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► **To cite this version:**

Inge Geurden, Peter Borchert, Mukundh Balasubramanian, J. Schrama, Mathilde Dupont-Nivet, et al.. Early-feeding exposure to a plant-based diet improves its future acceptance and utilization in rainbow trout. Larvi'13; Fish and Shellfish Larviculture Symposium, Sep 2013, Ghent, Belgium. pp.157-160. hal-01019221

HAL Id: hal-01019221

<https://hal.science/hal-01019221>

Submitted on 3 Jun 2020

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EARLY-FEEDING EXPOSURE TO A PLANT-BASED DIET IMPROVES ITS FUTURE ACCEPTANCE AND UTILIZATION IN RAINBOW TROUT

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Introduction

In mammals it is now widely accepted that early nutritional events may permanently alter the organism's physiology and metabolism in preparation for their predicted environment. If the prediction is correct, then the metabolism will be matched to the future nutritional environment, increasing its evolutionary fitness (Lucas et al., 1998; Gluckman and Hanson, 2008). In fish, only few studies explored the concept of early nutritional programming. These showed that early exposure to dietary factors such as high carbohydrate content (Geurden et al., 2007) or changes in fatty acid profile (Vagner et al., 2007) induced some persistent metabolic adaptations, at least at a molecular level. The present study explores the potential to improve, via early feed exposure, the poor growth response frequently seen in rainbow trout fed high levels of plant ingredients.

Materials and methods

Rainbow trout (*Oncorhynchus mykiss*) swim-up fry were fed for the first 3 weeks of exogenous feeding (see Fig. 1) either (i) with a plant-based diet (diet V) containing a blend of plant oils (palm, linseed, rapeseed) and plant-protein sources (wheat gluten, corn gluten, soybean meal, dehulled peas, white lupin) or (ii) with an isoproteic diet containing fishmeal and fish oil as sole protein and fat source (diet M). After a 7-month common rearing period on the control diet M, both groups (M- and V-fish) were challenged to feed the plant-based diet V (Fig. 1) during which voluntary feed intake (FI), growth, and nutrient utilization were monitored. We used three (isogenic) families of rainbow trout in order to test whether the potential early nutritional history effect is family-dependent.

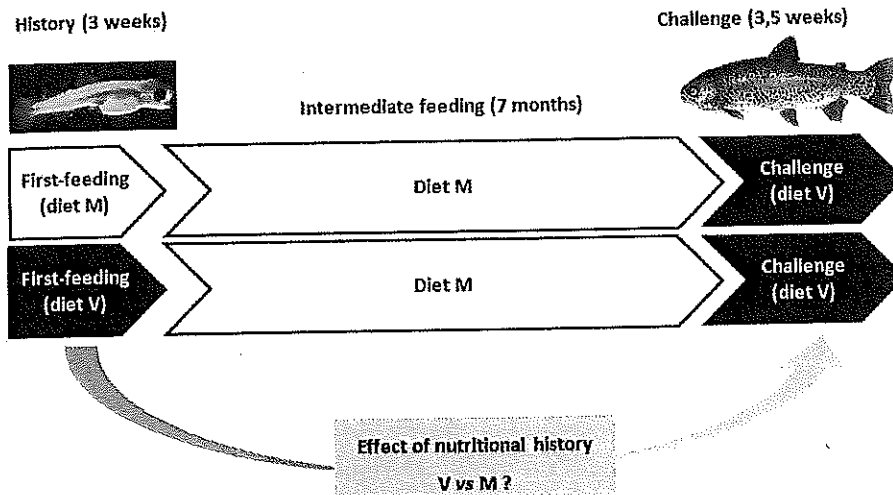


Fig. 1. Experimental feeding design

Results

The body weight (BW) of the trout at the end of the 3-wk first-feeding period was significantly affected by the diet (M-fish>V-fish). The body weight at the end of 7-month common M-rearing (start V-challenge, ~30-40g, data not shown) was not anymore affected by the nutritional history ($P>0.05$), but showed a significant family effect ($F1<F2<F3$).

The results of the V-challenge (averaged over the three families) show a 42% higher growth rate in trout juveniles of nutritional history V compared to M (Fig. 2A). FI drastically dropped in all groups challenged to eat diet V (data not shown). Key to the present study is the finding that voluntary FI was higher in V- compared to that in M-trout which had never been confronted before with diet V. This effect was more pronounced at the start of the challenge. Cumulated over the V-challenge and depending on the family, V-exposed fish consumed 20 to 70% more than M-fish (Fig. 2B). Besides the effects on FI, V-fish also utilized diet V more efficiently than M-fish, as reflected by the on average 18% higher feed efficiency (Fig. 2C). This was associated with better retention efficiencies for both lipid and protein being, averaged over the three families, respectively 36 and 11% higher in V- compared to M-fish. The positive effect of early V-history on later performances was consistent for all three families (no nutritional history x family interaction, $P>0.05$).

