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ABSTRACT BOOK

PRESENTATIONS Category

A REVIEW OF ADVANCEMENTS IN *Hermetia illucens* PRODUCTION FOR DIETARY INCLUSION IN SALMONID FEEDS (*English*)

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There is global recognition that the development and growth of aquaculture is necessary to supply a growing shortfall in protein, specifically seafood protein. The production of salmonids, like many cultured finfish species, relies on fish meal, at least as a substantial protein source. Recently, alternative sources such as black soldier fly larvae (BSFL) have been investigated as a more environmentally sustainable option for dietary protein. In recent years, there have been significant advancements in BSFL production techniques to provide adequate nutritional value for animal feeds and ensure optimal digestibility and gut health of BSFL-fed species. Feeding trials with salmonids have shown that BSFL meal inclusion can be included in up to 100 g/kg of dry feed, while some studies have shown success at 300 g/kg BSFL meal. However, the production method of BSFL meal used in different feeding trials varies between studies, which can greatly affect the proximate composition of the meal and consequently on the results on growth performance, fish health, and tissue biochemical composition. This review summarizes the main findings on the advancement on BSFL production methods and their use in salmonid aquaculture and highlights the importance of BSFL rearing and processing on the outcome of a nutritious protein source for salmonids. Further research into idealistic rearing and processing procedures for BSFL destined for aquafeeds, and standardizing BSFL sourcing based upon these findings may help future feed trials create more comparable and consistent results. These results could also prove useful for determining BSFL inclusion levels in other cultured species, further pushing the aquaculture industry into a more sustainably sourced future.

APPARENT DIGESTIBILITY OF NUTRIENTS, ENERGY AND FATTY ACIDS OF ATLANTIC SALMON (*Salmo salar*) DIETS CONTAINING WHOLE-CELL *Schizochytrium* sp. BIOMASS (*Hart*)

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Finding alternative sources of protein and oil for salmonid aquafeeds that are nutritious, and economically and environmentally sustainable is critical to the expansion of aquaculture. *Schizochytrium* sp. (Sc) is a promising nutritious and sustainable source of protein and polyunsaturated fatty acids (PUFAs) in aquafeeds for carnivorous fish. This study investigated the apparent digestibility coefficients (ADCs) of PUFAs, macronutrients, other major fatty acids (FAs) and gross energy of Sc whole cells when included in diets for Atlantic salmon (*Salmo salar*).

Thirty fish (27.9±1g) were randomly allocated to eight-120L tanks and fed a reference or test (70% reference diet and 30% Sc biomass) diet. Fish feces were collected over three weeks by sedimentation using fecal collection columns. Fecal samples and diets were analyzed for biochemical and proximate composition and ADCs of dry matter, gross energy, macronutrients, and FAs were calculated.

ADCs of protein, lipid, and gross energy of Sc were 93.9%, 67.1% and 70% respectively (Table 1). Major FAs in the Sc ingredient were palmitic acid (44.7%% FAME), docosahexaenoic acid (33.2% FAME) and docosapentaenoic acid (10.1% FAME). SFAs and PUF

As in the test diet were 15% and 7.4% higher than the reference diet, which was reflective of Sc's FA composition. Dry matter, total lipid, gross energy and SFAs were significantly ($p<0.001$) more digestible in the reference diet. PUFAs and DHA were well digested (>95%) in both diets but significantly ($p=0.032$ and $p<0.001$, respectively) more digestible in the test diet. This study shows that whole cell Sc offers a source of highly digestible (98%) PUFAs and protein with no need for oil extraction or cell disruption.

Table 1. Apparent digestibility coefficients (% ± SD) of DM, macronutrients, energy and FAs from *Schizochytrium* biomass when fed to Atlantic salmon

	ADC (%)
Macronutrients	
DM	70.0 ± 3.8
Protein	93.9 ± 7.0
Lipid	67.1 ± 3.6
Gross energy (MJ/kg^{-1})	70.0 ± 2.7
Fatty acids (% of FAME)	
14:0	66.3 ± 10.7
16:0	56.9 ± 12.3
16:1n-7	91.9 ± 4.4
18:1n-9	96.1 ± 5.1
18:2n-6	97.7 ± 4.2
18:3n-3 (ALA)	97.9 ± 3.4
20:4n-6	99.4 ± 2.5
20:5n-3 (EPA)	98.8 ± 2.4
22:5n-6 (DPA)	96.4 ± 1.0
22:6n-3 (DHA)	98.9 ± 1.9
∑SFA	57.4 ± 12.2
∑MUFA	94.2 ± 5.9
∑PUFA	98.0 ± 1.2
∑n-3	97.8 ± 2.2
∑n-6	97.5 ± 1.5

