AQUAFEED HORIZONS ASIA
"OPTIMIZE FOR PROFIT"
March 3, 2010, QSNCC, Bangkok, Thailand

RENDERED PRODUCTS IN AQUAFEEDS – extended abstract

Geoff Allan and Mark Booth

Port Stephens Fisheries Institute, Locked Bag 1, Nelson Bay, New South Wales, 2315 Australia

Summary

Rendered animal protein sources, such as poultry offal meal, meat and bone meal and blood meal products are excellent protein sources with no carbohydrates and few anti-nutrients. Approximately 14 million tones of rendered animal meals are produced globally, more than twice as much as fishmeal. In this presentation, the role of aquafeeds in the rapid escalation of aquaculture production is documented, the importance of fishmeal and fish oil to aquafeeds and the urgent need to find additional protein and energy sources described, and research and experience with rendered products for a range of aquaculture species presented.

Aquaculture and aquafeed production

Production of aquaculture species was estimated by FAO (FAO 2007) as approximately 60 million tonnes in 2006, up from approximately 26 million tonnes in 1994. For species that consume feeds, production increased from 16 to 38 million tonnes (FAO FishStat, 2006 data). One of the major drivers for this rapid increase in aquaculture production is the increased use of and improved formulations for aquafeeds. Production of aquafeeds has increased from approximately 4 to 23 million tonnes from 1994 to 2006. One of the reasons for the success of aquafeeds is the reliance on fishmeal and fish oil as primary protein and energy sources. Use of these products in aquafeeds has increased at the expense of use in feeds for terrestrial animals and in 2006 it was estimated that 68.2 and 88.5% of global production of fishmeal and fish oil respectively were used in aquafeeds (Tacon, 2008). These outstanding, high quality products are very well utilised by aquaculture species and contribute to the very high quality of aquaculture products. Unfortunately, even assuming continuing long term sustainable production of fishmeal and fish oil, for aquaculture to continue to grow, additional protein and energy sources are needed.

In addition to use of fishmeal and fish oil in aquafeeds, low value fish are caught and fed directly to aquaculture species in many countries. Estimates are that up to 10 million tonnes of low value fish (=trash fish) are fed to aquaculture species in Asia.

Rendered animal protein meals

Rendered animal protein meals offer an additional protein and energy source for aquaculture species. Approximately 14 million tonnes are produced each year (Swisher, 2007), more then twice the production of fishmeal. There are a variety of product types including meat and bone meals, blood meals, poultry by-product meals and feather meals. These ingredients have low of zero anti-nutritional factors, they have little or no carbohydrate and are widely available. Gross nutrient value, amino acid composition and fatty acid composition are presented in Tables 1-3.

Use of rendered products by aquaculture species

Research over many years has demonstrated that rendered products are well digested and utilised for aquaculture species (e.g. Allan et al., 2000; Booth et al., 2005; Bureau et al., 2006; Davies et al., 1989, 1993; Stone et al., 2000; Sugiura et al., 1998; Watanabe et al., 1993; Williams et al., 1998). In this presentation, data for digestibility and utilization of rendered animal products for trout, red sea bream, tilapia, shrimp and mud crabs from numerous research studies will be summarized and the potential for use of rendered products discussed.

For trout, digestible protein (DP) and digestible energy (DE) for a range of rendered products were measured to estimate within ingredient variability. Values for DP and DE respectively were: bloodmeal 57-59% and 20-22 MJ/kg; meat and bone meal 44-50% and 13-17 MJ/kg; poultry by-product meal 59-60% and 17-19 MJ/kg; and feather meal 67-72% and 19-21 MJ/kg (Bureau et al., 1999). Other studies showed that up to 100% of fishmeal could be replaced with rendered products for trout provided amino acids were balanced to requirements and that high quality rendered products were used.

For red sea bream, DP and DE values for rendered products were: bloodmeal 82% and 20 MJ/kg; meat and bone meal 36-37% and 12 MJ/kg; poultry by-product meal 58-60% and 22 MJ/kg; and low ash bovine meal 78-82% and 23-26 MJ/kg (Booth et al., 2005). Rendered products were successfully used to replace 73% of fishmeal protein or 38% of the diet with no adverse effect on fish taste provided fish oil was used. Greater use was restricted by high saturated lipid content and high ash content of many rendered products.

