Institution: University of Plymouth

Unit of Assessment: UoA6 Agriculture, Veterinary and Food Science

Title of case study: Legislative and industry impact of new ingredients for use in aquaculture feeds within the EU.

1. Summary of the impact

This case study concerns the impact of Plymouth University research relating to farmed fish diets, which led to changes to EU legislation with respect to two types of ingredients: animal proteins and probiotics. The impact of the reintroduction of certain animal proteins in farmed fish feeds (previously banned to protect human health) and to the authorization of a probiotic as a feed additive, involved industry investment in research, have reduced the environmental impact of farmed fishing, improved competitiveness, enhanced yield and quality and improved fish health and survival.

2. Underpinning research

This case study concerns research undertaken by the Fish Nutrition and Aquaculture Health Group at Plymouth University led by Professor Simon Davies (Lecturer in Aquaculture Nutrition 1986-2010, Professor 2008-present), and included Dr Daniel Merrifield (Research Associate 2009-2010, Research Fellow 2010-present), Dr Graham Bradley (Associate Professor in Microbiology 1986-2013), Dr Colin Munn (Associate Professor in Microbiology, 1974-present) Glenn Harper (Senior Technician 2005-present), Matthew Emery (Microbiology Technician 2008-present) and Ben Eynon (Aquarium Technician 2008-present).

Research relates to the safety and efficacy of species-specific, non-ruminant processed animal proteins (monoPAPs) the context of which arose from the BSE crisis and EU-wide legislation in 2001 to protect human health which banned the use of all processed animal proteins in the diets of animals and the concerns of the mode of action and effects on growth and fish health of inclusion of the probiotic *Pediococcus acidilactici* in the diets of farmed fish.

The negative economic, fish health and environmental consequences of these public and governmental concerns underlined the need to research the safety and efficacy of certain species-specific monoPAPS and probiotic organisms which had not previously been studied or fully characterised.

The research at Plymouth investigated fish health aspects of feed inclusion of monoPAPs in rainbow trout and digestibility aspects on salmonids (Owen *et al*. 2012), European sea bass, gilthead sea bream and turbot (Davies *et al*. 2009) and hybrid tilapia (Davies *et al*. 2011). The results of the research showed that monoPAPs from non-ruminant species could effectively and safely be incorporated in fish diets.

Growth promoting antibiotics (GPAs) in fish diets were banned in the EU in 2006 as a result of concerns about antibiotic resistance, implications for human health and negative environmental impacts. Their withdrawal was associated with deterioration in fish health, reduction in growth rates and productivity. However, the lactic acid bacterium *Pediococcus acidilactici MA18/5M* was authorized for inclusion in the diets of salmonids in 2009 but its mode of action was not clearly understood and additional research was required to provide the evidence base to present to the European Commission to support extended authorization for its use in aquafeeds for all fish species.

Four processes in the mode of action of *P. acidilactici* MA18/5M were investigated – 1. survivability in the gut (Merrifield *et. al.* 2010, 2011; Abid *et al*. 2012; Ferguson *et al*. 2010; and Merrifield et al. 2012); 2. effect on intestinal bacterial communities (Harper *et al.* 2011; Ferguson *et al*. 2010 and Merrifield *et al.* 2010 and 2012); 3. effect on gut integrity and nutrient uptake (Merrifield *et al.* 2010 and Abid *et al*. 2012); and 4. effect on the mucosal immune system (Ferguson *et al.* 2010, Merrifield *et al.* 2010 and Abid *et al*. 2012). The results provided key insights to underpin the impact in all four processes in the mode of action, clearly demonstrating

improvement in survival and in fish health.

3. References to the research (Plymouth authors in **bold**)

1. **Davies, S.J.** A.A. Abdel-Warith, A. Gouveia (2011) Digestibility characteristics of selected ingredients for developing bespoke diets for Nile tilapia culture in Europe and North America. *J. World Aquaculture Society*, 42: 388-398.
Peer reviewed journal with an impact factor of 0.708.

2. Davies, S.J., Gouveia, A., **Laporte, J.,** Woodgate, S.L., & Nates, S. (2009) Nutrient digestibility profile of premium (category III grade) animal protein by-products for temperate marine fish species (European sea bass, gilthead sea bream and turbot). *Aquaculture Research*. 40, 1759-1769.
Peer reviewed journal with an impact of factor 1.203.

