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Analysis of Traceability and Sustainability of Fish Meal and Fish Oil on Aquafeed Industry in Indonesia

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Abstract

Agung Sudaryono, Mahmud Hasan, and Candika Yusuf. 2013. Analysis of Traceability and Sustainability of Fish Meal and Fish Oil on Aquafeed Industry in Indonesia. *Aquacultura Indonesiana, 14 (3) : 135-148.* The artificial feeds or pellets turns out as important need in full filling the protein needs for fish or shrimp growth in semi-intensive and intensive aquaculture systems. One of the environment stressor factors on aquaculture is the process to full fill the protein source, the fish meal and oil, which act as the main components on pellets. The most possible impact to the environment which may occur is derived from unsustainable catch methods which may affect the fishes stocks. This study is aimed to discover the traceability and sustainability aspects of fish meal and oil in order to comply with global standards for responsible aquaculture such as the ASC (Aquaculture Stewardship Council) standards. The study used a descriptive analysis method by conducting the field survey and interview to collect the data. This study sistematically analyses and presents the facts obtained from the study in order to be understood and concluded easier. The aim of the descriptive study is to sistematically and accurately describe the facts. Data were collected from survey activities on 1) the five major compound aquafeeds manufacturers in Indonesia for shrimp in East Java and West Java Provinces, 2) fish meal and fish oil producers in Provincies of East Java and West Java, and 3) fish landing ports and fishermen to investigate the sustainability of fish meal and fish oil sources. The field survey activities were carried out based on the requirements and recommendations for the possibility of available environmental issues. In the process of collecting data, an intensive communication with the aquafeeds manufacturers and fish collectors/fishermen was conducted during the study. Estimated shrimp feed productions in Indonesia in 2010 and 2011 were reported similar approximately 250,000 mt/year. Fish meal sources used in compounded aquafeeds for shrimp from different shrimp feed manufacturers varied depending on the requirement levels of fish meal origin (imported fish meal or domistic fish meal). In general, the manufacturers more used the imported fish meal (54.6%) than the domistic one (45.4%). All imported fish meal used by the shrimp feedmills is from the same captured wild fish source (Peru origin; exclusively Peruvian anchovy, *Angraulis ringens*) completed by the certification of Global Aquaculture Practices (G.A.P). Similarly, on the other hand all domistic fish meal used by the shrimp feedmills is from the same captured wild fish source (Bali Bay–Banyuwangi origin; exclusively Bali sardine, *Sardinella longiceps*) with no G.A.P certification. Dietary fish meals for *Penaeus monodon* were higher (30%) than those for *Litopenaeus vanname* (20–25%). However, dietary fish oil for *Penaeus monodon* and *Litopenaeus vanname* were similar ranging from 1–3%. As the result, FFER (feed fish equivalence ratio) performances for *Penaeus monodon* were higher than those for *Litopenaeus vanname*. However, no difference was found between FCR (feed conversion ratio) performances for *Penaeus monodon* and *Litopenaeus vanname* with similar FCR values of 1.5–1.8. In conclusion, to sustain fish meal and fish oil availability for shrimp aquafeed industry in Indonesia for the future, efforts should be carried out on reduction of fish meal and fish oil inputs in feed, development of integrated farming system, promotion of environmentally sound aquaculture practices and resource management, and discovery of more alternative feedstuffs for fish meal and fish oil. More intensive collaborations between the government and the private sectors to this matter would safe and sustain shrimp aquaculture industry in Indonesia for the future.

Keywords: Fishmeal; Fish oil; Shrimp feed; Sustainability; Traceability

Introduction

Background of the Study

The worldwide decline of ocean fisheries stocks has provided momentum for rapid growth in shrimp farming. Between 2000 and 2009, global production of farmed shrimp more than doubled in weight and value, as did its contribution to world shrimp supplies (FAO, 2010). Fish produced from farming activities currently accounts for over onequarter of all fish directly consumed by humans. As the human population continues to expand beyond 7 billion, its reliance on farmed fish production as an important source of protein will also increase.

The finfish and crustacean aquaculture sector is still highly dependent upon marine capture fisheries for sourcing key dietary nutrient inputs, including fish meal and fish oil. This dependency is particularly strong within compound aquafeeds for farmed carnivorous finfish species and marine shrimp.

Shrimp aquaculture in Indonesia were started with traditional aquaculture system, whereas all of its practices had a highly dependency on the surrounding natural resources. In mid of 1980's, the product demand of shrimp from aquaculture sector were significantly increased thus affected the producers to raised its productivities. From that point, the aquaculture system has turned to be an intensive system whereas the nature could not provide supporting needs for traditional system any longer. The artificial feeds or pellets turns out as important need in full filling the protein needs for shrimp growth in semi-intensive and intensive aquaculture systems.

One of the environment stressor factors on aquaculture is the process to full fill the protein source, the fish meal and oil, which act as the main components on pellets. The fish meal and oil are generated from wild caught fishes. The most possible impact to the environment which may occur is derived from unsustainable catch methods which may affect the fishes stocks (Tacon and Metian, 2008).

The fish meal and oil percentages are varying between different pelleted feed products, as protein needs are also different between carnivorous and omnivorous fishes. This condition contributes on the fish resources exploitations level. The fish meal and oil products that have been used by pelleted feed manufactures in Indonesia are mostly imported and others are from domestic source.

This study is aimed to discover the traceability and sustainability aspects of fish meal and oil in order to comply with global standards for responsible aquaculture such as the ASC (Aquaculture Stewardship Council) standards. Output of the study was the recommendations on feed ingredients sustainability and activities which aquaculture farmers may implement in order to support the traceability issue.

