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Evolution of Fish Farm Feeding Strategies in Aquaculture

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ABSTRACT

The study investigated the effectiveness of three extruded feeds in the feed conversion index for the rainbow trout (*Oncorhynchus mykiss Walbaum, 1792*) reared at the Ain Aghbal fish farming station in Morocco. While the biochemical composition (moisture, protein, lipid, and carbohydrate percentages) and energy content (digestible and raw) of feeds A, B, and C are known, these factors alone are insufficient for selecting the optimal feed based on conversion index. The test was conducted over 222 days in tanks supplied with water from Oum Er-Rbia, flowing at 11.04m³/ h, with a water change every half an hour. Initial rearing conditions included a density of 1.58kg/ m³ and a volume-to-flow ratio of 1.05m³/ h. Fish were fed two to three times daily, depending on their growth stage. Results indicate that extruded feed B significantly improved the rainbow trout growth and achieved a conversion index not exceeding 0.9 for the trout weighing 1043g.

INTRODUCTION

Aquaculture has seen significant advancements in animal feed production over the past decades. However, the reliance on artificial feeds has been a major factor limiting further expansion of this sector **(Kolditz, 2008)**. Successful fish domestication involves understanding their nutritional needs and meeting these needs with well-formulated feeds that are cost-effective **(Burel & Médale, 2014)**. These feeds must promote optimal growth, health, and physiological well-being while ensuring high-quality flesh and minimal environmental impact.

Fish nutrition, while fundamentally similar to that of terrestrial animals, has unique aspects due to fish physiology and the aquatic environment. Fish start life as very small larvae, exhibit ectothermy (lack of thermoregulation), and excrete nitrogenous waste primarily as ammonia (ammonotelism). The aquatic environment adds complexity with factors like flotation, mineral presence, and nutrient availability—typically high in proteins and low in carbohydrates.

According to **Kaushik (2000)**, feed represents 40– 60% of the production cost in farmed fish. Therefore, feeds should contain high levels of digestible protein (nearly 70%) and should be rich in essential amino acids **(Burel & Médale, 2014)**. While fishmeal has traditionally been a primary ingredient, the use of plant-based alternatives has increased. By 2011, fishmeal constituted only 20 to 25% of the feed for carnivorous species, with vegetable ingredients becoming the dominant components. Vegetable oils have also replaced a significant portion of fish oil in formulations. Common plant-based protein sources include oilseeds (e.g., soya, rapeseed), protein crops (e.g., lupin, field beans), cereals (e.g., corn, wheat), and protein extracts from cereals (e.g., gluten).

Partial substitution of fishmeal with plant-based ingredients has shown positive results, although high substitution rates can lead to reduced feed consumption, feed efficiency, and growth rates, despite adequate nutrient content. Continued research is needed to enhance the nutritional efficiency of plant products by addressing their inherent nutritional limitations **(Burel & Médale, 2014)**.

The feed consumption index (FCI) and feed conversion ratio (FCR) are crucial metrics for evaluating feed quality and farm management. This study aimed to assess the impact of three extruded feeds, with different biochemical compositions, on the feed conversion ratio of the rainbow trout.

MATERIALS AND METHODS

1. Biological material

In this study, 4,574 rainbow trout (*Oncorhynchus mykiss*) with an average weight of ±40 g, sourced from the same batch of eggs, were randomly distributed across six experimental tanks (BC1, BC2, BC3, BC4, BC5, and BC6).

During the pre-fattening stage, the fish were manually fed three times daily (at 8 a.m., 12 p.m., and 3 p.m.), while during the magnification stage, they were fed twice daily (at 8 a.m. and 2 p.m.). The daily feed ration was calculated based on the feeding guidelines provided by the feed suppliers.

Every 15 days, a sample of 90 fish from each tank was captured, anesthetized after a 24-hour fasting period, and measured for size and weight. This process allowed for the evaluation of the average daily growth and feed conversion index (FCR).

The experimental tanks were supplied with spring water, maintaining a nearly constant temperature of 14°C, with a water renewal rate of every half an hour (48 times per day). The pH of the water ranged from 7 to 8, and the oxygen saturation level was consistently above 90%, with an average dissolved oxygen content greater than 7mg/ l. The fish density at the start of the experiment was adjusted according to the flow rate and tank volumes.

2. Composition of extruded feeds

Table (1) shows the biochemical composition of the three studied feeds (A, B, C) in percent.