Tilapia are omnivorous and are cultured in ponds, tanks and cages. Rendered products are well digested by tilapia and can replace 100% of the fishmeal in practical diets (Fasakin et al., 2005; Rodrigues Serna et al., 1996; Guimaraes et al., 2008).

For shrimp, up to 80% fishmeal replacement (30% of the diet) using high quality rendered products was successful. For shrimp, high lipid and ash content and low total protein content of some rendered products restricted greater use (Williams et al., 1997; Yu Yu, 2006, Cruz-Saurez et al., 2007). Limited research has been done with mud crabs but in one study rendered products were used successfully to

replace 40% of fishmeal. Poultry by-product was found to be an excellent and well accepted product (Richardson & Mather, 2008).

Cost:benefits

Using January 2010 data on feed ingredient prices, values for US$/kg crude protein for different ingredients were estimated (Table 4). These data show that protein price for rendered products ranged from US$0.73 – 0.84 compared with US$2.42 for fishmeal (65% CP) (Hammersmith Commodity prices 18 Jan 2010; http://hammersmithltd.blogspot.com/
**By-Product feed price listing Uni Missouri Extension 14 Jan 2010 http://agebb.missouri.edu/dairy/byprod/bplist.asp).

Conclusion

The data demonstrate that rendered animal meals can be excellent protein sources for aquaculture species, including carnivorous marine finfish. Substantial replacement of fishmeal is possible, particularly with blends of alternative protein sources based on rendered animal meals.

References

Allan, G.L., Parkinson, S., Booth, M.A., Stone, D.A.J., Rowland, S.J., Frances, J. & Warner-Smith, R. (2000) Replacement of fishmeal in diets for Australian silver perch, *Bidyanus bidyanus*: I. Digestibility of alternative ingredients. Aquaculture **186**:293-310.

Allan, G.L., Williams, K., Smith, D., Barlow, C. & Rowland, S. (1999) Fishmeal replacements for shrimp and fish feeds in Australia. Aquafeed International **4** 1999:10-16.

Booth, M.A., Allan, G.L. & Anderson, A.J. (2005) Investigation of the nutritional requirements of Australian snapper *Pagrus auratus* (Bloch & Schneider, 1801): apparent digestibility of protein and energy sources. Aquaculture Research **36**:378-390.

Booth, M.A., Allan, G.L., Fielder, D.S. & Anderson, A. (2008) Aquafin CRC Project 1B.3: Increasing the profitability of snapper farming by improving hatchery practices and diets Volume 1: Diet development. Final Report to Fisheries Research and Development Corporation Project no. 2001/208, 140 pp.

Bureau, D.P. (2006) Rendered products in fish aquaculture feeds. In: Meeker, D.L. (ed.), Essential Rendering. National Renderers Association, pp. 179-194.

Cheng, Z.J. & Hardy, R.W. (2002) Apparent digestibility coefficients of nutrients and nutritional value of poultry by-produce meals for rainbow trout *Oncorhynchus mykiss* measured *in vivo* using settlement. Journal of the World Aquaculture Society **33**(4):458-465.

Cruz-Suarez, L.E., Nieto-Lopez, M., Guajardo-Barbose, C., Tapia-Salazar, M., Scholz, U. & Ricque-Marie, D. (2007) Replacement of fish meal with poultry by-product

meal in practical diets for *Litopenaeus vannamei*, and digestibility of the tested ingredients and diets. Aquaculture **272**:466-476.

FAO (2007) The State of World Fisheries and Aquaculture 2006. FAO Fisheries and Aquaculture Department, Rome, Italy. 180 pp

Davies, S.J., Williamson, J., Robinson, M. & Bateson, R.I. (1989) Practical inclusion levels of common animal by-products in complete diets for tilapia (*Oreochromis mmossambicus*, Peters). In: M. Takeda & T. Watanabe (eds.) The Current Status of Fish Nutrition in Aquaculture. Tokyo Univ. Fisheries, Tokyo, Japan, pp. 325-332.

