Finding non-fish diets for prawns

Wendy Pyper finds that meat and lupin meals are showing promise as replacements for fish-based feeds in the aquaculture industry.

Aquaculture is the fastest expanding food producing sector in the world, with an annual growth rate of almost 12% a year since 1984.

This rate of expansion must continue if the supply of aquaculture species, such as prawns, silver perch and barrumundi, is to meet demand.

But there's a hitch. The production of one of aquaculture's most important feed ingredients – fishmeal – is expected to remain static or decline, as the wild fish stocks used to manufacture fishmeal struggle under the burden of heavy exploitation.

For the past 10 years, CSIRO Marine Research scientists have been looking for alternative high-protein feed ingredients to replace fishmeal in the diets of black tiger prawns (*Penaeus monodon*). Of about 28 ingredients evaluated, two show great promise: high quality meat meal and dehulled lupin meal.

Meat meal

According to project coordinator, Dr David Smith, for an ingredient to be considered suitable as a potential fishmeal replacement, it must be produced in significant and reliable quantities, and be relatively high in protein. Meat meal is one ingredient that fits that bill.

In a series of trials in the seawater laboratories at Cleveland, near Brisbane, Smith and his colleagues fed young (2–3 gram) prawns on various diets to see how well the prawns grew and survived. For the meat meal experiment, prawns were stocked in different tanks and fed either a reference diet of commercial feed, a standard fishmeal-based diet, or the experimental diet, with fishmeal replaced by regular increments of meat meal.

'The reference diet acts as our yardstick to see how well the prawns behave in the experiment, as sometimes you get good prawns and at other times you don't,' Smith says.

'Prawns fed the standard fishmeal diet are then compared with those fed on experimental diets containing different amounts of meat meal.'

After six or eight weeks on their allocated diet, the prawns' weight gain was measured. At the same time, the scientists measured the digestibility of the meat meal. Good digestion is important not only for the growth and health of the prawn, but also to limit the amount of waste produced, its impact on water quality, and production costs associated with cleaning up that waste.

An indigestible marker was included in the meat meal diets and then the faeces were collected from the bottom of each tank. The faeces were dried and weighed, and then analysed for protein, energy, total fat, individual amino acids and indigestible marker content. The digestibility of the meat meal was then determined by comparing the ratio of marker to nutrient in the feed and marker to nutrient in the faeces.

The scientists found that the growth and survival of prawns fed on diets where up to two-thirds of the protein came from meat meal, was not adversely effected. For good digestion, however, the meat meal had to be of a high quality, with high levels of protein, low levels of ash and moderate amounts of animal fat.

As prawns eat a low fat diet and require the omega-3 and omega-6 fatty acids found in fish oil, a delicate balance between the amount of animal fat and fish oil had to be maintained. Fishmeal and fish oil was also needed to maintain the palatability of the food.

'Prawn diets typically contain about 40% fishmeal protein, and we were able to replace two-thirds of that with meat meal protein,' Smith says.

Smith says high quality meat meal would be a viable alternative to fishmeal in

the diets of black tiger prawns. However the bovine spongiform encephalopathy outbreak in Europe and Japan means the ingredient cannot be used to feed prawns destined for these markets until the ban on meat meal is lifted and consumers are prepared to accept prawns fed diets containing meat meal.

'The European Union is now considering using meat meal from carcasses destined for human consumption. So if the Australian meat industry wants to capture the market, it may have to produce an aquaculture grade meat meal that meets this condition,' he says.

Sweet lupins

In the meantime, Smith and his colleagues have focussed their efforts on developing prawn feeds containing protein-rich ingredients of plant origin, such as lupin meal.

Australia is the world's largest producer of lupins, with more than one million tonnes produced annually across Western Australia, South Australia and Victoria. The legume is used in crop rotations to improve soil fertility, and the Australian sweet lupin or narrow leafed lupin (*Lupinus angustifolius*) is widely regarded as a quality feed amongst cattle, pig and poultry producers. A large international market, such as aquafeeds, however, would be a boon for Australian farmers.

As with meat meal, the scientists conducted growth and digestibility trials of dehulled lupin meal in their seawater laboratories. Whole lupins contain a lot of indigestible fibre, so dehulling is necessary to increase digestibility. Even so, dehulled lupins still contain approximately 40% fibre and are much lower in protein compared to fishmeal or meat meal.

The scientists found that they could replace about 40% of the fishmeal in the prawns' diet with lupin meal, but above that there was a decline in prawn growth by up to 30%. A number of hypotheses were proposed to explain this, and experiments to test each one began.

'A prawn farmer would be very concerned if his feed was reducing growth rates by as little as five percent, so we want to understand what's causing this decrease in performance and work out a way to offset it,' Smith says.

One hypothesis was that the fatty acids making up the oil in lupins could adversely alter the fatty acid profile of the feed. So the scientists removed the lupin oil from the lupin meal used in the feed, then added back either lupin or squid oil. The experiment showed that although the fatty acid profile of the feed was altered, it was not causing the decline in growth. Something else was going on.

Next, the scientists tested the effect of lupin fibre in the diet, by adding purified lupin fibre to the standard fishmeal diet. They found that the fibre decreased digestibility of the diet, but the prawns continued to grow at the same rate by eating more and, of course, producing more waste.

The research team is now looking at ways to test a third hypothesis relating to the deficiency in lupins of two essential amino acids, lysine and methionine.

In the pig and poultry industries, feeds are often supplemented with crystalline forms of these amino acids to offset any deficiencies. But in an aquaculture environment, the crystalline supplements leach rapidly from the feed pellets once they're immersed in water.

This leaching means that the scientists can't accurately measure the amount of supplementary amino acid consumed by the prawns, and hence, the precise effect of different concentrations of these supplements on growth. Methods of measuring these amino acids are being investigated.

The team is also investigating the presence of sugar molecules known as 'oligosaccharides', in lupin meal. These molecules are thought to interfere with digestion and metabolism.

Once the culprit is identified, the scientists hope to develop processing strategies that will enable lupin meal to replace three-quarters of the protein in the diets of black tiger prawns and other aquaculture species.

They may then be able to produce the evidence they want to convince feed manufacturers in Australia and South-East Asia that lupins are an attractive and viable replacement for fishmeal in prawn feeds.

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More about prawn feeds

Smith DM Allan GL Williams KC and Barlow CG (2001) Fishmeal replacement research for shrimp feeds in Australia. In: *The New Wave, Proceedings of the special session on sustainable shrimp culture, Aquaculture 2001*, pp 96–101. CL Browdy and DE Jory (Eds). The World Aquaculture Society, Baton Rouge, US.

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