Table 1. The biochemical composition of the three studied feeds (the different feed diameters)

Type of feeds	**A**			**B**			**C**		
Feed diameter	3mm	4.5mm	7mm	3mm	4.5mm	7mm	3mm	4.5mm	7mm
Protein (%)	40	39	39	45	43	41	46	45	40
Lipid (%)	23	27	27	20	22	24	20	24	26
NEF (%)	21	18.2	18.2	20	20.7	20.5	15	14	13
Cellulose	2.25	1.86	1.8	1.9	1.9	2.3	1	1	1
Ash	7.20	6.77	6	8.1	7.4	7.2	10	10	10
Phosphorus	1.05	0.98	0.9	1	1	1	1.5	1.5	1.40
Digestible energy (MJ/kg)	19.2	20.2	20.2	20	20.3		19	19.90	20.50
Digestible protein / Digestible energy (g/MJ)	19	17 .5	17.5	-	-	-	22.3	22.30	17.6

3. Feeding rate

To compare the different zootechnical parameters of the rainbow trout under iso-energetic conditions, the experimental test was conducted with three extruded feeds (A, B, and C) that varied in their biochemical compositions. The feeds were administered according to the feeding tables provided for each type, ensuring that the distribution of feed was aligned with the different digestible energies (DE) of the feeds. A = 19.2 MJ/kg; B = 20 MJ/kg; and C = 19 MJ/kg (these energies have been established by the suppliers).

According to the rationing table for feed A, rationing rates have been set relative to the temperature of the site, which is around 14°C.

Table 2. Transformation of the three extruded feeds (A, B and C) into iso-energy

	Pre-grow feed energy (40- 100g)	Rate rationing 14°C	Isoenergetic feeding rate for the feeds
Feed A	19,2 MJ/Kg	1.65%	1.65%
Feed B	20 MJ/Kg	1.58 %	1.58%
Feed C	19MJ/Kg	1.67%	1.67%

To estimate the growth of the fish during the experiment and to characterize the efficiency of the feed tested, various zootechnical parameters were calculated.

4. Weight gain (WG)

This parameter makes it possible to evaluate the weight growth of the fish for a given time compared to the initial weight. The weight gain was calculated using the formula **of Le Cren (1977)**:

$$WC = \frac{\text{Final average weight (g)} - \text{Initial average weight (g)} * 100}{\text{Initial average weight}}$$

5. Conversion index (CI)

The feed conversion index is the ratio of feed consumed to weight gain. It must be as low as possible, reflecting good efficiency of the feed in question and its good use by the fish.

The conversion index is given using the formula of **Bellet (1977)**:

$$CI = \frac{\text{Amount of dry feed distributed}}{\text{Body mass gain}}$$

RESULTS

The following table presents the zoo technical performances of the three feeds (A, B, and C) in the three stages of rearing fed by the different feed diameters (3, 4.5, and 7mm) obtained during this test.

Table 3. Zoo technical performances of the rainbow trout fed with extruded feeds during the three growth stages

Growth parameter	Feed A	Feed B	Feed C
Initial average weight (g)	41,05 ±1,16	42,15 ±0,75	44,65±1,00
Final average weight (g)	803,14± 1,72	1043±3,87	842,1±3,41
WG (%)	374,477±0,31	542,8±0,31	460,15±0,33
CI	0,9±0,26	0,8±0,63	0,9±0,31

At the conclusion of the experimental trial, the final weights of the rainbow trout were 803.14g for feed A, 1043.9g for feed B, and 942.1g for feed C. Statistical analysis using the Tukey test revealed no significant difference in final weights among the three feeds ($P > 0.05$). Weight gain was 374.47g for feed A, while feeds B and C resulted in weight gains of 542.28 and 893.15g, respectively. Significant differences in weight gain were observed between the three diets ($P < 0.05$).

The feed conversion index (IC) indicated that feeds B and C were more efficient than feed A. Feed B demonstrated the best conversion rate with an IC of 0.91. Fish fed with extruded diet B showed a superior weight growth and a lower feed conversion index. The data illustrate variations in the feed conversion index relative to the growth of the trout fed on feeds A, B, and C, highlighting how effectively the trout converted ingested feed into body mass.