Davies, S.J., Nengas, I. & Alexis, M. (1993) Partial substitution of fish meal with different meat meal products in diets for sea bream (*Sparus aurata*). In: S.J. Kaushi & P. Luquet (eds.) Fish Nutrition in Practice. Coll. Les Colloques No. 61 INRA, Paris, pp. 908-911.

Fasakin, E.A., Serwata, R.D. & Davies, S.J. (2005) Comparative utilization of rendered animal derived products with or without composite mixture of soybean meal in hybrid tilapia (*Oreochromis niloticus x Oreochromis mossambicus*) diets. Aquaculture **249**:329-338.

Guimaraes, I.G., Pezzato, L.E. & Barros, M.M. (2008) Amino acid availability and protein digestibility of several protein sources for Nile tilapia, *Oreochromis niloticus*. Aquaculture Nutrition **14**:396-404.

Hunter, B.J., Allan, G.L. & Roberts, D.C.K. (2000) Meal meal replacement in diets for silver perch, *Bidyanus bidyanus*: effect on growth, protein and lipid composition. Journal of Applied Aquaculture **10**(3):51-67.

Li, M.H., Robinson, E.H. & Lim, C.E. (2008) Use of meatpacking by-products in fish diets. In: Alternative protein sources in aquaculture diets. The Haworth Press, pp. 95-117

Nengas, I., Alexis, M.N., Davies, S.J. & Petichakis, G. (1995) Investigation to determine digestibility coefficients of various raw materials in diets for hilthead sea bream, *Sparus auratus* L. Aquaculture Research **26**:185-194.

Richardson, N. & Mather, P. (2008). Assessing the potential for low cost formulated diets for mud crab aquaculture in Australia, Indonesia and Vietnam. Final report to Australian Centre for International Agricultural Research Project no. FIS/2000/065. ACIAR, Canberra, 57 pp.

Rodriguez-Serna, M., Olvera, M.A., Carmona-Osalde, C. (1996) Nutritional value of animal by-product meal in practice diets for Nile tilapia, *Oreochromis niloticus* fry. Aquaculture Research **27**:67-73.

Stone, D.A.J., Allan, G.L., Parkinson, S. & Rowland, S.J. (2000) Replacement of fishmeal in diets for Australian silver perch, *Bidyanus bidyanus*. III. Digestibility and growth using meat meal products. Aquaculture **186**:311-326.

Sugiura, S.H., Dong, F.M., Rathbone, C.K. & Hardy, R.W. (1998) Apparent protein digestibility and mineral availabilities in various feed ingredients for salmonid feeds. Aquaculture **159**:177-202.

Swisher, K.J. (2006) The global market and rendered products. In: Meeker, D.L. (ed.), Essential rendering. National Renderers Association, pp. 213-228.

Tacon, G.J. (2003) Global trends in aquaculture and compound aquafeed production – A review. International Aquafeed Directory 2003, pp. 9-23.

Tacon, G.J. (2008) Compound aqua feeds in a more competitive market: alternative protein sources for a more sustainable future. In: Cruz Suarez, E., Marie, D.R., Salazar, M.T., Opez, M.G. N., Villarreal Cavazos, D.A., Lazo y Ma, J.P., Viana T. Avances en Nutricion Acuicola IX. IX Simposio Internacional de Nutricion Acuicola 24-27 November, Universidad Autonoma de Nuevo Leon, Monterrey, Nuevo Leon, Mexico, pp. 1-5.

Watanabe, T.J., Pongmaneerat, J. & Sato, S. (1993) Replacement of fish meal by alternative protein sources in rainbow trout diets. Nippon Suisan Gakkaishi **57**:495-501.

Williams, K.C., Allan, G.L., Smith, D.M. & Barlow, C.G. (1998) Fishmeal replacement in aquaculture diets using rendered protein meals. In: Proceedings of Fourth International Symposium on Animal Nutrition, Protein, Fats and the Environment, 24-26 September 1997, Novotel Bayside Hotel, St Kilda, Melbourne, Australia. Australian Renderers' Association Inc, pp. 13-26.