3. Harper, G.M., Monfort, M., Saoud, I.P., **Emery, M., Mustafa, S., Rawling, M., Eynon, B., Davies, S.J. & Merrifield, D.L.** (2011) An ex vivo approach to studying the interactions of probiotic *Pediococcus acidilactici* MA18/5M and *Vibrio (Listonella) anguillarum* in the anterior intestine of rainbow trout *Oncorhynchus mykiss*. *J Aquac Res Development* S1:004. DOI:10.4172/2155-9546.S1-004.
Peer reviewed journal with an impact factor of 0.62

4. Ferguson, R.M.W., Merrifield, D.L., Harper, G.M., Rawling, M.D., Mustafa, S., Picchietti, S., Balcazar, J.L. and Davies, S.J. (2010). The effect *of Pediococcus acidilactici* MA18/5M on the gut microbiota and immune status of on-growing red tilapia *(Oreochromis niloticus). Journal of Applied Microbiology*, 109, 851-862.
Peer reviewed journal with impact factor of 2.337

5. Merrifield, D.L., Bradley, G., Harper, G.M., Baker, R.T.M., **Munn, C.B., Davies, S. J**. (2011). Assessment of the effects of vegetative and lyophilised *Pediococcus acidilactici* MA18/5M on growth, feed utilisation, intestinal colonisation and health parameters of rainbow trout (*Oncorhynchus mykiss Walbaum*). *Aqua. Nutr* 17, (1), 73-79.
DOI: 10.1111/j.1365- 2095.2009.00712.x.
Peer reviewed journal with impact factor of 2.179

6. Merrifield, D. L., Harper, G., Baker, R. T. M., Ringø, E., **Davies, S. J.,** (2010). Possible influence of probiotic adhesion to intestinal mucosa on the activity and morphology of rainbow trout (*Oncorhynchus mykiss*) enterocytes. *Aquacult. Res*. 41, (8), 1268-1272 DOI: 10.1111/j.1365 2109.2009.02397.x.
Peer reviewed journal with impact factor of 1.203

4. Details of the impact

The body of research undertaken at Plymouth University provided important components of scientific evidence leading to regulatory change at the EC level and involved significant industry investment in research and development leading to improved competitiveness of the EC aquaculture industry, a reduction in the environmental impact of fish farming and improved fish health and welfare.

New scientific information about the safety and efficacy of inclusion of monoPAPs in farmed fish diets was established, which led to regulatory change at the EC level (Regulation introduced Feb 2013), permitting re-authorization of the use of monoPAPs in aquaculture diets.

The Plymouth team worked closely with The European Fat Processors and Renderers Association (EFPRA) and this industry investment in research and development directly led to regulatory change. EFPRA Technical Director stated that "*I can say with certainty that the success of the programme to achieve re-authorisation of the use of these important resources could not have been completed without the scientific input from Professor Simon Davies and his team."*

As a result of this research, EU dependency on imported alternative protein sources for use in aquaculture feeds is now decreasing and there is a measured contribution to global food security by reducing seafood imports. The research has also contributed to the Common Fisheries Policy of aligning sustainable wild fisheries with sustainable aquaculture development.

The new legislation has been welcomed for its environmental impact; by using PAPs to provide feed for fish, the EU aquaculture industry's dependency on fishmeal and soya, which have high environmental costs, will be reduced. "*The production of soya meal requires vast areas of land, fertiliser and water and has to be transported great distances to reach European borders"* EFPRA *President Niels Leth Nielsen.*

The regulatory change means that competitiveness in world markets has been enhanced. It has been welcomed by countries across Europe. "*This measure paves the way for our EU aquaculture producers to step up their efforts to encourage the sustainable development of EU aquaculture by creating a level playing field with seafood imports from third countries*". "*The new measure contributes to global food security, by reducing the EU dependency on seafood imports which account for more than 70% of the current EU consumption*". FEFAC President Patrick Vanden Avenne.

The re-introduction of monoPAPs for fish is seen as the first step for a range of new policies in the EU. The EU (press release) has stated that the re-introduction of PAPs "*will improve the overall sustainability of the aquaculture sector, since these PAPs could be a valuable substitute for fishmeal, which is a scarce resource. Yesterday's measure is a first step as the Commission, subject to specific analytical tests, intends to propose a further measure to re-introduce the use of pig and poultry PAPs for poultry and pigs*." Europa press release Feb 2013.