Materials and Methods

The activities of the study consisted of data collection, field assessment as needed, data analysis, and recommendations for environmental issues. On data collection and field assessment process, it was needed to intensively communicate and coordinate with compound aquafeeds manufacturers and fish middlemen or fishermen.

The study used a descriptive analysis method by conducting the field survey and interview to collect the data. This study sistematically analyses and presents the facts obtained from the study in order to be understood and concluded easier (Azwar, 2001). The aim of the descriptive study is to sistematically and accurately describe the facts.

Data were collected through some activities such as survey on the five major shrimp aquafeeds manufacturers in Indonesia and survey on fish meal and fish oil producers in East Java and West Java Provinces. The collected data from survey on the five major shrimp aquafeeds manufacturers were fish meal and fish oil suppliers/producers, the feed specification, and percentage of fish meal and fish oil usage (%) in the feeds. Survey on fish meal and fish oil producers in Provincies of East Java and West Java was conducted to collect the information of origin fish sources, the kind of fish species caught and the fish seasons, and various relevant issues to traceability and sustainability of fish meal and fish oil productions.

In addition, another survey to get information on the sustainability of fish meal and fish oil sources such as fishing area management, types of fishing methods and fishing gears, possible by-catch products, and marketing chain from fishermen to fish meal producers was also conducted.

The field survey activities were carried out based on the requirements and recommendations for the possibility of available environmental issues. In the process of collecting data, an intensive communication with the aquafeeds manufacturers and fish collectors/fishermen was conducted during the study.

Results

Survey On Shrimp Aquafeed Industry

The present study attempts to analyse the use of fish meal and fish oil within industrially compounded aquafeeds for shrimp, including constraints and future prospects. The information contained in this analysis was obtained from the responses received from a field survey conducted to the 5 major shrimp aquafeeds manufacturers in Indonesia ie. PT. Central Proteinaprima (CP) Tbk., PT. Gold Coin (GC), PT. Matahari Sakti (MS), PT. CJ Feed (CJF), and PT. Suri Tani Pemuka (STP) between October 2011 and December 2011 by using an interview with the management.

Estimated national shrimp feed productions in 2010 and 2011 were reported similar approximately 250,000 mt/year (personal communication with Denny Indradjaja, the Chairman of Indonesian Aquaculture Feedmills Division). Based on the market share (%) of the national shrimp feed production, the biggest market share was from PT. Central Proteinaprima (60%) with approximately 150,000 mt/year, followed by PT Gold Coin (12%) with 30,000 mt/year, and the least producer was from PT. Suri Tani Pemuka (5.4%) with 13,500 mt/year. However, the rest of market share (6%) with approximately 15,000 mt/year were produced by other shrimp feedmills (see Table 1).

Fish meal sources used in compounded aquafeeds for shrimp from different shrimp feed manufacturers varied depending on the requirement levels of fish meal origin (imported fish meal or domistic fish meal). In general, the manufacturers more used the imported fish meal (54.6%) than the domistic one (45.4%). PT. Gold Coin was the only one that used the imported fish meal at the highest level of 98% and on the other hand, PT. Matahari Sakti and PT. Suri Tani Pemuka were the two lowest in using the imported fish meal (@50%) (Table 1). As can be seen in Table 1, all imported fish meal used by the shrimp feedmills is from the same captured wild fish source (Peru origin; exclusively Peruvian anchovy, *Angraulis ringens*) completed by the certification of Global G.A.P. Similarly, on the other hand all domistic fish meal used by the shrimp feedmills is from the same captured wild fish source (Bali Bay–Banyuwangi origin; exclusively Bali sardine, *Sardinella longiceps*) with no Global G.A.P certification.

Nutrition composition of compound shrimp feeds for penaeid shrimp species of *Litopenaeus vanname* and *Penaeus monodon* of the 5 major shrimp feedmills in Indonesia is presented in Table 2. Dietary protein requirements for *Litopenaeus vanname* (33–35%) were lower than those for *Penaeus monodon* (39–42%), whereas the other dieatary nutrition such as fat, fiber, ash, moisture were similar. In consequence, a higher dietary protein requirement will result in a higher dietary fish meal requirement.

Dietary fish meal and fish oil (%), feed fish equivalence ratio (FFER), and feed conversion ratio (FCR) for *Litopenaeus vanname* of the 5 major shrimp feedmills in Indonesia are presented in Table 3. Fish meal and fish oil usages (%) in compounded feeds for *Litopenaeus vanname* from different manufacturers were similar ranging from 20–25% for dietary fish meal and from 1–3% for dietary fish oil. Similar results were also shown for FFER (feed fish equivalence ratio) and FCR (feed conversion ratio) values of *Litopenaeus vanname* feeds produced by the different shrimp feedmills. The FFER and FCR values ranged from 1.4 to 2.1 and 1.4 to 1.8, respectively. Based on the data in Table 3, for example, the highest FFER of 2.1 indicates that 1 kg *Litopenaeus vanname* is equivalence to 2.1 kg wild fresh fish, Bali sardine (*Sardinella longiceps*) or Peruvian anchovy. The next is that 2.1 kg fresh fish can be made to produce 0.42 kg fish meal (20% conversion ratio). FCR 1.7 means that to produce 1 kg shrimp is required 1.7 kg shrimp feed. Similarly, the lowest FFER of 1.4 indicates that to produce 1 kg *Litopenaeus vanname* is required 1.4 kg wild fish and then 1.4 kg fresh fish can produce 0.28 kg fish meal (20% conversation ratio of fish to fish meal) with a FCR value of 1.4 (See Table 3).