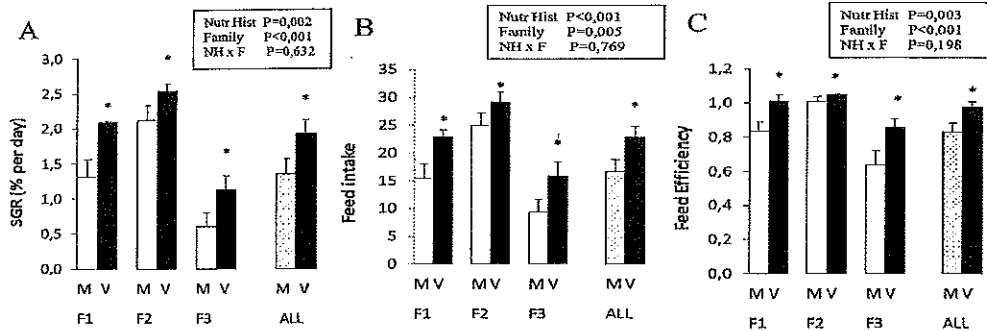


Fig. 2. A. Specific growth rate (SGR, %BW d⁻¹), B. Feed intake (mg kgBW^{-0.8} d⁻¹) and C. Feed efficiency (BW gain per dry matter intake) of the trout during the 25-day V-challenge according to early nutritional history (M or V) and family (F1, F2, F3). Values are means ±SE (n=4). ALL represent the effect of nutritional history (M or V) averaged over the three families. The significance of the main effects and interaction (2-way ANOVA) is added in the figure, * indicates a significant effect of nutritional history (V>M, p<0.05).

Discussion

The positive nutritional V-history effect on FI implies that the V-fish were able to 'recognize' diet V, and this almost 7 months after the early exposure. In mammals, early flavor experiences are important in establishing life-long food flavor acceptances (Beauchamp and Mennella, 2009). Knowledge on the development of flavor preferences in fish is scarce. Of specific interest, although not directly related with the development of later feed flavor acceptance, is the susceptibility of the salmonid olfactory system to imprinting, helping adult salmon to find their way back to the natal streams. L-amino acids, derived from a variety of living organisms in and near streams, have been suggested to function as guiding substances for salmonids homing (Shoji et al., 2003). In our study, specific compounds released in the water from diet V during the trout's early-life exposure perhaps provoked an olfactory imprinting responsible for the reduced neophobia and higher FI later in life.

Besides FI, also feed utilization efficiency was higher in V- relative to M-fish. Although actual FI was not monitored during the early feed exposure, it is likely that V-fry at early feeding consumed less than M-fry. In mammals, early-life exposure to a nutrient-limited environment has been reported program obesity and hyperphagia later in life (Gluckman and Hanson, 2008). We therefore conceived the possibility that a general early 'malnutrition' effect, resulting in overcompensation, might explain the superior FI and/or feed utilization of the V-fish during the V-challenge. However, no such effects were seen with diet M during the 7-month intermediate rearing. This finding points toward a directed diet V response in the juvenile V-fish rather than to an overall compensatory sign of malnutrition.

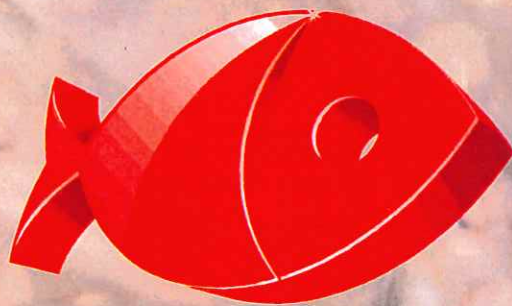
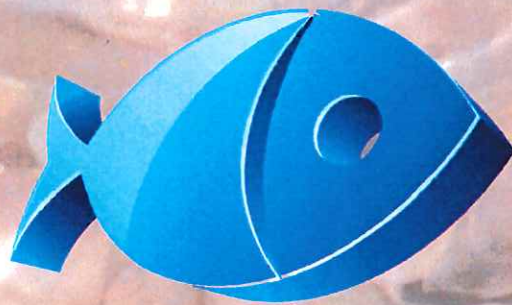
In summary, our study shows that an early short term exposure of trout fry to a plant based diet improves its acceptance and utilization when given later in life. Further studies need to evaluate the persistency of the observed effects and to determine the mechanisms which mediate the positive effects set by the early life diet V exposure.

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Larvi 2013

6th fish & shellfish larviculture symposium
september 2 - 5, 2013, ghent university, belgium



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