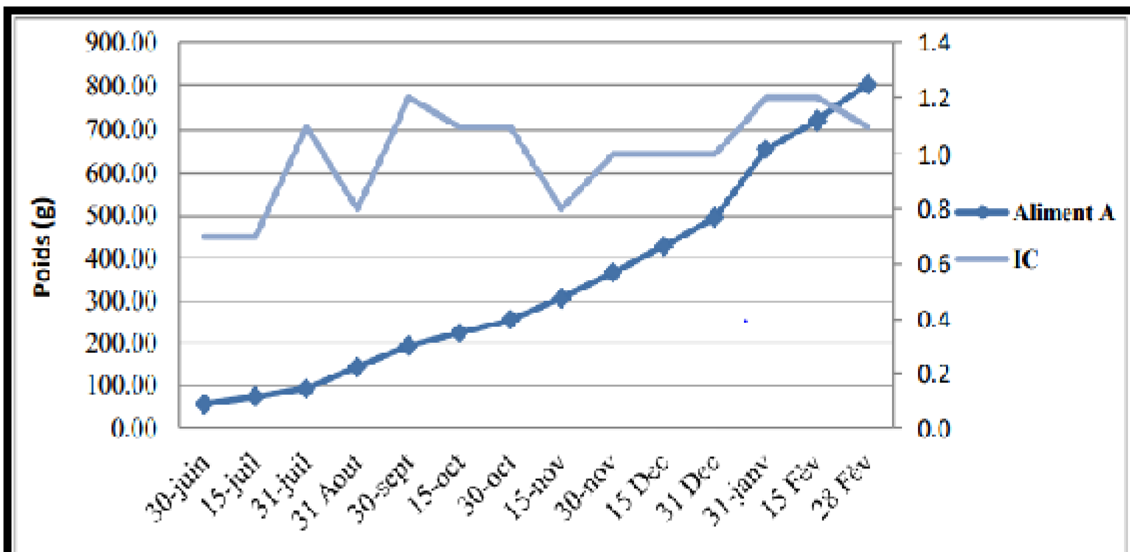

Fig. 1. Variation of conversion index for feed A

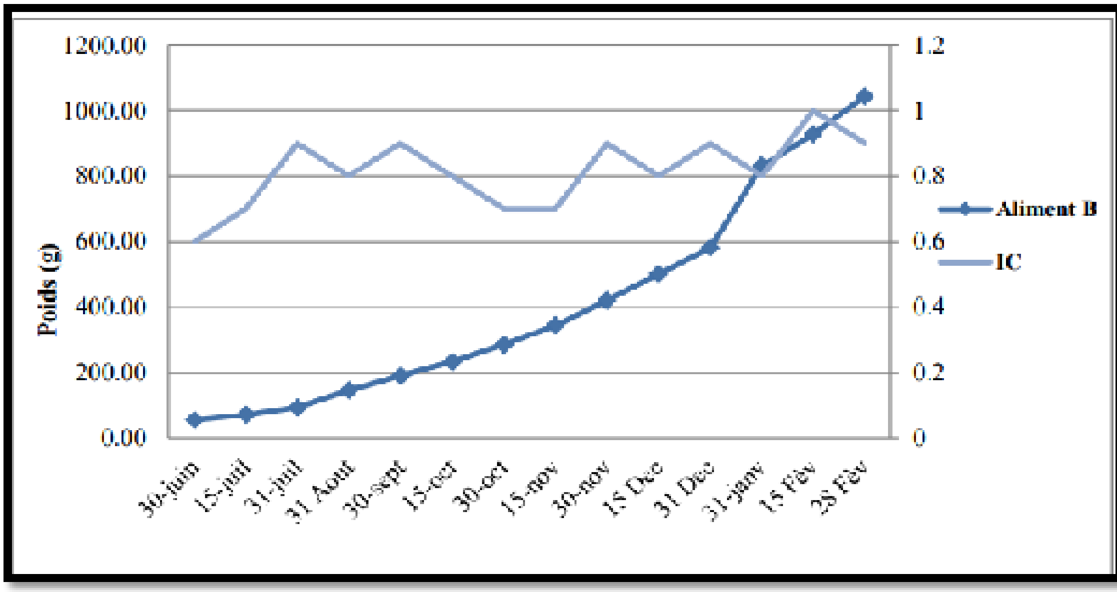

Fig. 2. Variation of the conversion index for feed B

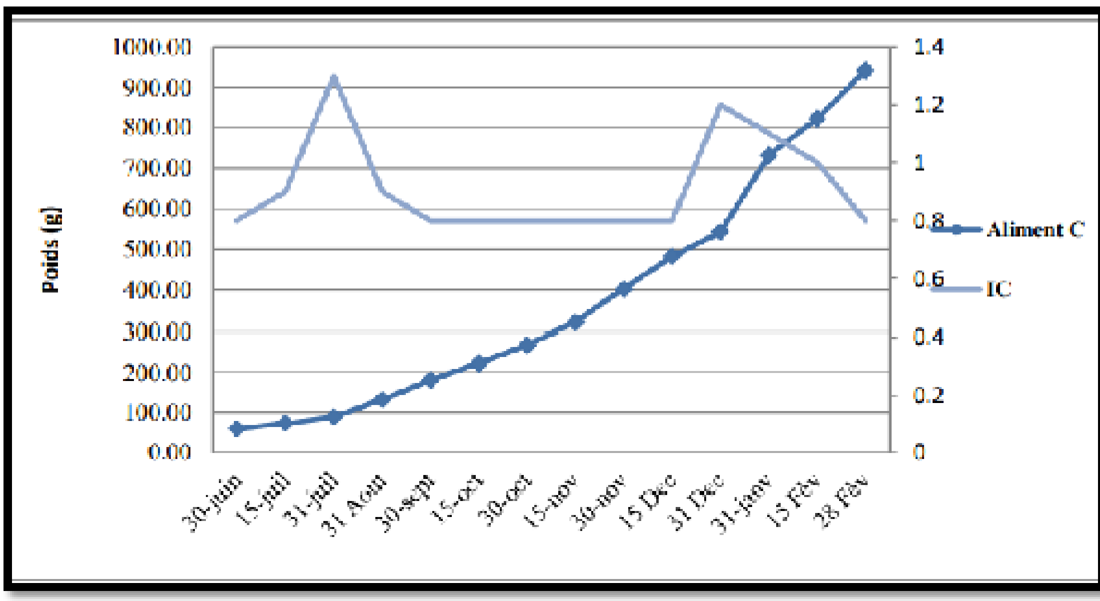

Fig. 3. Variation in the conversion index for feed C

DISCUSSION

In fish farming, achieving optimal growth, weight, and age is crucial for maximizing market value. Throughout the trial, the rainbow trout specimens were reared under ideal conditions, with temperature, dissolved oxygen, and pH levels meeting the established standards for optimal trout rearing **(Wedemeyer, 1996)**.

To determine the best feed for the rainbow trout, it's essential to assess their energy and protein requirements, which are critical for their growth and body composition **(Watanabe, 2002)**. The recommended digestible protein and energy requirements for the rainbow trout are 22-25% **(Cho, 1982; Cho & Kaushik, 1990; NRC, 1993; Higgs *et al.*, 1995)**.

In this study comparing three extruded feeds (A, B, and C), feed B showed the most significant growth across all rearing stages. Specifically, during the pre-fattening stage (40–100g), growth rates were as follows: Feed C = 132.68g, Feed A = 143.28g, and Feed B = 147.22g. This finding aligns with other studies showing that young fish exhibit greater relative body growth and have higher absolute protein requirements **(Robinson & Lovell, 1986; Xie *et al.*, 1997; NRC, 2011)**.