Table 1. Estimated national shrimp feed production, market share and fish source (fishmeal) used in commercial shrimp feeds of the 5 major shrimp feed companies in Indonesia.

	Company	Estimated National Shrimp Feed Production / Market Share (%)	Fish Meal Source
1	PT. Central Proteinaprima (CP) Aquafeed Division Cikampek	60% = 0.6 x 250,000 mt = 150,000 mt/year	**Imported fish meal (70%)**: Peru origin, Peruvian Anchovy (*Angraulis ringens*). Global G.A.P certification **Domistic fish meal (30%)**: Bali Bay-Banyuwangi origin, Bali sardine (*Sardinella longiceps*). No Global G.A.P certification.
2	PT. Gold Coin (GC) Bekasi	12% = 0.12 x 250,000 mt = 30,000 mt/year	**Imported fish meal (98%)**: Peru origin, Peruvian Anchovy (*Angraulis ringens*). Global G.A.P certification **Domistic fish meal (2%)**: Bali Bay-Banyuwangi origin, Bali sardine (*Sardinella longiceps*). No Global G.A.P certification.
3	PT. Matahari Sakti (MS) Surabaya	9.6% = 0.096 x 250,000 mt = 24,000 mt/year	**Imported fish meal (50%)**: Peru origin, Peruvian Anchovy (*Angraulis ringens*). Global G.A.P certification **Domistic fish meal (50%)**: Bali Bay-Banyuwangi origin, Bali sardine (*Sardinella longiceps*). No Global G.A.P certification.
4	PT. CJ Feed (CJF) Jombang	7% = 0.07 x 250,000 mt = 17,500 mt/year	**Imported fish meal (75%)**: Peru origin, Peruvian Anchovy (*Angraulis ringens*). Global G.A.P certification **Domistic fish meal (25%)**: Bali Bay-Banyuwangi origin, Bali sardine (*Sardinella longiceps*). No Global G.A.P certification.
5	PT. Suri Tani Pemuka/ Comfeed (STP) Surabaya	5.4% = 0.054 x 250,000 mt = 13,500 mt/year	**Imported fish meal (50%)**: Peru origin, Peruvian Anchovy (*Angraulis ringens*). Global G.A.P certification **Domistic fish meal (50%)**: Bali Bay-Banyuwangi origin, Bali sardine (*Sardinella longiceps*). No Global G.A.P certification.

Source : Interview with the managements of the 5 major tilapia feedmills (CP, GC, MS, CJF, STP).

Table 2. Nutrition composition of compound shrimp feeds for *Litopenaeus vanname* and *Penaeus monodon* of the 5 major shrimp feedmills in Indonesia.

Feed Company	Shrimp	Nutrition				
		Protein (Min %)	Fat (Min %)	Fiber (Max %)	Ash (Max %)	Moisture (Max %)
PT.Central Proteinaprima	*L. vanname*	33–35	5	2	13	11
PT. Gold Coin	*L. vanname*	33–35	5	2	13	11
	P. monodon	39–42	5	2	13	11
PT. Matahari Sakti	*L. vanname*	33–35	5	2	13	11
	P. monodon	39–42	5	2	13	11
PT. CJ Feed	*L. vanname*	33–35	5	2	13	11
	P. monodon	39–42	5	2	13	11
PT. SuriTani Pemuka	*L. vanname*	33–35	5	2	13	11
	P. monodon	39–42	5	2	13	11

Source : Interview with the managements of the 5 major tilapia feedmills (CP, GC, MS, CJF, STP).

Table 4 shows dietary fishmeal and fish oil (%), feed fish equivalence ratio (FFER), and feed conversion ratio (FCR) for *Penaeus monodon* of the 5 major shrimp feedmills in Indonesia. Dietary fish meals for *Penaeus monodon* were higher (30%) than those for *Litopenaeus vanname* (20–25%). However, dietary fish oil for *Penaeus monodon* and *Litopenaeus vanname* were similar ranging from 1–3%. As the result, FFER performances for *Penaeus monodon* (2.25–2.7; Table 4) were higher than those for *Litopenaeus vanname* (1.4–2.1; Table 3). However, no difference was found between FCR performances for *Penaeus monodon* and *Litopenaeus vanname* with similar FCR values of 1.5–1.8.

Traceability of raw materials (fish meal) in compounded shrimp feeds is presented in Table 5. Present status of traceability of fish meal with regard to country and species of origin, as demonstrated by the feed manufacturers, was 68.6% imported fish meal from Peru origin, Peruvian anchovy (*Angraulis ringens*) and 31.4% domistic fish meal from Bali Bay-Banyuwangi origin, Bali sardine (*Sardinella longiceps*). List of all dietary major feed ingredients present in a proportion of > 1% is fish meal, soybean meal, shrimp waste meal, meat and bone meal (MBM), corn meal, fish oil, and squid meal. All the imported major feed ingredients used in the shrimp feeds is from responsible sources and internationally recognized due to the feed ingredients already have Global G.A.P certification (Table 5). However, all local fish meal and fish oil used in shrimp feeds has not been certified yet. Local fish oil products used in the feeds are very limited due to unregular availability in quantity and quality (Table 6).

Table 3. Dietary fish meal and fish oil (%), feed fish equivalence ratio (FFER), and feed conversion ratio (FCR) for *Litopenaeus vanname* of the 5 major shrimp feedmills in Indonesia.