THERMAL TOLERANCE OF MALE ATLANTIC SALMON (*Salmo salar*) BASED ON PHENOTYPIC STRESS COPING RESPONSE *(Ignatz)*

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Fish can be identified as either low responders (LR) or high responders (HR) based on whether they exhibit a proactive or reactive stress coping style, respectively. In this study, male Atlantic salmon (*Salmo salar*) of 17 genetic families reared at 9°C were repeatedly exposed to an acute handling stress over a period of four months, with plasma cortisol levels measured at 1 h post-stress. Fish were identified as either LR or HR if their cortisol concentrations consistently fell into the lower or upper quartile ranges, respectively; with intermediate responders (IR) classified as the remainder. The percentage of LR and HR fish varied considerably between families, with some families having no LR individuals. Salmon characterized as LR, IR or HR were then subjected to an incremental thermal challenge, where temperature was raised at 0.2°C day^{-1} from their acclimation temperature (12°C) to mimic natural sea-cage conditions during the summer/early fall in Newfoundland. Growth performance was also measured from 12-20°C, as well as in control fish that were kept at 12°C over the same period. Contrary to previous results, HR fish weighed more than LR fish when held at 12°C. However, no difference in weight gain was found between the groups warmed to 20°C. The temperature increase in the experimental tanks was then continued at 0.2°C day^{-1} to determine each fish's incremental thermal maximum (IT_{max}). In addition, after the first two mortalities were recorded (at 23.6°C), a subset of LR and HR salmon was exposed to another acute handling stress event. Basal and post-stress measurements of plasma cortisol, glucose and lactate did not differ between treatments at 23.6°C, and their average IT_{max} was 25.1°C. Finally, the critical thermal maximum (CT_{max}) of the remaining IR fish that had been held at 12°C was measured; this test, which was conducted at 2°C h^{-1}, is a measure of a fish's acute thermal tolerance. The CT_{max} of these fish was 28.5°C. Collectively, these results: 1) show that this population of Atlantic salmon is quite thermally tolerant, and further question the relevance of CT_{max} in assessing the thermal tolerance of sea-caged salmon; and 2) indicate that characterization of stress phenotype at low temperatures is not predictive of their stress response or survival at high temperatures. Therefore, the selection of fish based on this trait would not be beneficial to incorporate into Atlantic salmon breeding programs if the goal is to improve growth performance at high temperatures and upper thermal tolerance under culture conditions.

EVALUATION OF GENETICALLY ENGINEERED *Camelina sativa* OIL AS A SOURCE OF DIETARY LIPID FOR RAINBOW TROUT (*Oncorhynchus mykiss). (Osmond)*

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Farmed fish require a dietary source of eicosapentaenoic acid (EPA; 20:5n-3) and docosahexaenoic acid (DHA; 22:6n-3), typically supplied by fish oil. With increasing production demands on the aquaculture industry with the growing human population and the dependency on wild fish, the continued use of fish oil is both environmentally and economically unsustainable. As a sustainable alternative, the oilseed *Camelina sativa* was genetically engineered (GE) to produce EPA and DHA at levels similar to fish oil. The present study evaluated the effectiveness of GE Camelina oil as a sustainable source of EPA and DHA in aquafeeds as a dietary lipid replacement.

Three experimental diets were designed: a fish oil control (FO), a low-level transgenic camelina oil (LCO) and a high level transgenic camelina oil (HCO). Rainbow trout (initial weight 49.8 ± 11 g $fish^{-1}$) were fed diets for 12 weeks and growth performance, fatty acid content (muscle, liver, brain and eye tissue) and sensory properties of fillets were evaluated.