Contrary to some studies **(Xie *et al.*, 1997)**, our results indicate that Feed C, with its 46% protein level, was the least efficient for growth. This discrepancy may be due to the fact that excessively high protein levels in trout feed can lead to inefficiencies, as noted by **Luquet (1975)**. The digestibility of protein and its effectiveness are critical factors in feed performance.

Overall, extruded Feed B demonstrated superior zootechnical performance in all three rearing stages (40–100, 100–500, and 500–1000g) compared to feeds A and C. Feed B resulted in the highest average final weights, mean daily growth rates, and feed conversion efficiencies. This highlights the importance of iso-energetic diets in achieving effective feed conversion. The feed conversion index (IC) for Feed B was 0.9, comparable to values reported by **Brauge *et al.* (1994)**, **Azevedo *et al.* (2004)** and **Erik *et al*. (2007)**, who also found good growth and feed conversion efficiency with similar feed types. Additionally, it is known that phosphorus deficiency in the diet does not always affect growth and feed conversion **(Roy & Lall, 2003)**.

CONCLUSION

The study reveals that the extruded feed, distinguished by its high energy content, efficient digestibility, optimal digestible protein-to-digestible energy ratio, and non-protein energy levels, significantly enhances growth performance in the trout. Despite the higher cost of extruded feeds, their superior feed efficiency, better feed conversion, and reduced fish waste justify their use. These feeds contribute to more sustainable aquaculture practices by improving overall efficiency and reducing production costs. Effective feed formulation and technical expertise are crucial to maximizing these benefits in intensive fish farming.