Company	Dietary fishmeal (%)	Dietary fish oil (%)	FFER*	FCR
PT. Central Proteinaprima (CP) Aquafeed Division, Cikampek	20	1	1.6 : 1	1.6
PT. Gold Coin (GC) Bekasi	20–25	1–1.5	1.5–2.1: 1	1.5–1.7
PT. Matahari Sakti (MS) Surabaya	20–25	2–3	1.5–1.88 : 1	1.5
PT. CJ Feed (CJF) Jombang	20	2	1.4–1.8 : 1	1.4–1.8
PT. Suri Tani Pemuka/ Comfeed (STP), Surabaya	20	1	1.7 : 1	1.7
	Mean = 21%	Mean = 1.6%	Mean = 2.9:1	Mean: 1.6

Source : Interview with the managements of the 5 major tilapia feedmills (CP, GC, MS, CJF, STP).

** 1 kg fish (raw materials) can produce 0.2 kg (20%) dry fish meal with 10–12% water contents. A conversion from fresh fish to be fish meal (20%) will be used as a basic to calculate the FFER (Feed Fish Equivalence Ratio).*

Table 4. Dietary fishmeal and fish oil (%), feed fish equivalence ratio (FFER), and feed conversion ratio (FCR) for *Penaeus monodon* of the 5 major shrimp feedmills in Indonesia.

Company	Dietary fishmeal (%)	Dietary fish oil (%)	FFER*	FCR
PT. Central Proteinaprima (CP)	30	1	2.4 : 1	1.6
Aquafeed Division, Cikampek PT. Gold Coin (GC) Bekasi	30	1–1.5	2.25– 2.55 : 1	1.5–1.7
PT. Matahari Sakti (MS) Surabaya	30	2–3	2.25– 2.55 : 1	1.5–1.7
PT. CJ Feed (CJF) Jombang	30	2	2.4–2.7 : 1	1.6–1.8
PT. Suri Tani Pemuka/ Comfeed (STP), Surabaya	30	1	2.55 : 1	1.7
	Mean = 30%	Mean = 1.55%	Mean = 2.9:1	Mean: 1.6

Source : Interview with the managements of the 5 major tilapia feedmills (CP, GC, MS, CJF, STP).

Table 5. Traceability of raw materials (fish meal) in compounded shrimp feed.

	Indicator	Standards	Present Status
5.1	Presence and evidence of traceability of raw feed ingredients > 1% with regard to country and species of origin, as demonstrated by the feed manufacturer	<5 years of the date of ShAD publication	**Imported fish meal (68.6%)**[a)]: Peru origin, Peruvian Anchovy (*Angraulis ringens*). Global G.A.P certification **Domistic fish meal (31.4%)**[a)]: Bali Bay-Banyuwangi origin, Bali sardine (*Sardinella longiceps*). No Global G.A.P certification.
5.2	Disclosure of all major feed ingredients	list of feed ingredients present in a proportion of >1%, including all marine, terrestrial plant, and terrestrial animal ingredients	Fishmeal, soybean meal, shrimp waste meal, meat and bone meal (MBM), corn meal, fish oil, squid oil
5.3	Responsible sourcing of feed ingredients	the feed manufacturer must provide evidence of policies to source only feed ingredients which comply with internationally recognized moratoriums and local laws, including vegetable ingredients or products derived from vegetable ingredients. The ingredients must not come from the Amazon Biome, as geographically defined by the Brazilian Soya Moratorium.	ISO 22000:2005 (based on food safety standard): All feed ingredients is antibiotic free and all the imported feedstuffs is under Global G.A.P certification. No ingredients are from the Amazon Biome.

[a)] *Mean of total imported and domistic fish meal requirements based on fish sources*

Table 6 presents origin of aquatic ingredients. In general, the major shrimp feedmills in Indonesia used more certified and imported fish meal products (68.6%) of Peru origin than the domistic ones (31.4%) of Bali Bay- Banyuwangi origin. Whereas, imported fish oil products used in shrimp feeds were approximately more than 80%. Local fish oil products used in shrimp feeds were very limited due to unregular availability either in quantity or in quality. Feed ingredients allowance derived from penaeid shrimp materials (shrimp waste meal) used in shrimp feeds were > 1%. All imported fisheries products used in shrimp feeds was under certification of Global G.A.P and accredited by ISO 22000: 2005.

The fish source score for the fisheries products from which a minimum 80% of the fish meal and fish oil derivation used in shrimp feeds was > 6. It means that the fish stock management is still in healthy condition. No local fish meal made from fisheries by-products or by-catch products was used in shrimp feeds and this is due to the protein quality requirement standard for shrimp meal must contain at least 60% crude protein. A range of 20 to 25% dietary fish meal and 1–3% dieatry fish oil was used for shrimp feeds (*Litopenaeus vanname*) (Table 6).

Table 6. Origin of aquatic ingredients.

