in the excretion of ammonia nitrogen (Dias *et al*, 1999 ; Aba *et al.*, 2011).

**Table 2.**Results of rainbow trout Environmental conditions.

| Parameters | Temperature (°C) | pH | DO (mg/l) |
|---|---|---|---|
| Diet A | 14° ± 0,2 | 7,2 ± 0,2 | 8,30 ± 0,14 |
| Diet B | 14° ± 0,2 | 7,2 ± 0,2 | 8,28 ± 0,13 |

The impact of discarding fish on the environment has been studied in several fish species among which are, the gilthead seabream (*Sparus aurata*) (Tovar *et al.* 2000), bass (*Dicentrarchus labrax*) (Pagand *et al.*, 2000). Salmonids (Einen, 1997; Young and Bureau, 1998).

It is well known that an excess of amino acids in food will lead to catabolism of the amino acids with ammonia excretion associated with a loss of energy, where the importance of the balance between digestible protein and digestible energy in the diet (Lazzari *et al.*, 2008). The results obtained during these study, clearly demonstrate the potential benefits of lower digestible protein /digestible energy (dp / de) report because the excretion of total nitrogen was influenced by the lipid content of dietary carbohydrates by better optimization of protein utilization (Kaushik, 2000; Peres and Oliva Teles, 2001).

**Table 3.**Results of analyzes of the water quality from the fish pond effluents at the two extruded foods.

| Parameters | Extruded diet A | Extruded diet B |
|---|---|---|
| Total Solids Suspension (TSS) | $9,80^{a} \pm 2,04$ | $12,60^{b} \pm 3,06$ |
| Nitrites (mg/l) | $<0,01^{a}$ | $<0,01^{a}$ |
| Nitrates (mg/l) | $0,21^{a} \pm 0,02$ | $0,28^{b} \pm 0,03$ |
| Total Nitrogen | $0,98^{a} \pm 0,04$ | $1,26^{b} \pm 0,06$ |
| Total Phosphate (TP) | $0,13^{a} \pm 0,02$ | $0,18^{b} \pm 0,03$ |

Similarly, studies of Green (2002), Azevedo (2004), and Bureau (2004) showed that the decrease in the ratio dp / de led to a reduction in nitrogen while studies of Green and Hardy (2008), when the increasing the ratio dp / de results in a reduction of the retention of nitrogen is associated with an increase in excretion of the total nitrogen and these results are in good agreement with our own.

The same studies by Einen (1997) , Cho (2001) on salmonids fish, have found a better nitrogen retention in PD / ED ratios low and their results are consistent with those of this *experimental test, and results are similar to results obtained by (Medale 1995; Boaventura et al.*, 1997; Pulatsu *et al.*, 2004, Maillard *et al.*, 2005; Sindilariu 2007; Tekinay *et al.*, 2009).

Phosphorus is an important mineral found in nucleic acids, cell membranes, bone skeletal tissues, and is directly involved in energy processes (NRC, 1993), as it is essential for the phosphorylation reaction (Kaushik, 2005). Phosphorus deficiency results in anorexia, decreased weight and skeletal growth, bone demineralization, skeletal deformities (Kaushik, 1999; Lall, 2002; Sugiura *et al.*, 2004).

The excess of this mineral in the diet of fish leads to higher levels of P excreted, which is the main cause of eutrophication of aquatic environments, and impaired water quality (Kim *et al.*, 1998). With the global concern to reduce water pollution, minimizing the phosphate excretion by the fish has become imperative (Rodehutscord *et al.*, 2000). In general, fish with stomach, such as trout; assimilated phosphorus better than the fish without stomach as carp (Blancheton, 2004).

In general, diets of fish that depend on fish meal, the main source of proteins containing a total level of P which exceeds the minimum requirements necessary for growth optimal (Satoh *et al.*, 2003). The optimization of digestible phosphorus in 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. The total unavailable phosphorous level of the feed formula and consequently minimizes water pollution as a result of decreased phosphorous excretion into the water of the aquatic system.

The phosphate excretion is proportional to the content of P in the feed, from which the correlation with those of our réultats Hernandez (2004) and are also similar to those of Boaventura (1997) Sugiura *et al.*, (2000 ) Roy and Lall (2003); and Pulatsu (2004), Maillard (2005), Sindilariu (2007), Tekinay (2009), Aba (2013), concordant results were also observed with those of Vandenberg (2010).

**Conclusion**

The first source minimization of discards will be the result of better control of feed formulation (metabolic waste) and feeding methods (not ingested food). And current trends in the nutrition of fish are especially oriented feed to formulation characterized by a reduction in the ratio dp / de through the saving effect by increasing protein intake of non- energy protein, in order to have better growth performance and quality of the fish with less fish waste, and the reduction of the protein portion of the food for energy coverage, by incorporation of fats and carbohydrates results in a decrease dp/de ratio.

For phosphate discharges, the phosphate excretion is proportional to the amount of phosphate in the food. The decrease in phosphate supply with improved availability improves retention and reduce discards of this element.

A major objective of this study is the reduction of discharges of nitrogen and phosphorus potentially harmful to the environment. This strategy of sustainable development of freshwater aquaculture in Morocco reconciles both the protection of the environment and the needs of fish farmers through better optimization of the formulation of the diet, and which will allow for a better contribution to the sustainable development of aquaculture in Morocco.

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