GROWTH AND TISSUE COMPOSITION OF ATLANTIC SALMON (*SALMO SALAR*) FED NOVEL ALTERNATIVE FEEDS REARED IN AQUACULTURE SETTING

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Introduction

One of the biggest challenges in aquaculture production is formulating feeds that are suitable for the species in terms of meeting nutritional requirements for optimal health and growth, while also being economically and sustainably productive

- Aquaculture production had increased 609% between 1990-2020 and is responsible for 56% of aquatic food available for direct human consumption[1]
  - Canada's largest aquaculture export is Atlantic salmon[2]

Aquafeeds

- Aquaculture feeds started with wild less marketable fish, but as the industry expanded, that caused a stress on fisheries[1]
  - Primarily fish meals (FM) and fish oils (FO)
- Declines in wild fish stocks let to an increase in plant-based sources for feeds, which is also unsustainable[3]

Alternative Feed Sources

- Black Solider Fly Larvae (BSFL)
  - High in protein (30-58%), with a similar amino acid profile as FM[3]
  - Consumes decaying matter, quickening nutrient cycles[3]
- Microalgae Biomass
  - High in DHA[4]
- Sustainable Fish Meal
  - Grown from aquaculture-agriculture co-cultivation practices[5]

Objectives

- Formulate aquaculture feeds for Atlantic salmon that contain alternative ingredients that are more environmentally sustainable than the current commercial standard feeds that are FM and FO based.
- Test the effectiveness of alternative feeds based on fish growth performance and tissue biochemical analysis

Hypothesis

Atlantic salmon fed with sustainable feed with have similar growth rates and tissue composition compared to those fed with industry standard

Methods

- 198 Atlantic salmon were randomly assigned among 9 circular tanks (22 fish per tank)
- After an acclimation period, all fish were PIT tagged
- Salmon were weaned onto one of three experimental diets over 6 days

Table 1 Composition of experimental diets and crude protein and lipid content.

Ingredients (%)	Diet 1	Diet 2	Diet 3
BSFL	0	20	20
Binder (Corey)	0.3	0	0
Binder (BSFL)	0	0.3	0
Pacu FM	0	12.5	12.5
Whole cell biomass	0	10	15
Standard fish meal	59.25	19.4	13.8
Fish oil	20.3	15.75	15.4
Ground wheat	17.4	19.3	2.5
Vitamin/mineral mix	0.25	0.25	0.25
Special premix (pigment)	2	2	2
Choline chloride	0.5	0.5	0.5
	100.0	100.0	100.0
Crude protein	40.0	40.0	40.0
Total fat	25.0	25.0	25.0

- Fish were hand fed the assigned diet daily until satiation, and feed consumption weights were recorded per tank
- 60 day grow out period
- Initial and final fork lengths and weights were recorded for all individuals
- 5 individuals from each tank were sampled for VSI, HSI, GSI, SSI and biochemical analysis of the tissues

Results

Table 2 Growth performance of Atlantic salmon (*Salmo salar*) fed experimental diets for 60 days

Parameters	Diet 1	Diet 2	Diet 3	P-value
Initial Weight (g)	2160.6 ± 286.9	2108.7 ± 254.3	2075.1 ± 262.3	0.218
Final Weight (g)	2131.8 ± 229.8	2119.6 ± 322.3	2024.2 ± 278.4	0.093
Weight Gain	28.8 ± 205.4	-10.9 ± 232.9	50.9 ± 146.3	0.198
Initial Length (cm)	54.7 ± 2.97	54.7 ± 2.56	54.1 ± 2.86	0.466
Final Length (cm)	55.4 ± 3.13	55.5 ± 2.63	54.9 ± 2.93	0.360
Initial Condition Factor (CF)	1.3 ± 0.18	1.3 ± 0.18	1.3 ± 0.17	0.675
Final Condition Factor (CF)	1.3 ± 0.17	1.2 ± 0.16	1.2 ± 0.17	0.685
Visceral Somatic Index (VSI)	11.3 ± 5.98	12.5 ± 8.69	11.3 ± 5.98	0.864
Hepatosomatic Index (HSI)	1.1 ± 0.29	1.1 ± 0.24	0.95 ± 0.15	0.415
Gonadosomatic Index (GSI)	3.89 ± 6.44	4.97 ± 10.44	3.96 ± 7.23	0.922
Spleen Somatic Index (SSI)	0.27 ± 0.12	0.29 ± 0.14	0.34 ± 0.11	0.294
Specific Growth Rate	-0.02 ± 0.044	0.009 ± 0.0222	-0.0407 ± 0.0332	0.277
Apparent Feed Intake	130.2 ± 56.8	174.0 ± 20.0	113.9 ±35.4	0.247
Feed Conversion Ratio	-0.45 ± 4.18	-2.15 ± 8.19	4.52 ± 4.87	0.422

