Filamentous Fungi as a Sustainable Ingredient for Fish Feed

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Thesis for the degree of Doctor of Philosophy at the University of Borås
to be publicly defended on February 23rd 2024, 10:00 a.m. in room C203
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Language: English

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Abstract

Limited feed ingredients hinder aquaculture's rapid growth. Current unsustainable fish feeding practices use ingredients like fishmeal and soybean meal, which could be directly consumed for as human food. This demands novel alternatives for fish nutrition. While studies have explored plant/animal-based protein sources, they have not fully met fish feed nutritional needs.

Single-cell proteins like bacteria, algae, and fungi are gaining attention as sustainable alternatives to traditional fish feed protein sources. Filamentous fungal biomass stands out with its high protein content, essential amino acids, and functional amino acids like lysine and arginine. This biomass also provides other nutrients that fish commonly require, such as essential fatty acids (linoleic acid, linolenic acid, arachidonic acid), minerals (phosphorus, potassium, calcium), vitamins (B, C, E), and pigments. Incorporating cell wall components like chitin, chitosan, and beta-glucans makes fungal biomass a functional feed ingredient that enhances fish immune systems. When applied to rainbow trout diets, fungal-based feed is highly digestible, comparable to fishmeal-based feed, and positively impacts gut microbiomes. The increase of lactic acid bacteria (*Lactococcus lactis*) after consuming fungal-based feed suggests its potential as a fish feed prebiotic.

While fungal biomass holds promise as a nutrient-rich fish feed source, its large-scale production on synthetic substrates poses economic challenges. To optimize production, organic-rich waste like Distiller's Dried Grains with Solubles (DDGS) and thin stillage from ethanol production are explored as substrates. Thin stillage, previously considered for fungal biomass production, faces difficulties due to its high solid content. Optimizing thin stillage's suspended solids for cultivating different filamentous fungi from Ascomycetes and Zygomycetes is necessary. Submerged cultivation of *Aspergillus oryzae*, *Rhizopus delemar*, and *Neurospora intermedia* was tested using various thin stillage dilutions. Cultivating these species in 75% diluted thin stillage yielded the highest biomass. The harvested fungal biomass contained around 50% protein and 45% essential amino acids, with ash content below 10%, enhancing fish digestibility. Notably, when 75% diluted thin stillage was used, the washing step could be skipped without compromising final biomass quality, streamlining production processes.

Using fungal-based feed in fish nutrition presents a sustainable alternative to traditional fishmeal-based feed. It goes beyond protein and amino acids, providing other essential nutrients such as fatty acids, minerals, pigments etc. High digestibility and positive effects on fish health through gut microbiome modulation make it a valuable substitute for common protein sources. To enhance sustainability, scaling up fungal biomass production using diluted thin stillage as a substrate is a promising avenue.

Keywords: compound feed; edible filamentous fungi; essential amino acids; low-value substrates; polyunsaturated fatty acids; protein sources; submerged cultivation, thin stillage