REFERENCES

Azevedo, P.A.; Leeson, S.; Cho, C.Y. and Bureau, D.P. (2004). Growth, nitrogen and energy utilization of juveniles from four salmonid species: diet, species and size effects, "Aquaculture 234 **:** 393–414. https://doi.org/10.1016/j.aquaculture. 2004.01.004.

Bellet, R. (1977). Coefficient de transformation des aliments granules complets en salmoniculture.Pisc. Fr., 49:7-11.

Brauge, C.; Médale, F. and Corraze, G.(1994). Effect of dietary carbohydrate levels on growth, body composition and glycaemia in rainbow trout, Oncorhynchus mykiss, reared in seawater, "Aquaculture 123, 109–120. https://prodinra.inra.fr/record/115983.

Burel, C. and Médale, F. (2014). Protein source in animal feed. Guide d'utilisation des protéines d'origine végétale en aquaculture. OCL, Aquapole INRA. 21(4).

Cho, C.Y. (1992). Feeding systems for rainbow trout and other salmonids with reference to current estimates of energy and protein requirements. Aquaculture 100, 107–123.

Cho, C.Y and Kaushik, S.J. (1985). Effect of protein intake on metabolizable and net energy values of fish diets.In : Nutrition and feeding of Fish,, C.B. Cowey. A.M. Mackie and J.G Bell (Eds). Academic Press, London. Pp 95- 117.

Cho, C.Y and Kaushik, S.J. (1990). Nutritiona1 energetics in fish: Protein and energy utilization in rainbow trout, «In.' Aspects of food production, consumption and energy values (G.H. Boume, Ed). World Rev. Anim. Nutr., 61,132-172.

Erik, J.E.; David, A.H. and Anthony, P.F. (2007). Effect of iso-energetic diets with different protein lipid content on the growth performance and heat increment of rainbow trout, Aquaculture : 272 -723.

FAO. (2010). Gestion des pêches. 2. L'approche écosystémique des pêches. Les dimensions humaines de l'approche écosystémique des pêches. Directives techniques pour une pêche responsable n° 4, suppl. 2, Add. 2. Rome, 98 pp.

Higgs, D.A.; Macdonald, J.S.; Livings, C.D and Dosanjh,B. (1995). Nutrition and feeding habits in relation to life history stage". In: Groot, C., Margolis, L., Clarke, W.C. (Eds.), Physiological Ecology of Pacific Salmon. UBC Press, Vancouver, pp. 161–315.1995.

Kaushik, S.J. (2000). Feed formulation, diet development and feed technology. CIHEAM : 43-5.

Kolditz Catherine-Inès. (2008). Déterminisme nutritionnel et génétique de la teneur en lipides musculaires chez la truite arc-en-ciel (Oncorhynchus mykiss) : étude par analyse de l'expression de gènes candidats, du protéome et du transcriptome du foie et du muscle. école doctorale des sciences de la vie et de la santé, l'université bordeaux 1.

Le cren, E.D. (1977). The determination of the âge and growth of the Perch (Perçafluviatilis) from the opercular bone.J. An. Eco. 16, p.188-204.

Luquet, P. (1971). La Pisciculture française - 442 (11a) II trimester.

NRC. (1993). National Research Council. Nutrient requirements of fish. National Academy Press, Washington, DC, 114 pp.

NRC. (2011). National Research Council. Nutrient requirements of fish. National Academic Press, Washington, DC, 96 pp.

Robinson, E.H and Lovell, R.T. (1986). Nutrition and feeding of channel catfish (Revised). Southern Cooperative Series Bullettin. vol. 296. Southern Cooperative, USA. 56 pp

Roy, P.K. and Lall, S.P. (2003). Dietary phosphorus requirement of juvenile haddock (Melanogrammus aeglefinus L.). Aquaculture 221(1-4): 451-468.

Watanabe, T. (2002). Strategies for further development of aquatique feeds Fish,
" Sci., 68 : 242-52p. 2002.

Wedemeyer, G.A. (1996). Physiology of fish in intensive culture systems, " chapmanhall, london. UK.

Xie, S.Q.; Cui, Y.B.; Yang, Y.X and Liu, J.K. (1997). Effect of body size on growth and energy budget of Nile tilapia, Oreochromis niloticus. Aquaculture 157: 25-34.