Precise selection of legumes for fish

Predicting the dietary performance of legumes

Katerina A. Moutou

Legumes Translated

Legumes are protein-rich crops that can be suitable ingredients for fish feed. Soybean meal has been widely used in fish feed formulations. However, the bioavailability of the legume protein varies between fish species. Moreover, legumes often contain anti-nutritional factors that impair digestion and phytoestrogens that might suppress growth. Suitable screening methods can determine the level and effect of these substances precisely and support informed choice of legumes for use in fish feed manufacturing.

Outcome

European finfish farming is a fast-growing business that requires large quantities of fish feed. Between 1995 and 2015, world-wide production of industrial aquaculture feed increased sixfold, from 8 to 48 million tonnes. Ensuring sufficient quantities of raw materials is vital to support this growth trajectory. Methods in place will help feed manufacturers to precisely select suitable legumes and their cultivars as raw materials establishing a solid value chain. Fish feed manufacturing could be a big client for European legume producers provided that the legumes fulfil certain requirements.

Legumes contain anti-nutritional factors

Grain legumes that are valuable protein and energy sources in fish feed produce and store protease inhibitors in their seeds. These are potent anti-nutritional factors in animals, including fish. The two predominant protease inhibitor groups in legume seeds are the Kunitz trypsin inhibitors (KTI) and Bowman–Birk protease inhibitors (BBI). KTIs and BBIs inhibit trypsin and chymotrypsin activity respectively, impairing protein digestibility and the bioavailability of amino acids. They can also severely affect pancreatic function.

Applicability

Theme: Alternative market

For: All legume growers and fish feed manufacturers

Where: Fish feed manufacturing

Timing: Post harvest

Equipment: Laboratory analysis

Follow-up: No follow-up action required

Impact: Increase sustainability of fish feed production; Lower the ecological footprint of aquaculture

Anti-nutritional factors usually exert increasing negative impact as their content increases. The effect of increased levels varies between fish species (Figure 1).

The legume cultivar and the cultivation parameters are also known to affect the content of anti-nutritional factors (Figure 2).

Microclimatic legume farming conditions appear to significantly influence the content of anti-nutritional factors.

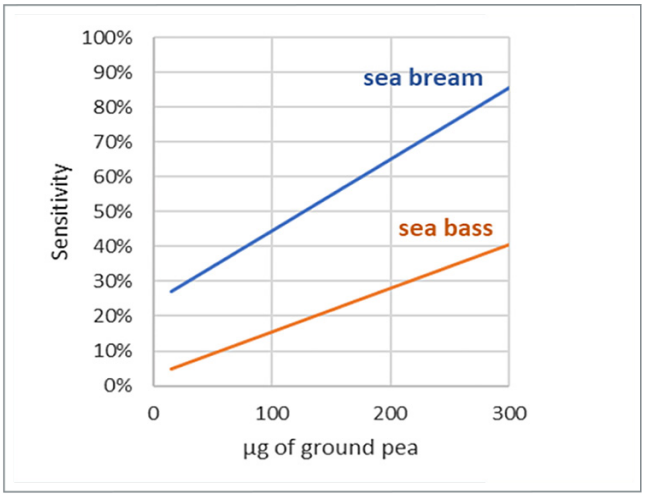

Figure 1. There are differences between fish species in sensitivity to legume anti-nutritional factors.