	Indicator	Standards	Present Status
6.1	Timeframe for at least 90% fishmeal and fish oil used in feed to come from fisheries certified under an ISEAL member's accredited certification whose primary goal is to promote ecological sustainability AND the certification scheme is compliant with all FAO Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries.	<5 years following the date of standards publication	Approximately only 68.6% fish meal and > 80% fish oil used in shrimp feeds was imported and certified under Global G.A.B Certification. Approximately 31.4% fish meal used in shrimp feeds was from domistic products and not certified yet. Local fish oil products used in shrimp feeds were very limited due to the unregular availability in quantity and quality
6.2	Allowance of feed ingredients from *Penaeid* shrimp	None	Using >1% shrimp waste meal in shrimp feeds
6.2a	Demonstration of chain of custody and traceability for fisheries products in feed through an ISEAL accredited or ISO 65 compliant certification scheme that also incorporates the FAO[2] Code of Conduct for Responsible Fisheries	Yes	Accredited by ISO 22000:2005 (food safety standard)
6.2b	FishSource score[3] for the fishery(ies) from which a minimum of 80%[4] of the fishmeal and fish oil is derived. (See Appendix IV, subsection 3 for explanation of FishSource scoring)	• 6 or higher • Score 2 (do managers follow scientific advice) and Score 4 (stock assessment) must not have an N/A (not available) • N/A in no more than 1 other score	Fish source scores: > 6 (fish stock is healthy), Sustainable enough (exploitation < MSY) and need improvement. Sustainable annual National fishmeal production = 150,000 mt ➢ Total fish meal used in shrimp feed = 25.5% x 250,000 mt = 63,750 mt ➢ Total domistic fish meal in shrimp feed = 31.4% x 25.5% x 250,000 mt = 20,018 mt
6.2c	Allowance for the use of fish meal and fish oil in shrimp feed (including those made from fisheries by-products) containing products from either a) target fisheries that are on CITES Appendix I, on the IUCN's Red List in categories: Near Threatened, Vulnerable, Endangered, and Critically Endangered, or b) from the use of byproducts that come from a target fishery that has by-catch listed on CITES Appendix I, on the IUCN's Red Listed species (categories as above) above x amount by volume, upon landing, on an annual basis or c) from by-catch that contains CITES/IUCN listed species	None	Using 20–30% fish meal and 1–3% fish oil in shrimp feeds. No local fish meal used in shrimp feed are made from fisheries by-products. This is due to reasons of the quality where the fish meal in shrimp feed must contain at least 60% protein

[1] This standard applies to fishmeal and oil from forage fisheries and not to by-products or trimmings used in feed.
[2] Food and Agricultural Organization of the United Nations (FAO).
[3] Or equivalent score using the same methodology.
[4] By volume.

Origin and content of terrestrial feed ingredients used in shrimp feeds are shown in Table 7. Non-marine ingredients (soybean meal and corn gluten meal) used in shrimp feeds was 100% from imported sources certified. A range of 20–30% imported soybean meal and 20–40% imported corn gluten meal was used in shrimp feeds. All these plant ingredients is imported from US and not in the Amazon biome.

No available information regarding the use of genetically modified (GM) ingredients in shrimp feeds. The manufacturers do not know whether they used the GM ingredients or not in the shrimp feeds because there was no available information in the imported products for soybean and corn gluten meals (Table 8).

Table 7. Origin and content of terrestrial feed ingredients.

	Indicator	Standards	Present Status
7.1	Percentage of non-marine ingredients from sources certified by an ISEAL member's certification scheme that addresses environmental and social sustainability	100% within 5 years of the date of ShAD standards publication for soy and 3 years for palm oil	Using 20–30% imported soybean meal and 20-40% imported corn gluten meal in shrimp feeds and these plant feedstuffs are 100% certified already
7.2	Evidence that all other vegetable feed ingredients are not sourced from internationally recognized moratoriums such as the Amazon biome	Yes	Soybean meal and corn gluten meal are imported from US

Table 8. Use of Genetically Modified (GM) ingredients in feed.

	Indicator	Standards	Present Status
8.1	Use of feed that contains ingredients that are genetically modified	Allowed with product label that specifies inclusion	N.A. (shrimp feed manufacturers do not know whether they used GM ingredients in feeds or not)
		Full disclosure by Auditor on compliance report and accessible to retailer on demand.	N.A
8.2	Transparency requirements for use of GM ingredients	GM-transparent audits accessible to buyers	N.A
		Database for consumers on ASC website	N.A
		Mandatory claim on label (with liability falling to label-user vs. accreditation body)	N.A
8.3	Price feasibility for sourcing non-GM ingredients	If a 20% difference exists for non- GM ingredients costs then ok to use GM feed ingredients in the interim	N.A
		When the price of non-GM inputs approaches within X% of GM-free inputs, GM-free will become mandated	N.A

Table 9. Use of wild fish for fish meal and oil.

	Indicator	Standards	Present Status
9.1	Feed Fish Equivalence Ratio (FFER)[5]	*L. vannemei:* 1.1:1 *P. monodon*: 1.5:1	*L. vannemei*: 1.7:1 *P. monodon*: 2.4:1
9.2	Economic Feed Conversion Ratio (eFCR)[6]	*L. vannemei*: 1.7 *P. monodon*: 1.5– 2.1	*L. vannemei*: 1.6 *P. monodon*: 1.5 –1.8

[5] *Feed Fish Equivalency Ratio (FFER): the quantity of wild fish used per quantity of cultured fish produced.*
[6] *Economic Feed Conversion Ratio (eFCR): the quantity of feed used to produce the quantity of fish harvested.*

Use of wild fish for fish meal and oil in compounded feeds for *Litopenaeus vanname* and *Penaeus monodon* with indicators of FFER (feed fish equivalence ratio) and eFCR (economic feed conversion ratio) is presented in Table 9. It can be noted that the quantity of wild fish used to produce the quantity of cultured *L. vanname* was lower (1.7) than that of cultured *P. monodon* (2.4). In general, *L. vanname* is also more efficient (1.6) in utilisation of feed for growth than *P. monodon* (1.5–1.8). The lower FFER for *L. vanname* was due to a lower fish meal content (20–25%; Table 3) in the compounded feeds than those in feeds for *Penaeus monodon* (30%; Table 4). On the other hand, the higher FFER for *P. monodon* was due to a higher fish meal inclusion level (30%) in the compounded feeds (Table 4). So, the average dietary fish meal in *L. vanname* and *P. monodon* feeds is 25.5%.

