Brief for GSDR – 2016 Update

A Horizon Scan on Aquaculture 2015: Fish Feed

D. Schalekamp, K. van den Hill, Y. Huisman[1]*

Introduction

This brief outlines the future trends in fish feed use in aquaculture. Fish feed is important because of its high costs, the nutritional value for both the fish and humans consuming it, and the environmental impacts. Contemporary feed mainly consists of two types of resources: marine and terrestrial. However, an increased demand for fish species and more competition with other sectors limits the supply of conventional fish feed resources for aquaculture. These factors make that the industry is more and more looking for alternatives sources to provide the necessary nutrients. There are a lot of different alternative options, some of which are more promising than others, but it is likely that in the future multiple ingredients will be used for the formulation of feed pellets. Nevertheless, reliance on traditional sources will continue in the near future. These trends will lead to that the interlinkage between aquaculture, wild fisheries and agriculture will become more important. Important focal areas remain: guidance of small-scale farmers, communication along the value chain, responsible harvest of fishmeal and fish oil, and use of local feed ingredients. The rapid growth of modern aquaculture has mostly been due to the advances made in fish feeds [1] and its progress will be driving the expansion of the industry in the future [2,3]. Fish feed is very important for aquaculture production because it usually constitutes over 50% of the production costs and it has a significant impact on the quality, safety and nutritional value of farmed fish [4]. However, certain aspects of feed can cause environmental impacts such as nutrient runoff and overexploitation of resources [5,6]. Feed types can be divided into three groups: industrially compounded feeds, farm-made feeds and raw organisms. The total use of industrially compounded feed in the production of major species is estimated at 39.62 million tons [7], while the use of farm-made aqua feeds is estimated to be between 15 and 30 million tons, and direct use of raw organisms, mostly trash fish, is estimated to be between 3 and 6 million tons [8,9,10,11,12]. South American and European aquaculture facilities mostly use high-performance compounded feeds, while Asian aquaculture facilities still largely rely on trash fish and farm-made diets, Africa's aquaculture facilities mostly use locally made fishmeal [10].

[1] A collaboration between Wageningen University and Research Centre (WUR) and the State University of New York (SUNY) College of Environment Science and Forestry.

The main considerations for a farmer to decide upon the choice of feed are: feeding habit and market value of the produced species, the type of culture system used, the availability of a feed type on the market and personal financial resources [1,2].

State

Feeds are made up of approximately forty essential nutrients such as amino acids, vitamins, minerals, and fatty acids [13]. Contrary to people and livestock, fish species and shrimp do not require specific ingredients, however, their diets need to contain these vital nutrients [14]. The exact diet differs per fish type and species: Annex I contains a table that provides an overview of the differences in feed composition for different fish types. A part of the species produced in the aquaculture sector do not need external food supply [15,16]. For fed aquaculture species, the ingredients can be roughly divided into two categories: marine resources and terrestrial resources. Marine resources mainly consist of fishmeal and fish oil, as these provide the necessary energy inputs to achieve optimal growth [4]. Aquaculture is depended on wild fisheries for the production of fishmeal and fish oil: in 2012 16.3 Mt of fish landed by wild fisheries was used for this purpose [9]. Since production from wild fisheries is stagnating [17,18] and competition for fishmeal and fish oil by other sectors is increasing [19], fishmeal and fish oil are therefore only available in limited quantities. This is perceived as a threat to the growth of the aquaculture sector [20]. Despite often given less attention in the feed debate than fishmeal and fish oil, key terrestrial resources for feed include soybeans, maize and rice [21]. The availability of these terrestrial resources for feeds is jeopardized due to increased competition with the human food market and concerns about environmental degradation [21,22,23]. Key issues regarding the sustainability of these sources need to be solved in order to ensure a secure supply in the future.

TRENDS IN FISHMEAL AND FISH OIL

1. Higher demand for carnivorous species. Particularly rising income growth in emerging economies causes an increased demand for high-value, carnivorous species [21,22,23]. A growing production of mainly salmon and trout species results in a higher demand for fish oil, since these species consume approximately 62% of the fish oil supply available for aquaculture [24].