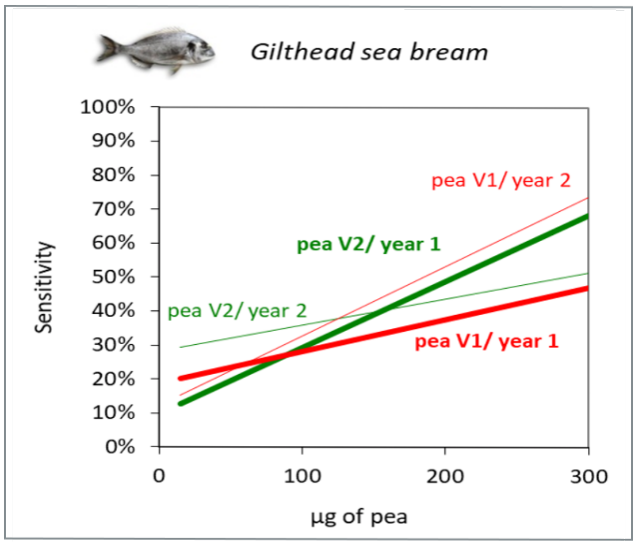

Figure 2. Two pea varieties (V1, V2) cultivated in the same location in two successive years (year 1, year 2) produced anti-nutritional factors with different inhibitory action against sea bream enzymes.

The concentration of anti-nutritional substances is determined indirectly through the inhibition of trypsin and chymotrypsin activity of the fish species of interest. A simple extraction protocol is used to isolate them from a specific quantity of ground legume seed. Subsequently, the extract is added to fish digestive enzyme preparations and the inhibition of trypsin or chymotrypsin activity is recorded. An established algorithm converts the level of inhibition into units/mg legume.

Legume digestibility is affected by many factors

Feed digestibility is the result of the interaction between the feed and the digestive enzymes and is affected by a series of factors. Digestibility in fish is affected by all biological factors that shape the activity of the digestive enzymes (fish species, developmental stage, size), by abiotic factors of the aquatic medium such as temperature and salinity, and by the intrinsic properties of the feed (Figure 3).

As soon as the feed reaches the water, it is attacked by water molecules and several hydrolysis reactions release nutrients that might be easily absorbed by the fish. The speed of this autohydrolysis is an important attribute determining nutrient bioavailability and totally depends upon the raw materials and the technology of formulation. The further hydrolysis reactions after ingestion that are facilitated by the presence of digestive enzymes make up the enzymatic digestibility. The total digestibility measurement is the sum of autohydrolysis and enzymatic digestibility (Figure 4).

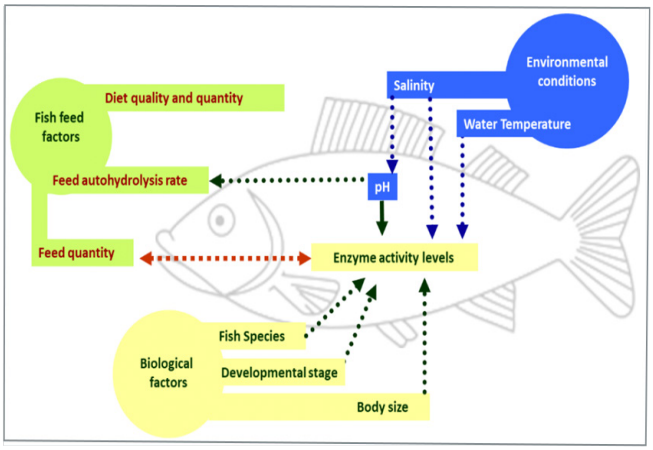

Figure 3. Feed digestibility is the result of the interaction between the feed and the digestive enzymes and it is affected by a series of factors.