Survey on Fish Meal and Fish Oil Producer

Survey on fish meal and fish oil producers was carried out in East Java Province, West Java Province and Bali. The local fish meal with a good quality standard (55-65% crude protein content) as required by the aquaculture feed companies is from exclusively captured wild fish of *Sardinella* sp., especially Bali sardine, *Sardinella longiceps* obtained from Bali Bay (Bali Bay, East Java and Pangambengan, Negara-Bali). According to the Indonesian Feedmills Association of Aquafeed Division (IFA–AD), the fish meal production from Bali Bay and Negara-Bali is up to 94.3% (49,500 mt) of annual national local fish meal production (52,500 mt) used by the major aquaculture feed industry in Indonesia. The rest (5.7% = approximately 3,000 mt) is from other *Sardinella* sp. sources (*Sardinella sirm*, *Sardinella leigaster*, and *Sardinella clupeoides*) obtained from Pekalongan, Tegal and Pelabuhan Ratu, respectively. More information in detail for fish meal source, estimated national fish meal production and fish source in detail can be seen in Table 10.

As can be seen in Table 10, total annual fish meal national production as required by aquaculture feed industry in Indonesia in 2010 noted 150,000 mt (Personal communication with IFA–AD). This amount consisted of 65% imported fish meal and 35% domistic fish meal. All imported fish meal was already completed by global GAP certification, however all domistic fish meal has no global GAP certification.

Table 10. Fish meal production source, estimated national fish meal production, and fish source (fish meal).

	Fish meal production source	Estimated annual natio- nal fish meal production (Share %)	Fish Source
1	**Imported Peruvian fish meal** (Crude Protein= 65–70%)	**65%** = 0.65 x 150,000 mt = **97,500** mt/year	Peru origin, Peruvian Anchovy (*Angraulis ringens*). Global GAP certification
2	**Domistic fish meal, Banyuwangi/** Bali Bay Origin (CP = 60–62%)	**26%** = 0.25 x 150,000 mt = **39,000 mt**/year	Bali Bay-Banyuwangi/Bali Bay origin; Bali sardine, *Sardinella longiceps*. No Global GAP certification.
3	**Domistic fish meal, Pengambengan**, Bali BayOrigin (CP =60–62%)	**7%** = 0.07 x 150,000 mt = **10,500 mt**/year	Pengambengan-Negara- Bali/ Bali Bay origin; Bali sardine, *Sardinella longiceps*. No Global GAP certification.
4	**Domistic fish meal,** Non-Bali Bay and Negara Origins (CP =50–60%)	**2%** = 0.02 x 150,000 mt = **3,000 mt**/year	Tegal origin (*Sardinella sirm*), Pekalongan origin (*Sardinella leigaster*), Pelabuhan Ratu origin (*Sardinella clupeoides*) and other by-catch products (layang scad, round hering, fringscale sardine). No Global GAP certification.

Source : Interview with the management of the major national shrimp feed companies, IFA-AD and fish meal producers.

Ninety percent domistic fish meal with high quality standard (crude protein contents = 60–62%) used by the 5 major aquaculture (shrimp, tilapia, grouper) feed companies in Indonesia is from Bali Bay origin (Bali Bay, Banyuwangi and Pengambengan, Negara-Bali; Bali sardine, *Sardinella longiceps*). The remaining 10% domistic fish meal with a bit lower quality standard containing 50–60% crude protein is from Tegal origin (*Sardinella sirm*), Pekalongan origin (*Sardinella leigaster*), and Pelabuhan Ratu origin (*Sardinella clupeoides*). In general, to meet the quality standard of the major aquafeed manufacturers, the fish meal used in aquafeed must have following requirement standards (maximal TVBN content 120 mg/L; crude protein >60%; ash contents 12–18%; maximal free fatty acid content 15%/lipid; pepsin digestibility >90%).

According to Association of Fish Canning and Milling Producer (APPI) in Muncar - Banyuwangi, there were 27 fish meal enterprise units with total fish meal production capacity 8,100–9,930 mt per mounth in peak fishing season. So the total production of fish meal obtained from captured wild fish (Sardinella lemuru) in Bali Bay and landed in Nusantara Fishing Port of Muncar, Banyuwangi – East Java was up to 39,000 mt/year and in Nusantara Fishing Port of Pengambengan, Negara – Bali was up to 10,500 mt/year (see Table 10). Total production of the domistic fish meal sourcing from Bali sardine origin and other sources was 52,500 mt/year. Whereas, the total domistic fish meal requirement used by the major aquafeed manufacturers to produce total shrimp, tilapia and grouper feeds in 2010 was approximately 49,433 mt/year (Personal Communication; Interview with the 5 major aquafeed manufacturers).

Bali sardine (lemuru, *Sardinella longiceps*) is wild fish exclusively captured from Bali Bay Water. Fish is processed to be fish meal with crude protein content of 60–62% and moisture content of 10–12%. A hundred kg wild fish (i.e. Bali sardine) will be approximately 20% dry fish meal (20 kg) and 3–8% fish oil. Bali Bay–Banyuwangi is one of the biggest fish meal and fish oil producer in East Java Province and even the biggest one in Indonesia.

Survey on Fish Landing Port and Fishermen

Bali sardine (*Sardinella longiceps*) is the major pelagic wild fish captured in Bali Bay, Banyuwangi and Jembrana (Negara) Bali Regencies with fishing area of 960 miles^2 (Sue and Junita, 2007). This area consists of North Banyuwangi, Muncar, Jembrana (Bali), and South Banyuwangi with each fishing carrying capacity potency of 120.140 mt/year, 16.801 mt/year, 40.419 mt/year, and 759,717 mt/year, respectively (Dinas Perikanan dan Kelautan Kabupaten Banyuwangi, 2007). In addition, sustainable fishing source potency of Bali Bay Water (Indonesia Ocean including South Banyuwangi: Pancer and Grajagan) in 2005 was 103,000 mt/year (demersal fish) and 109,500 mt/year (pelagic fish). Production of the captured fish landed depends on quality and quantity of fishermen and natural resources (fish season). Nusantara fishing port of Muncar in Banyuwangi is one of the highest fish landing production centres in Indonesia. The fishing port in Muncar become the centre of fish landing production due to the availability of completely infra structures supporting the fish processing industry (cold storage, canning, fish meal, other fish processings). Muncar is also as fish meal industry centre.