Yamamoto, T., Shima, T., Furuita, H. & Suzuki, N. (2002) Influence of feeding diets with and without fish meal by hand and by self-feeders on feed intake, growth and nutrient utilization of juvenile rainbow trout (*Oncorhynchus mykiss*). Aquaculture **214**:289-305.

Yu Yu (2006) Rendered projects in shrimp aquaculture feeds. In: Meeker, D.C. (ed.), Essential rendering. National Renderers Association, pp. 195-211.

Yu Yu (2008) Replacement of fish meal with poultry by-product meal and hydrolysed feather meal in feeds for finfish. In: Alternative protein sources in aquaculture diets. The Haworth Press, pp. 51-93.

Table 1. Gross nutrient value of selected ingredients

Ingredient	Ash (%)	N (%)	Protein (%)	Fat (%)	GE (MJ/kg)
fish meal	14	11	68	10	20
blood meal	3	13	84	0	21
meat and bone	33	8	53	7	16
meat low ash	3	13	81	10	26
poultry meal	14	9	57	17	21
feather meal	3	12	74	10	22
soybean	8	7	45	3	16
lupin	3	5	32	5	17
field pea	3	4	24	1	16
cow pea	3	4	22	2	16
wheat gluten	1	12	72	0	22
corn gluten	1	9	58	0	22
wheat	1	2	11	2	17
sorghum	2	2	13	4	17

Table 2. Amino acid content relative to fishmeal for selected ingredients
(values underlined are first limiting amino acids for each ingredient)

Ingredient	Arg	His	Iso	Leu	Lys	Met	Phe	Thr	Val
fish meal	100	100	100	100	100	100	100	100	100
blood	48	170	<u>17</u>	148	90	47	151	106	148
meat	144	74	81	103	86	<u>64</u>	105	95	108
poultry	101	93	104	105	<u>83</u>	85	106	100	108
feather	92	39	110	111	29	<u>25</u>	118	104	149
soybean	100	89	111	106	83	<u>48</u>	130	91	103
lupin	173	94	96	102	56	<u>23</u>	104	87	80
field pea	141	83	100	97	88	<u>41</u>	119	68	101
cowpea	113	102	101	105	86	<u>54</u>	138	81	102
wheat glut.	66	95	114	129	<u>30</u>	63	180	86	110
corn glut.	40	53	97	229	<u>20</u>	82	154	72	94
wheat	82	84	99	119	<u>45</u>	92	141	83	112
sorghum	62	67	103	193	<u>29</u>	67	139	75	110

Table 3. Fatty acid composition of selected ingredients (value are % of total lipid)

		Lard	Palm	Rape	Soya	Olive	Lins	Herr	Anch
	16:00	26	61	5	11	14	7	13	17
	16:1n-7	3	tr	tr	tr	2	tr	7	9
	18:00	15	5	2	4	3	5	1	4
oleic	18:1n-9	49	26	60	22	69	18	10	12
linoleic	18:2n-6	9	7	21	54	12	17	1	1
linolenic	18:3n-3	tr	tr	10	8	1	54	1	1
	20:1n-9	tr	0	2	tr	tr	0	13	2
EPA	20:5n-3	0	0	0	0	0	0	6	17
	22:1n-9	0	0	1	tr	0	0	0	0
	22:1n-11	0	0	0	0	0	0	23	2
DHA	22:6n-3	0	0	0	0	0	0	6	9

Table 4. Cost per unit protein for fishmeal and selected rendered products

Ingredient	Crude protein (CP) (%)	Price (US$/t)	Price/unit protein ($/kg CP)
Fishmeal*	65	1570	2.42
Meat and bone meal*	50	380	0.76
Bloodmeal**	80	675	0.84
Poultry by-product meal*	60	440	0.73

*Hammersmith Commodity prices 18 Jan 2010
http://hammersmithltd.blogspot.com/
**By-Product feed price listing Uni Missouri Extension 14 Jan 2010
http://agebb.missouri.edu/dairy/byprod/bplist.asp