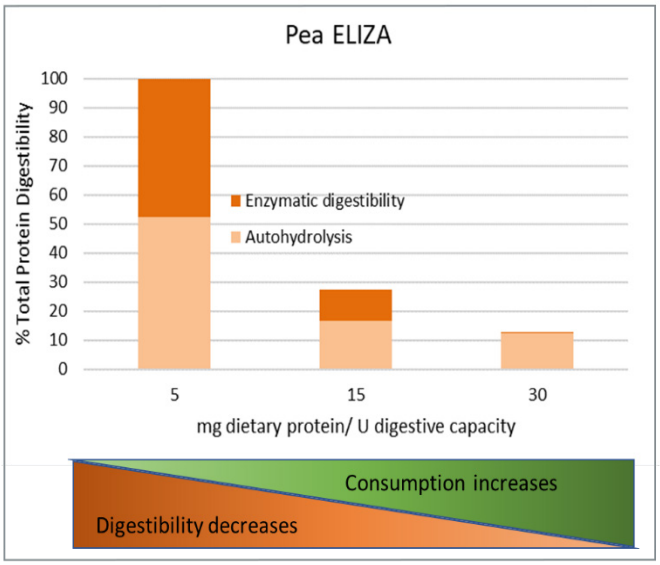

Figure 4. Autohydrolysis contributes to total digestibility. Both autohydrolysis and digestibility decrease with increasing legume quantities.

Different legumes exhibit different autohydrolysis rates as well as enzymatic digestibilities. Similarly, post-harvest processing affects protein digestibility and bioavailability. Dietary protein digestibility can be measured in vitro, in a set-up that simulates the conditions *in vivo.*

Key practice points

A key point for farmers and traders is that batches of the same grain legume species and even cultivars with the same basic nutritional characteristics vary greatly in their performance as fish feed. The technology described here allows easy assessment of the real feeding value potential of grain legume materials using biological laboratory-based techniques that simulate directly the digestive processes. This supports the precise benchmarking of legumes for use in fish feed that includes the determination of:

1. The content of anti-nutritional factors.
2. The autohydrolysis rate and the rate of enzymatic hydrolysis by digestive enzymes of the fish species in focus.
3. The rate of enzymatic hydrolysis by digestive enzymes of the fish species in focus.

Methodologies based on assays in vitro are used for the time- and cost-effective benchmarking. These methodologies are used to screen ground or processed legumes and fish feed including legumes and can be applied to any fish species of interest.

Further information

Zeytin-Schüning, S., Weiss, M. and Slater, M., 2019. Making aquafeeds more sustainable: Regional legumes for salmon aquafeeds. www.true-project.eu/2019/08/02/making-aquafeeds-more-sustainable-regional-legumes-for-salmon-aquafeeds/

ARRAINA (undated) ARRAINA Technical Booklets. https://arraina.eu/results/arraina-technical-booklets

TETHYS AQUACULTURE Optifeed Services. www.tethysaquaculture.com

Sources

Adamidou, S., Nengas, I., Grigorakis, K., Nikolopoulou, D. and Jauncey, K., 2011. Chemical composition and anti-nutritional factors of field peas (Pisum sativum), chickpeas (Cicer arietinum), and faba beans (Vicia faba) as affected by extrusion preconditioning and drying temperatures. Cereal Chemistry 88, 80-86.

Domoney C., 1999. Inhibitors of legume seeds. In: Shewry P.R., Casey R. (eds) Seed proteins. Springer, Dordrecht

FAO 2018. The State of World Fisheries and Aquaculture.

Moutou K.A., Boisot, P., Devresse, B. and Christofilogiannis, P., 2013. OptiFeed: An in vitro system for accurate prediction of biological larval performance. Hatchery Feed 1, 14-19.

Nikolopoulou, D., Grigorakis, K., Stasini, M., Alexis, M. and Iliadis, K., 2007. Differences in chemical composition of field pea (Pisum sativum) cultivars: Effects of cultivation area and year. Food Chemistry 103, 847-852

About this practice note and Legumes Translated

Authors: Katerina A. Moutou

Publisher: University of Thessaly

Production: Donau Soja

Permalink: www.zenodo.org/record/5667163

This practice note was prepared within the Legumes Translated project funded by the European Union through Horizon 2020, Project Grant Number 817634.

Citation: Moutou, K. A., 2021. Precise selection of legumes for fish. Legumes Translated Practice Note 32. University of Thessaly. www.legumestranslated.eu

This project is funded by the European Union

eip-agri AGRICULTURE & INNOVATION