2. Improved efficiency and usage. The fish in fish out (FIFO) ratio has fallen well below 1.0 [25], and feed conversion rates (FCRs) have improved in recent decades as well [26]. FCR is estimated to decrease for many species between 2015 and 2025, albeit with small amounts [7]. In Annex II FIFO and FCR are explained.

3. Increasing competition for fish oil. There is growing demand for fish oil by the pharmaceutical industry to produced human nutritional supplements [24,27], leading to a higher price for the product.

4. Increased use of fish oil, but decrease use in fishmeal. The percentage of fish oil in feeds by weight is estimated to decrease from 2.7% to 1.3% between 2008 and 2020, but absolute amounts are estimated to increase from 0.8 Mt to 0.9 Mt. The total use of fishmeal is predicted to continue to decline: it decreased from 4.23 Mt in 2005 to 3.72 Mt in 2008 and is expected to lower to 3.49 Mt by 2020 [25].

5. Human concern about sustainability. Demand for fishmeal and fish oil will probably decrease in the long run due to human concern about the state of oceans and the desire of consumers to eat sustainable products [28]. By some the use of fishmeal and fish oil is considered unsustainable.

Feed production grew with 10.3% per year between 2000 and 2012 [7], but if the current growth rate is to be maintained in the future, the supply of nutrients and feed inputs will need to grow at a comparable rate [24]. Alternative fish feed sources are needed to allow the aquaculture industry to increase production in a way that does not put pressure on limited wild fisheries, maintains the human health benefits of seafood, minimizes negative environmental effects and is economically viable [13]. This policy brief will outline the key trends in fishmeal, fish oil and terrestrial resources, analyse the accompanying threats and opportunities, and investigate the possible use of alternatives that are necessary for a sustainable feed production.

Future Trends

Fishmeal and fish oil will stay important in future diets. However, the concerns about the sustainability of these ingredients and their growing prizes on the global market incentivize a more efficient use of these ingredients and the use of alternative feed sources [29,30]. Fish oil will remain a highly demanded ingredient in the foreseeable future [31], but competition from industries that are often more financially capable threatens its supply for the aquaculture industry [24,27]. The total use of fishmeal will likely decline due to increased competition with the human consumption market for raw fish and availability of alternatives that become more cost-effective [32,33]. Finite supply of fishmeal and fish oil may or may not become a major constraint to aquaculture development [16,20,34], but the stagnating production from wild fisheries [17] and growth of the aquaculture sector could lead to increased harvest of wild stock and unsustainable fishery practices [5,24].

The sustainability of the aquaculture sector is linked to the sustainable supply of terrestrial resources, since herbivorous and omnivorous species are still dominating the aquaculture sector [26]. A lot of terrestrial sources currently used in feeds, such as soybeans, maize, rice and wheat are also important for the terrestrial livestock industry and for direct human consumption [21]. Due to the

TRENDS IN TERRESTRIAL RESOURCES

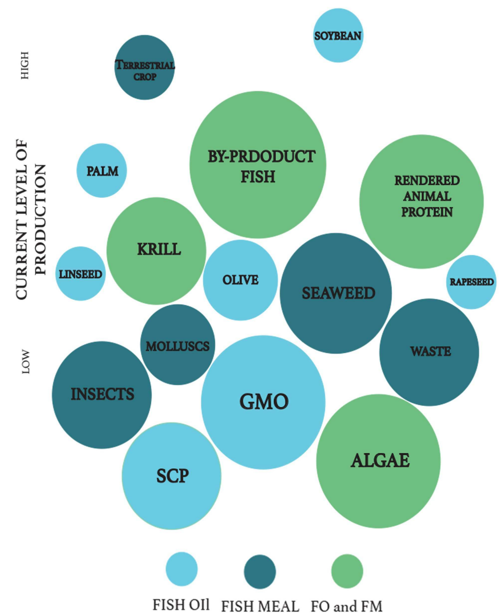
1. Higher demand for omnivorous and herbivorous species. Domination of low-value species in aquaculture will probably continue in the foreseeable future, causing an increase in demand for terrestrial resources [35].
2. Replacement of fishmeal by terrestrial resources. The reliance on fishmeal has been reduced with 15% for carnivorous species and the ingredient is continuously replaced by plant-based ingredients or other feed sources [25].
3. Increased use of plant and animal proteins and oils. There is higher usage of protein meals and oils derived from terrestrial animals or plants [19].
4. Increased competition. The scarcity of land and higher demands from the agriculture feed sector increase the competition for terrestrial resources [35].
5. Rising environmental concerns. Environmental concerns arise with the production of terrestrial ingredients, since they are associated with nutrient and chemical input use and loss, land clearing, high energy-dependency ratios, and greenhouse gas emissions [22, 23].

growing competition with these markets the price for these commodities has increased dramatically [36]. Especially for the availability of soybean this development is relevant, since this is the most common source of plant-based proteins in compound feeds [26].