Most of the captured wild fish production (layang scad, *Decapterus macrosoma*/ *Decapterus roselli*; round hering (japuh), *Disumeiria acuta*; fringscale sardine (tembang), *Sardinella fimbiriata*; Eastern little tuna (tongkol banyar), *Euthynnus alfiris*; mackerel (kembung), *Scomberomorus commerson*) from North Java Sea Water landed in fishing ports in Madura, Besuki, Probolinggo, Pasuruan, and Lamongan during fishing season of April to June is transported to Muncar to be processed as fish processing industry raw materials. Most of wild fish captured during fishing season of South Sea Water (October to December) and landed in fishing ports of Sendang Biru (Malang), Prigi (Tulung Agung), Puger (Jember), Grajegan (Banyuwangi) is also transported to Muncar as fish processing industry raw materials (personal communication with fish collectors/traders and fishermen in Muncar, Grajagan, Puger, Prigi, Brondong Lamongan).

There are two types of fishing method to capture sardine fish, the first one is “Oncoran” and the second one is “Burahan”. Oncoran is the method to capture the fish using small fish as bite and if capturing the fish without feeding by bite is called Burahan. Purse seine is fishing gear used to capture sardine fish in Bali Bay Water. There are two types of purse seine used to catch the fish: 1) using payang (purse seine is manually operated) and 2) using selerek (purse seine is automatically operated by machine). Payang system involves 20 people in one day trip (10 hours) with a 15–20 GT purse seine fishing boat. Whereas, Selerek system involves 40 people in one day trip with a 30–50 GT purse seine fishing boat. Payang purse seine can catch the fish up to 20 mt/day and Selerek purse seine can catch the fish up to 50 mt/day (personal communication with fisherrmen in Muncar-Banyuwangi and Pangambangan Jembrana–Bali).

Approximately 35% of national fish meal production (150,000 ton/year) or 52,500 mt/year on the fishing season was produced from approximately 27 fish meal producers in Bali Bay, Muncar - Banyuwangi – East Java Province (74.3% = 39,000 mt), 15 fish meal producers in Bali Bay, Pangambengan – Negara, Jembrana Bali (20% = 10,500 mt), and non-Bali Bay origin (Pelabuhan Ratu, Tegal and Pekalongan; 5.7% = 3,000 mt) (personal communication; Yulia Pujiastuti, chairman of Fish Canning and Milling Enterprise Association (APPI) of Muncar; Ketut Wahyu, fisherman of Jembrana – Negara, Bali).

Discussion

Fish Meal and Fish Oil Ratio in Aquaculture Feeds

As aquaculture production continues to increase and intensify, both its reliance and its impact on ocean fisheries are likely to expand even further. The balance between farmed and wild-caught fish, as well as the total supply of fish available for human consumption, will depend on future aquaculture practices. Aquaculture should be able to contribute to global (net) fish supplies only if current trends in fish meal and fish oil use for aquaculture are reversed and policies are enforced to protect coastal areas from environmental degradation. According to this study, total domistic fish meal used in shrimp aquafeed industry in Indonesia was reported 20,017 mt in 2010 (see Table 6). This amount was still less than total domistic fish meal production (52,500 mt) in 2010 sourcing from Muncar-Banyuwangi origin (39,000 mt), Pengambengan – Jimbrana Bali origin (10,500 mt), and non-Bali Bay source origins (3,000 mt)(see Table 10). However, the production of domistic fish meal in 2010, so far, only provided 35% of total national fish meal requirement (150,000 mt) for national aquafeed industry.

Many intensive and semi-intensive aquaculture systems use 2–5 times more fish protein, in the form of fish meal, to feed the farmed species than is supplied by the farmed product (Tacon, 1998). Dietary requirements vary widely among fish species, depending on the aquaculture system, fish meal source and other dietary components. In this study, it was found that fish meal and fish oil are dominant ingredients in compound feeds for marine shrimp (*Litopenaeus vanname* and *Penaeus monodon*). These two ingredients supply essential amino acids (such as lysine and methionine) that are deficient in plant proteins and fatty acids (eicosapentanoic acid (EPA) and docosahexanoic acid (DHA)) not found in vegetable oils (De Silva and Anderson, 1994). These ingredients also provide energy, which is important because fish tend to convert carbohydrates to energy inefficiently (De Silva and Anderson, 1994).

Omnivorous and carnivorous finfish all require about the same quantity of dietary protein per unit weight. But omnivorous freshwater finfish, such as tilapia, utilize plant-based proteins (such as soybean meal) and oils (corn oil) better than carnivorous finfish (such as grouper and penaeid shrimp), and they require minimal quantities of fish meal to supply essential amino acids (De Silva and Anderson, 1994). Nevertheless, compound feeds for omnivorous fish often contain about 15% fish meal, exceeding required levels (Tacon, 1998). Manufacturers sometime over-formulate feeds, in part because dietary information for particular species is insufficient. However, no over feed formulations was not indicated in this study, the manufacturers had already included efficiently fish meal in feed formulation.