- No significant differences were found between the diets for any of the growth performance measurements
- Some fish lost weight, with Diet 2 having average negative weight gain

Discussion

- The growth performance data supports the hypothesis
  - However, this could have been impacted by the limited feed intake and short study period as larger salmon have a slower growth rates
- The salmon ate less in experimental conditions than in the RAS system they were obtained from. Reasons for this could include:
  - Incomplete smoltification[6]
  - Did not enjoy feed (surviving on reserves, only eating if must)
  - Stressed due to different environment[7]
  - Energy reallocation due to sexual maturation[8]
    - About 20% were egg bound upon initial measurements
- Further biochemical analysis of the tissues could give more insight into growth performance and variation between diets

Conclusion

- No significant differences in growth performance between the diets could indicate that the alternative feeds are viable options to replace current FM and FO based aquafeeds
  - However, the results may be reflective of insufficient growth period and feed consumption

Next steps

- Recreating the study with longer grow out period
- Another study to look at full life cycle on alternative feed
- Increasing production and utilizing feed in aquaculture settings

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1 FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en
2 Fisheries and Oceans Canada [DFO]. (2017, Mar 15). *Farmed salmon*. https://www.dfo-mpo.gc.ca/aquaculture/sector-secteur/species-especes/salmon-saumon- eng.htm
3 English G, Wanger G, Colombo SM. 2021. A review of advancements in black solider fly (*Hermetia illucens*) production for dietary inclusion in salmonid feeds. Journal of Agriculture and Food Research. 5(100164): 1-9. doi.org/10.1016/j.jafr.2021.100164
4 Kobayashi T, Sakaguchi K, Matsuda T, Abe E, Hama Y, Hayashi M, Honda D, Okita Y, Sugimoto S, Okino N et al. 2011. Increase of Eicosapentaenoic Acid in Thraustochytrids through Thraustochytrid Ubiquitin Promoter-Driven Expression of a Fatty Acid 5 Desaturase Gene. Applied and Environmental Microbiology. 77(11): 3870-3876.
5 Ahmed N, Turchini GM. 2021. The evolution of the blue-green revolution of rice-fish cultivation for sustainable food production. 16:1375-1390 IGES. doi.org/10.1007/s11625- 021-00924-z
6 Björnsson B, Ogasawara T, Hirano T, Bolton JP, Bern HA. 1988. Elevated growth hormone levels in stunted Atlantic salmon, *Salmo salar*. Aquaculture. 73: 275-281.
7 Folkedal O, Torgersen T, Olsen RE, Fernö A, Nilsson J, Oppedal F, Stien LH, Kristiansen TS. 2012. Duration of effects of acute environmental changes on food anticipatory behaviour, feed intake, oxygen consumption and cortisol release in Atlantic salmon parr. Phys and Behaviour. 105: 283-291.
8 Kadri, S. Mitchell, DF, Metcalfe NB, Huntingford FA, Thorpe JE. 1996. Differential patterns of feeding and resource accumulation in maturing and immature Atlantic salmon (Salmo salar) Aquaculture. 142(3-4): 245-257.

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