Alternatives

Competition for fishmeal and fish oil, stagnating fisheries and environmental concerns have driven the fish feed industry to look for alternatives for both ingredients [27,37]. Figure 1 provides an overview of alternative ingredients for fishmeal and fish oil, visualised by current level of production and its promise.

In order to be a suitable alternative to fishmeal or fish oil, the alternative ingredient should possess similar nutritional properties. An alternative for fish oil should therefore contain sufficient levels of essential fatty acids [39], while fishmeal replacements should be a protein source that is digestible by the species for which the feed is meant [26,27]. However, not just the nutritional value of the alternative ingredients but also the sustainability of the ingredients production process should be taken into account. According to the triple bottom line theory the sustainability of a source is determined by whether in the long term its production will not have a negative impact on the environment, livelihoods and whether it is economically viable in the long term [39]. Increased use of an alternative source can have negative environmental impacts; particular concerns include deforestation and global water shortages [29]. There is a lack of knowledge about the potential impacts an increased production of alternatives sources could entail for both the environment and livelihoods.



These knowledge gaps make it difficult to determine the sustainability of certain alternative ingredients.

Perfect substiutes for fishmeal and fish oil have not yet been identified [39, 40]. There is not yet an alternative source known that both meets the nutritional and economical requirements [39]. Fishmeal is still an important ingredient in fish feed, in particular for marine and carnivorous species, while fish oil remains at this moment an irreplaceable ingredient in feed for all type of fish.

Formulate pelleted feed is becoming the most significant source of nutrition for farmed fish [41]. Pellets consist of a variety of ingredients that are pressed together. Even though there is not yet one alternative source that can completely substitute fishmeal or fish oil, it is likely that in the future the use of substitute ingredients for fish oil and fish meal in pellets will increase [40].

Figure 1 above shows an overview of feed sources that could potentially be an alternative for fish oil, fishmeal or both. Annexes III, IV and

V provide more tailed information on the alternative sources displayed in figure 1.

Prospects

Although aquaculture today is more sustainable than terrestrial animal production, there will be some key challenges in the production of fish feed. The growth in production of carnivorous, herbivorous, and omnivorous species will most likely put increased pressure on both marine and terrestrial feed resources, and competition from multiple sectors will probably drive up the price. The interlinkage between aquaculture, wild fisheries and agriculture is growing and these sectors will become more depended upon each other for future production. Research in the area of alternative lipid and protein sources in feed are promising and will trigger the shift from the dominant use of one ingredient, like fishmeal, towards multiple ingredients that can be formulated into feed pellets. Nevertheless, in the near future fishmeal and fish oil will remain important due to their unique nutritional properties, which influence growth and survival rates and the nutritional value of the final fish for human consumption [13].

- ***Communication along the value chain.*** Many consumers, producers, and purchasers remain unaware about the suitability and sustainability of alternative feed sources [25].
- ***Responsible harvest of fishmeal and fish oil.*** As long as fishmeal and fish oil is derived from sustainable fisheries, there is no problem with using it in fish feed [6]: any fishmeal and fish oil that comes from wild fisheries should be managed under the FAO Code of Conduct for Responsible Fisheries and countries should follow the guidelines on the use of wild fish as feed in aquaculture [26].
- ***Guidance small-scale farmers.*** Currently, little guidance is given to small-scale farmers to formulate and manage their feeds, while they still form the backbone of (especially Asian) aquaculture [26]. Farmers could be assisted to improve their feed formulation. This would reduce their production costs and minimise use of unnecessary feed additives and chemicals to reduce waste [19].
- ***Use of local feed ingredients.*** The use of local feed ingredients that are safe, nutritionally sound and sustainable, should be maximised to improve efficiency and reduce environmental impacts.

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