Nofima
Norwegian Institute of Food, Fisheries and Aquaculture Research

BINDERS AND NOVEL INGREDIENTS IN ATLANTIC SALMON (*SALMO SALAR*) FEEDS TO MODULATE FECAL QUALITY FOR BETTER WATER QUALITY AND FECAL REMOVAL IN AQUACULTURE SYSTEMS

SIS-Feed Ctrl: A strategic project to understand the impact of ingredients in aquafeeds on fecal waste in Atlantic salmon

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Feed utilization and sludge properties

- Feed should be formulated for optimized nutrient utilization and minimized feed spill.
- Nofima have designed a device, **Spillbox**, that can separate spill feed and feces at the tank outlet, enabling better utilization of the resources.
- Feed ingredient for improved feces quality and sludge collection should be selected and included at levels favoring beneficial rheological and physicochemical properties without compromising nutritional value.

Binders in feeds for improved feed and fecal collection

- Ingredients with lower nutritional values, intended to act as binders, are added in the feeds to maintain strength during transport and feeding.
- Binders in RAS feed improve fecal collection but can lower digestibility.

Trial: Pellet quality, digestibility, and fecal collection efficiency in the Spillbox were studied in Atlantic salmon (30 fish, á 500g) fed either a control feed with 60% (FM) or 15% (PM) fishmeal , and in test-feeds with 2% binders added to the PM-feed.
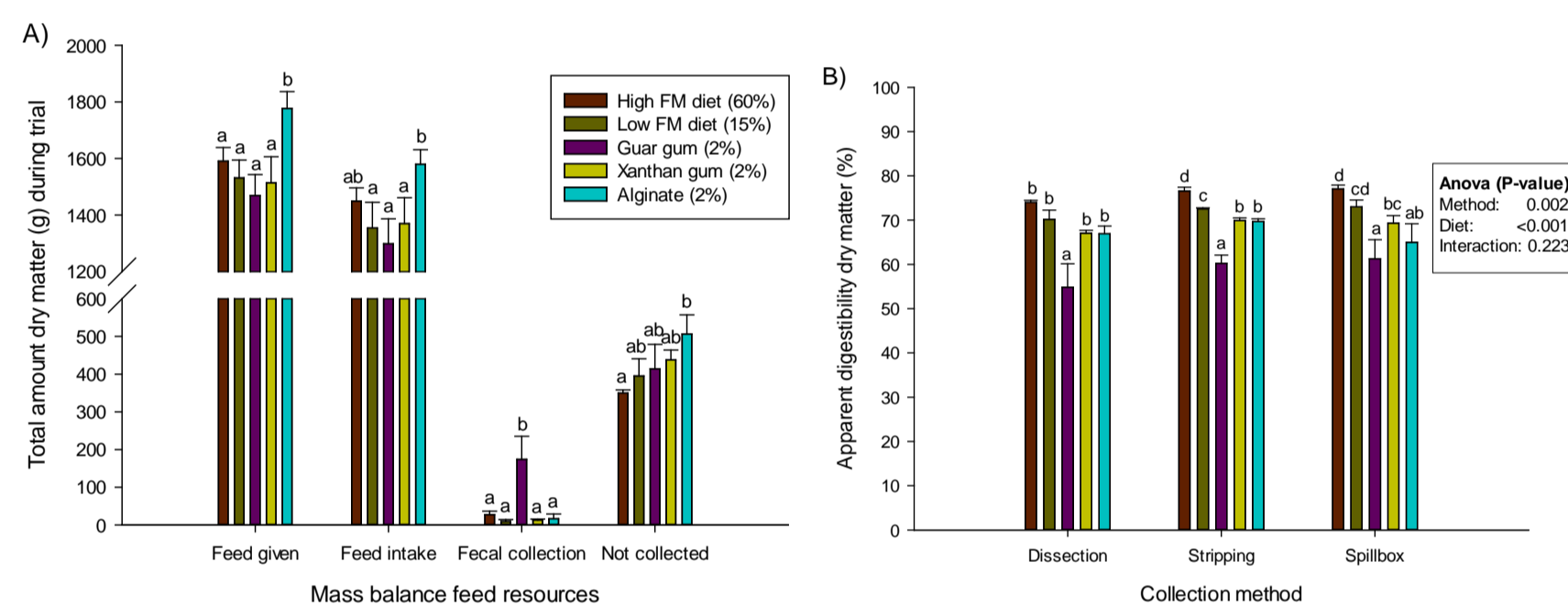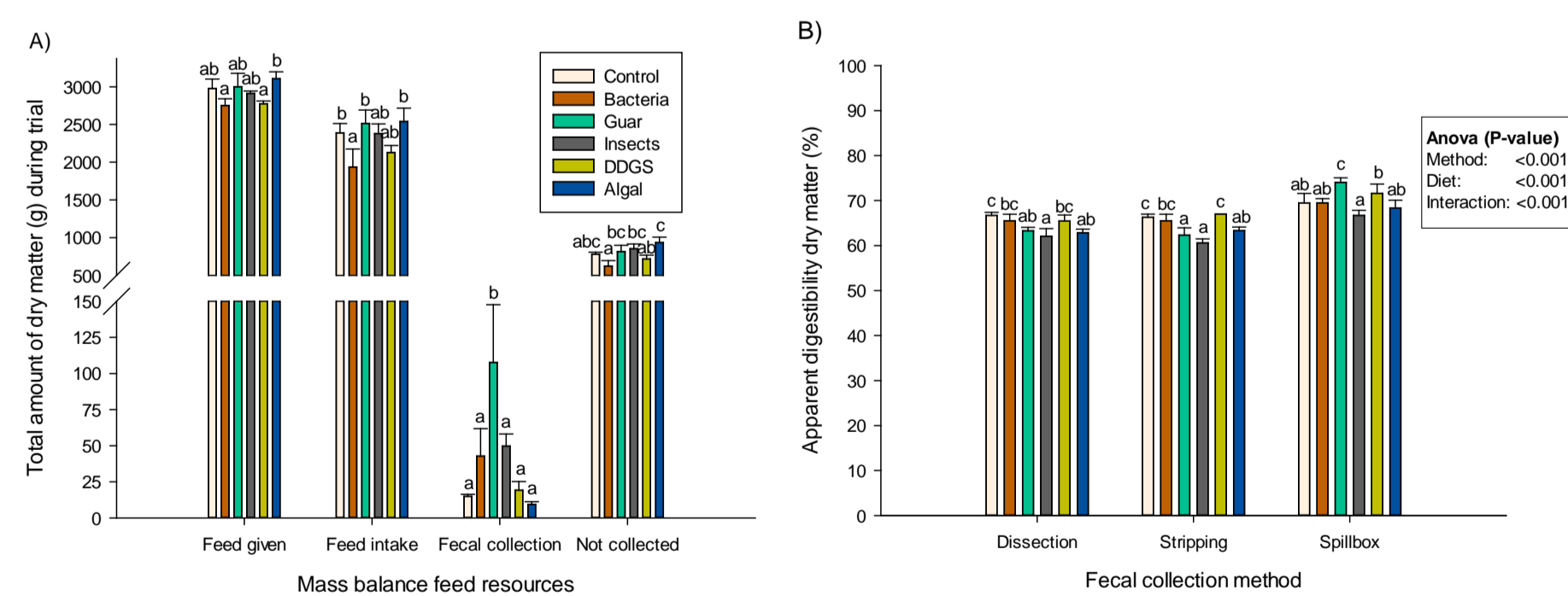

Results in figure 1. A) Mass balance in feed given, feed intake and fecal collection in 2-week trials shows higher feed intake with alginate and higher fecal collection with guar gum. **B)** Nutrient digestibility in fecal content from spillbox, stripped and dissected compared. Lower digestibility values observed with binders.

Proteins in feeds for improved fecal collection

- Protein ingredients with residues of starch or other indigested nutrients can have properties that improves fecal stability and collection efficiency.