The research on the inclusion of the probiotic *P. acidilactici* in fish diets was carried out in close collaboration with Lallemand SAS and enabled them to present new evidence to the EC. This is a Lallemand SAS probiotic and Lallemand SAS extensively cited the research undertaken at Plymouth in their successful submission to the EC. This industry investment in research and development resulted in *P. acidilactici* MA18/5M (Bactocell®) being authorized in 2012 as a zootechnical additive in aquatic diets for all fish species.

Dr Mathieux Castex of Lallemand SAS indicated that the *"scientific information and particularly the invaluable contribution from the University of Plymouth group allowed Lallemand to support several evidences to demonstrate and confirm the then proposed mode of action of P. acidilacitici MA 18/5M (Bactocell®) in fish"*

The authorization has impacted on the commercial success of global feed additive and aquaculture companies including Lallemand SAS and BioMar. BioMar's Research and Development Director stated that "*the research output of the Aquatic Animal Nutrition and Health Research Group was a significant component in the scientific data of the extension dossier".* There has been a considerable economic impact; BioMar has increased annual production of fish feed with Bactocell from 8000 tonnes of fish feed to 35,000 tonnes (NB figures in commercial confidence). BioMar's Technical Director also attributes improved fish welfare as a benefit of this research estimating that the cost of fish deformities to hatcheries in the Mediterranean area alone amounts to over 20 – 25 million EUR per year. He indicates that "*even a minor reduction in the number of deformities will mean an enormous economic saving in the hatcheries and a reduced workload.*"

5. Sources to corroborate the impact

1. EUROPEAN COMMISSION REGULATION - EC No 56/2013 of 16 January 2013 amending Annexes I and IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies. OJ: L: 2013: 021:0003. p3-16, and **News from the European Commission's Midday Briefing confirming the regulation,** February 14th 2013.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:021:0003:0016:EN:PDF

2. Statement from Technical Director, European Fat Processors and Renderers Association; Chief Executive, Foodchain & Biomass Renewables Association; Vice President, World Renderers Association. Confirming the central role of Plymouth University in providing the evidence base. http://europa.eu/rapid/midday-express-14-02-2013.htm

3. Press release from FEFAC (the European Compound Feed Manufacturers' Federation) on the impact of the authorisation of PAP for fish on global food security, sustainability and industry. http://www.fefac.eu/file.pdf?FileID=42891

4. Press release from European Fat Processors and Renderers Association on the environmental and nutritional impact of PAP. http://www.efpra.eu/Objects/3/Files/EFPRA_WELCOMES_VOTE_ON_PAP_IN_AQUAFEED.pdf

5. EUROPEAN COMMISSION IMPLEMENTING REGULATION - EC No 95/2013 of 1 February 2013 concerning the authorisation of a preparation of *Pediococcus acidilactici* CNCM MA 18/5M as a feed additive for all fish other than salmonids (holder of authorisation Lallemand SAS). OJ: L: 2013: 0033, 02.02.2013, Volume 56, p.19-20. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:033:FULL:EN:PDF Demonstrates that Lallemand SAS hold the authorization for the probiotic.

6. Statement from Product manager, Aquaculture and Yeast Derivatives, Lallemand SAS confirming the role of Plymouth University in providing scientific evidence which allowed them to get the probiotic authorized for the EU.

7. Lallemand's submission to the EU - *Pediococcus acidilactici* CNCM MA 18/5M "BACTOCELL PA"or "FERMAID PA". Application for the extension of the use of Bactocell (Fermaid) in Aquaculture (including all fish species). Annex 1 Scientific paper on the mode of action of Pediococcus acidilactici MA 18/5M in aquaculture

8. Statement from The Research and Development Director, BioMar on the impact on their feed production and the contribution of Plymouth research to the evidence. The BioMar group is one of the leading suppliers of high performance fish feed to the aquaculture industry.

9. BioMar press release estimating the cost of fish deformities to hatcheries in the Mediterranean http://www.biomar.com/Global/global%20press%20releases/AQUA%202012%20Probiotics%2020120906.pdf

10. BioMar press release announcing the launch of their products containing the probiotic and that demand from the market is so high they are almost fully booked with pre-orders. http://www.biomar.com/Global/global%20press%20releases/UK_BioMar%20Ready%20to%20fight%20deformities%2020120927.pdf