After 12 weeks, no significant differences were found in weight gain (127.5-146.9 g $fish^{-1}$) or feed conversion ratio (0.95-1.13 g $fish^{-}$) of fish among treatments. Significant differences were found in final weights of fish fed diets containing GE camelina oil (FO = 178.5 ± 30.7 g $fish^{-1.}$, LCO = 193.3 ± 25.0 g $fish^{-1}$, HCO =197.6 ± 25.0 g $fish^{-1}$; p = 0.001). Final lengths were significantly increased in fish fed GE camelina oil when compared to FO (FO = 23.5 ± 1.3 cm $fish^{-1}$; LCO = 23.9 ± 1.1 cm fish-^{1}; HCO = 24.2 ± 1.4 cm $fish^{-1}$; p = 0.008). Significant differences were noted in the fatty acid profiles of experimental diets and tissues. In the experimental diets, EPA and DHA content was higher in FO and HCO diets while Linoleic acid (LNA, 18:2n-6) and a-linolenic acid (ALA, 18:3n-3) was higher in LCO and HCO diets than in FO. EPA in muscle tissue was highest in fish fed HCO and FO diets in comparison to LCO. DHA stored in muscle tissue was significantly higher within fish fed FO and HCO diets. No significant differences were noted within EPA and DHA within brain tissue of rainbow trout. Orange intensity and firmness of trout fillets fed the HCO diet were increased in comparison to the FO control group, as determined by a qualitative sensory panel. Compound specific stable isotope analysis indicated that rainbow trout fed the FO diet stored isotopically enriched DHA compared to the lighter DHA in fish fed transgenic camelina. Our results indicate that genetically engineered *Camelina sativa* at a high inclusion is an effective substitute for FO as a dietary source of EPA and DHA in juvenile rainbow trout.

TRIPLOIDY IN *Mytilus Edulis* ENABLES BETTER ATTACHMENT *(Osterheld)*

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Abstract :

Weakened byssal threads may cause mussels to fall to the bottom where they lose any commercial value. Byssal weakening is particularly important following spawning events. Massive work has been devoted over the past few decades to the production of triploid bivalves, which are known to have a lower reproductive investment. In this study, we compared the byssal investment of triploid and diploid mussels as well as their energetic rates. To determine the effect of triploidy on byssal threads, diploid and triploid mussels were placed in a recirculating flume to induce production of byssal threads. The threads were then counted and collected for tensile testing. Results show that triploid mussels produced up to 40% more threads than diploid mussels. Further, tensile measurements indicated that the byssal threads from triploid mussels had a higher Young's modulus and elicited multiple yields. Energetic rates and metabolic investments were measured through oxygen consumption. Results show that triploids elicited higher scope for growth than diploids. Morphological comparisons also revealed differences between the two groups, with triploid mussels having larger shell than diploids of the same length.

BIOLOGICAL CONTROL OF PLANT PATHOGENS IN AQUAPONIC SYSTEMS: A THEMATIC REVIEW

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Aquaponics is a sustainable and efficient method of food production that combines recirculating aquaculture with hydroponic crop cultivation (Munguia-Fragozo et al. 2015; Somerville et al. 2014). Despite multiple production advantages, aquaponic systems are susceptible to contamination by a variety of pathogenic organisms, and effective plant disease control strategies are limited (Goddek et al. 2015; Mori and Smith 2019).

Biological control agents are prime candidates for use in aquaponic systems; genera such as *Pseudomonas, Bacillus, and Azospirillum* have received substantial attention over recent years. Multiple studies suggest that *Pseudomonas* species have strong potential as effective control agents for pathogens in aquaponic and recirculating-hydroponic systems; especially as direct antagonists against zoospore producing oomycetes (Hultberg et al. 2011). Early research regarding the efficacy of using *Bacillus* species in aquaponic systems has also been promising. The bacteria are thought to be endemic in aquaponic production systems (Sanchez et al. 2019), and inoculation of aquaponic biofilters with *Bacillus subtilis* and *Bacillus lichenformis* was found to have beneficial effects on multiple physiological parameters of aquaponically cultivated lettuce (da Silva Cerozi and Fitzsimmons 2016). One particular species of *Azospirillum, A. brasilense*, has been repeatedly demonstrated as positively impacting a variety of different vegetable crops grown in aquaponic production systems (Mangmang et al. 2015a; Mangmang et al. 2015b; Mangmang et al. 2016a; Mangmang et al. 2016b).

Progress has certainly been made in research regarding the practicality of using microbial biocontrol agents in aquaponic production, however, further studies are needed to determine the mechanisms of suppression used by specific biocontrol agents for direct antagonism of pathogens. Furthermore, in vitro studies that have identified potential control agents must progress to large-scale, in vivo experiments to investigate the efficacy of known antagonists against pathogens in functioning aquaponic production systems.