Trial: Feed intake, digestion and fecal collection efficiency in the Spillbox were studied in Atlantic salmon fed a control (25% fishmeal) and test diets with 15% of either bacteria meal, guar meal, black soldier fly larvae meal (insects), algal meal or 8% distiller's dried grains with solubles (DDGS) in a 4-weeks trial.

Results in Figure 2. A) Mass balance in feed given, feed intake and fecal collection. Significant lower feed intake of fish given diets with 15% bacterial meal and higher fecal collection in spillbox connected to tanks with fish fed guar protein. **B)** Apparent digestibility of dry matter affected by collection method, i.e. spillbox overestimate digestibility (particullarily for guar protein feed), but significant lower digestibility of fish fed 15% insect meal compared to the other dietary groups similar for all collection methods.

Nofima Aquafeed Technology Centre, Bergen, Norway (https://aquafeed.science/)

Fish feed ingredients:
1. Tunicate meal
2. Feed pellets
3. Fish meal
4. Black soldier fly larvae
5. Microalgae
6. Seaweed meal
7. Feather meal
8. Krill meal
9. Yeast meal

Photo: Eivind Senneset   Photo: Helge Skodvin

Downstream processing of raw material to dry ingredient

Feed extrusion in pilot (200kg/h) and lab (10kg/h) scale

Analytical platforms:
- Rheological properties
- Pellet quality analysis
- Chemical analysis
- Chromatography

Photo: Eivind Senneset   Photo: Helge Skodvin

Fish trial research models are essential for ingredient selection for optimal feed conversion ratio (FCR) based on appetite stimulating properties, feed digestibility and nutritional composition for good growth.

Animation: Mount Visual

Research Station for Sustainable Aquaculture, Sunndalsøra (www.nofima.no)

The fish facility is divided into six halls with a total floor area of 6,500 m2, including 600 units for hatching and 1,000 fish tanks of various sizes.

Fresh water, seawater and recirculated water, can be used to carry out biological and technological experiments along the complete aquaculture value chain.

Spillbox: New research tool for separation of uneaten feed and fecal waste, enable mass balance calculation and digestibility analysis without handling the fish. In the scope for further developed to a commercial scale by Vard Aqua .

Photos: Kjell J. Merok   Photo: Pål Mugaas Jensen

Ingredients selection impacts fecal quality

- Guar gum and most likely residues of guar gum in guar meal have the largest impact on the indigested content for efficient fecal collection.
- However, relatively low fecal collection (1%-10%) was observed in the trials, with highest collection efficiency achieved by guar gum (12%), but at the expense of lower digestibility. Digestibility and fecal collection were not correlated to protein ingredients, which is important knowledge for the ingredients to be utilized and explored in future feed formulations.
- Ingredients can be selected in feed formulation both for digestibility and physicochemical properties, for a more sustainable use of feed resources in the future.

Feeds for water quality and environment

- Nitrogen and particles in the water are critical concerns in recirculating aquaculture systems (RAS). The selection of ingredients in feeds for RAS, for improved digestibility and efficient fecal collection, is important to prevent detrimental conditions that will negatively affect systems functioning and fish welfare.
- Improved feed digestibility appeared to be the most important factor for fecal load and collection efficiency in our trials. However, further studies on ingredient selection in diets with similar digestibility, for improved water quality and fecal collection efficiency in RAS, are needed.

Feeds for improved water quality in recirculating aquaculture systems (RAS)

- Feeds for fish in RAS should reduce fecal waste losses that could impact the water quality of the systems.

Trial: Water quality measures during a 4-weeks trial in single-RAS units with Atlantic salmon fed either a control feed with 60% (FM) or 25% (PM) fishmeal, and PM-feeds added 0.5% guar gum or 15% insects.

Results: Apparent digestibility of dry matter highest in FM feed (79%)>PM feed (75%)>Guar (73%)>Insects (72%). Solid waste collection through the drum filter was strongly correlated with feed digestibility (R=0.95, p<0.001), with the most being collected from the systems fed with insect meal. Although diet composition did change particle size and settling properties in fecal waste assays, this did not result in significant differences in turbidity or TSS in RAS.

Photos: Terje Aamodt