ALLIANCE™
(https://debug.globalseafood.org)

Responsible Seafood ADVOCATE

Aquafeeds

Shrimp feed sustainability conundrum: Fishmeal substitution

25 March 2019

By Wesley Malcorps and Roy D. Palmer, FAICD

Shift to plant ingredients brings concerns about land demands, nutrition

The sustainability of substituting fishmeal by plant ingredients should not be taken for granted, especially since aquaculture has been one of the fastest growing food sectors. Photo by Kurt Servin Arce.

The shrimp industry is one of the dominant consumers of fishmeal in the aquaculture sector and to meet demand for a growing industry in the face of a finite supply of marine ingredients, feed manufacturers have decreased the inclusion of fishmeal in most commercial diets.

Mainly driven by economic incentives, aquafeed is shifting to crop-based ingredients. Some consider this a sustainable transition, as it reduces the dependency on finite marine resources. However, a shift in ingredients could affect the nutritional value of shrimp and would shift resource demand from the oceans onto the land. Current knowledge suggests that aquaculture growth and its increasing demand for plant ingredients in aquafeed could affect agricultural supplyand its resources, such as land, freshwater and fertilizer. However, the quantitative impact is relatively unknown.

This issue demanded **a study** (https://www.mdpi.com/2071-1050/11/4/1212/htm) that has been carried out by a global group headed by Wesley Malcorps, Björn Kok and Simon J. Davies and which included Mike van't Land, Maarten Fritz, Davy van Doren, Kurt Servin, Paul van der Heijden, Neil A. Auchterlonie, Max Rietkerk, Maria J. Santos and Roy Palmer. The research has just been published in the journal *Sustainability* under the title "The Sustainability Conundrum of Fishmeal Substitution by Plant Ingredients in Shrimp Feeds" (https://doi.org/10.3390/su11041212 (https://doi.org/10.3390/su11041212)). The financial support from the University of Stirling regarding the Article Processing Charges (APC) made it possibly to publish this research open access and free for readers.

Seafood demand and supply

Firstly, it is imperative to note that global fish consumption per capita almost doubled from 9.96 kg in 1961 until 19.86 kg in 2013 and capture fisheries and aquaculture are becoming increasingly important contributors to the global food supply. Together both sectors produced in 2013 approximately 17.7

percent of the total 30 g capita^{-1} day^{-1} animal protein, which is more than poultry (17.4 percent), pig (15.7 percent), and bovine (12.0 percent).

In 2015, global per capita fish supply reached 20.2 kg, and an annual increase in fish consumption of 0.3 percent until 2030 is projected with a growing global middle-class (especially in Asia) increasing demand for high value species. In that same year, 59.9 percent of the global fish stocks were fully fished, while 33.1 percent of the global fish stocks experienced fishing at an unsustainable level. Since 2000, capture fisheries have been close to their production limits of 90 million metric tons (MT) annually. As a result, the aquaculture sector is growing faster than any other food-producing sector, and in 2016, aquaculture contributed to 46.8 percent of the global fish production.

Currently, more than 50 percent of the global shrimp supply originates from aquaculture with an estimated production volume between four and 5 million MT in 2015, making it one of the largest consumers of aquafeed and most valuable aquaculture production group. The shrimp industry, consequently, is one of the dominant consumers of fishmeal in the aquaculture sector and demands attention from feed manufacturers to find solutions.

Aquafeeds and fishmeal

To meet demand for a growing industry in the face of a finite supply of marine ingredients, as mentioned, has seen feed manufacturers decreasing the inclusion of fishmeal in commercial diets and shifting mainly towards crop-based ingredients. Of course, economic issues such as the relative price of fishmeal increases compared to common plant ingredients (e.g. soy protein concentrate, cereal, and wheat gluten) have come into the equation.

Fishmeal substitution by plant ingredients is mentioned as being environmentally sustainable, as it reduces dependency on finite marine resources. However, the nutritional requirements of certain aquatic species may limit the amount of fishmeal substitution due to the need of essential nutrients, which are variable or imbalanced in terrestrial plant ingredients.

Trade-offs between marine and terrestrial resources

Substituting fishmeal by plant ingredients would shift resource demand from the oceans onto the land, potentially adding pressure to the land-based food production systems, affecting the environment, biodiversity and availability and prices of crops. Additionally, it must be noted, that minor price changes could have significant impacts in developing countries (where much of aquaculture is based), as 50 percent of the household income is spent on food. A price increase of one percent could result in an estimated 16 million undernourished people.

These potential implications do not contribute to a sustainable diet as defined by the Food and Agriculture Organization (FAO), neither is it in line with the United Nations Sustainable Development Goals (SDGs) relating to food security, hunger reduction and protection of life on land and in the sea.

Although fishmeal can be used more strategically in various aquafeed formulations, there is a need for more innovation to optimize its value in relation to alternative ingredients (e.g. utilizing by-products, microbial biomass, algae, insect meals, etc). Photo by Kurt Servin Arce.

The sustainability conundrum and the challenge moving forward

In the study (https://www.mdpi.com/2071-1050/11/4/1212/htm) the natural resource demands were modelled of a transition to plant-based ingredients in shrimp feed formulations. Feed formulation algorithms were used to create unique feed formulations per shrimp species, with intermediate declining steps of 20 percent fishmeal substitution by plant ingredients while accounting for the dietary requirements of individual shrimp species. These diets were modelled in combination with a comprehensive multifactorial assessment of marine and terrestrial resource demand for agricultural crop production and processed ingredients. The model forming the basis of the group's investigation is available as an excel file in supplementary materials.

This results clearly demonstrated that complete fishmeal substitution by plant ingredients in this manner could lead to an increasing demand for freshwater (up to 63 percent), land (up to 81 percent), and phosphorus (up to 83 percent). These are significant increases when you consider that only a share (20 to 30 percent) of the feed is actually substituted. This is mainly caused by the inclusion of resource-intensive crops and their derived ingredients to meet nutritional requirements, such as soybean meal concentrate, rapeseed meal concentrate and pea protein concentrate.

While aquafeed consumes approximately 4 percent of the global feed crops and therefore consumes only a small share of the agricultural resources (such as water and land), a shift from fishmeal to plant ingredients should not be taken for granted as a sustainable solution to meeting a rapidly expanding (shrimp) aquaculture industry. The additional pressure on crucial terrestrial resources inflicted by the rapidly growing aquaculture sector may become more obvious over the next decades.

Although fishmeal can be used more strategically in various aquafeed formulations there is a need for more innovation to optimize its value in relation to alternative ingredients. Strategic management and utilization of fish byproducts shows potential for higher resource use efficiency of valuable marine resources. Additionally, improvement of feed conversion ratios, side streams up to 30 to 40 percent of the global food system, and novel protein sources might allow acceptable solutions to supplement high-quality fishmeal. This would enable the shrimp farming industry to operate and contribute in a sustainable manner to global food security and the economy, providing the much-needed high nutritionally valuable seafood.

This is a great challenge to all those involved in the aquaculture industry. We all know how much time, effort and research is going into the feed/nutrition area of the industry and how innovative and progressive the industry is in finding solutions and we look forward toreporting the successes in this area. Do not hesitate to let us know your ideas and solutions.

Authors

WESLEY MALCORPS

Ph.D. student
Institute of Aquaculture
University of Stirling
Stirling FK9 4LA, Scotland UK

ROY D. PALMER, FAICD

Corresponding author
GILLS
2312/80 Clarendon Street
Southbank VIC 3006 Australia
www.seafoodprofessionlas.org

palmerroyd@gmail.com (mailto:palmerroyd@gmail.com)