N-3 LC-PUFA synthesis in Landlocked salmon compared to farmed Atlantic salmon (*Zhang*)

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Farmed Atlantic salmon require 1-2% of n-3 long-chain polyunsaturated fatty acids (LC-PUFA) in their diet, which is mainly sourced by and fish oil (FO). Terrestrial plant oils have been used to replace FO; however, they do not supply LC-PUFA. Landlocked Atlantic salmon in freshwater may have a higher capacity for LC-PUFA biosynthesis compared with the commercial Saint John River (SJR) strain. This trait could be highly valuable as a genetic resource for the commercial strain to reduce FO as a source of LC-PUFA. The objective of this study is to determine if landlocked salmon have a higher capacity to synthesize LC-PUFA in the absence of dietary LC-PUFA. Salmon parr (58 g/fish initial weight) from Grand Lake (GL), Maine, US, and SJR were both fed FO control diet and FO-free diet for 16 weeks. Diet ($p>0.01$) and strain ($p<0.0001$) were significant factors in final weight and weight gain of salmon in the study; however, the interaction between diet and strain was not significant. SJR salmon gained significantly more weight than GL strain; both strains fed FO-free diets gained significantly more weight than FO-control diet. Liver fatty acid data suggests that diet is a more explanatory factor than strain; however, for many fatty acids such as total PUFA, total monounsaturated fatty acids, total n-3 PUFA, and 18:1n-9, 20:4n-6, 22:5n-6, 22:6n-3 , the interaction between diet and strain was significant. Principal coordinates ordination revealed strong separation in fatty acids due to diet, with n-3 LC-PUFA associated with salmon fed the FO-control diet. A permutational multivariate analysis of variance revealed that diet, strain and their interaction effects were significant factors in determining salmon liver fatty acid profiles.

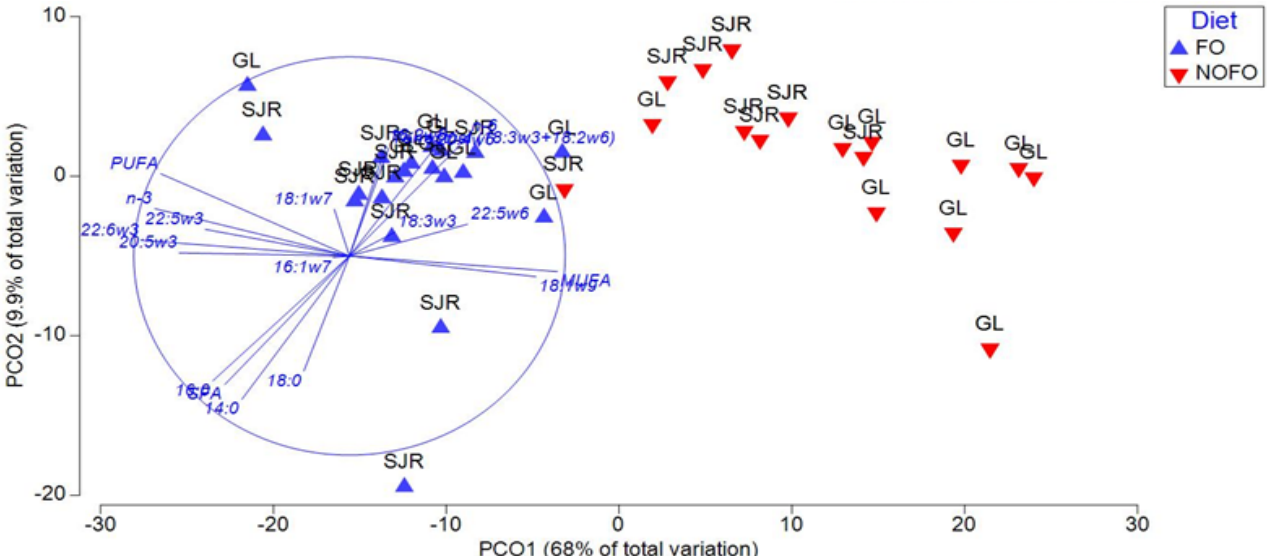

Figure 1. Principal coordinate ordination analysis of liver fatty acid profiles of Saint John River and Grand Lake salmon fed FO control and FO-free diets.