Because of the high levels of fish meal and fish oil in aquaculture feeds, it was found in this study that penaeid shrimp require more fish biomass as inputs than the farmed shrimp produced. An average of 1.7 kg and 2.4 kg of wild fish is required for every kilogram of farmed shrimp *Litopenaeus vanname* and *Penaeus monodon* raised on compound feeds, respectively (Tables 3 and 4).

The relative feed efficiency of fish farming is a complex subject that has not yet been fully analysed. Some aquaculture proponents argue that even if farmed fish production requires more wild fish biomass than is ultimately harvested, it is still more efficient than the production of commercially valuable carnivorous species in the wild (Forster, 1999). Assuming a canonical value of a 10% energy flow between trophic levels (Odum, 1979), producing 1 unit of predatory fish requires 10 units of food (largely small pelagic fish) compared with 2–5 units to produce a unit of farmed fish. This comparison is subject to debate, because energy flows between marine fish at different trophic levels are not well documented. Nevertheless, such efficiency comparisons strengthen the logic for using some small pelagic fish in fish feeds.

Regardless of the exact efficiency ratio used, however, the growing aquaculture industry cannot continue to rely on limited stocks of wild-caught fish, a number of which are already classified as fully exploited, overexploited or depleted (FAO, 2010; NRC, 1999). Taking efficiency arguments to their logical conclusion – that ever increasing amounts of small pelagic fish should be caught for use in aquaculture feeds to expand the total supply of commercially valuable fish – would clearly be terrible for marine ecosystems. Such an approach would also severely constrain the long-term growth of the aquaculture industry itself.

According to Pike (1998), if capture fisheries landings (excluding discarded by-catch) percentage to 100%, of which 69% of whole fish is consumed by humans. The remaining 31% of fish catch plus another 2% of processing waste from aquaculture and fisheries are used for fish meal production. The proportion of fish meal supplies used for farming fish rose from 10% in 1988 to 17% in 1994 and 33% in 1997 (Pike, 1998; Tacon, 1998).

Traceability of Fish Meal and Fish Oil

As has been discussed the above that marine shrimp (*Litopenaeus vannamei*, *Penaeus monodon*) require more fish meal as protein sources and more fish oil as essential fatty acids (n-3) in compound feeds than omnivorous farmed finfish. High dietary fish meal (20–30%) and fish oil (1–3%) requirement levels for marine shrimp, as consequence, resulted in a high fish meal and oil availability demand for expanding shrimp aquaculture production (Tables 3 and 4). This high demand of fish meal and fish oil was mainly supplied by 54.6–67.5% imported aquatic ingredients (Peru origin, peruvian anchovy; Table 5) and the remaining 32.5–45.4% was from domistic fish meal production (Bali Bay origin, Bali sardine). The imported aquatic feed ingredients were from responsible source certified by Global G.A.P, however, the domistic aquatic ingredients (fish meal) were not from the certified sources.

The majority 74.3% of domistic fish meal was from exclusively captured wild fish of Bali sardine (*Sardinella longiceps*) caught in Bali Bay Water and landed in Muncar fishing port, Banyuwangi. Approximately 20% of domistic fish meal was supplied by captured wild fish in Bali Bay Water and landed in Pengambengan fishing port, Jembrana Bali. The last 5.7% domistic fish meal was from by-catch products (round hering, layang scad, fringscale sardine, other sardine species: *Sardinella sirm*, *Sardinella leigaster*, *Sardinella clupeoides*) landed in Tegal, Pekalongan, and Pelabuhan Ratu fishing ports. Total domistic fish meal required for shrimp aquafeed industry was 20,017 mt (31.4% x 25.5% x 250,000 mt)(Table 6). This amount is still under the healthy fisheries stock of Bali Bay Water with fish source score >6. However, expanding aquaculture production in the near future to supply more fish for human consumption by relying on the production of domistic fish meal made from wild pelagic fish caught in Bali Bay Water and other places as major ingredients in shrimp feeds industry is difficult. The stock of pelagic fish may be becoming over fishing and this will reduce the fish source score < 6. However, relying on the use of imported fish meal and fish oil in aquafeeds in the near future will be stronger and this will result in aquafeeds production became more costly due to increasing demand and price of imported fish meal.

Sustainability of Fish Meal and Oil Sources for Aquaculture

Sustainability of fish meal and oil sources becomes unstable since small pelagic fishes, such as mackerel, anchovy and sardines used for fish meal and fish oil in fish feeds became potentially food sources for human consumption. The demand for small pelagic fish for direct human consumption is likely to increase with population growth in the developing world. Recently, an increase of demand competition between fish meal for aquaculture feeds and for human foods makes depletion of pelagic wild fish availability to catch.

It is very urgent to act efforts to sustain fisheries resources mainly for fish feeds and human foods. The use of wild fish to feed farmed fish places direct pressure on fisheries resources. However, aquaculture can also diminish fisheries resource indirectly through 1) mangrove

conversion to aquaculture ponds, 2) collection of wild seedstock, and 3) nutrient pollution. The scale of such effects varies considerably among aquaculture systems.

Low law inforcement in regulation for fishing area management, types of fishing gears, and possible by-catch products is one of reasons for diminishing sustainability of fisheries resources. No control from the local government in management of fishing area causes fishermen free to catch wild fish in the prohibited fishing areas such as fishing corservation area. Fishing regulation enforcement for the use of responsible fishing gears only is not well followed by the fishermen. For example, the use of trawl net is not allowed and this is unresponsible and not environmental friedly fishing gear. By using trawl net, all fish with different sizes (including juvenile and small fish) can be totally captured due to the small mesh size used. Fishermen should use types of environmental friendly and responsible fishing gears such as purse seine (selerek or payang) used by fishermen to catch pelagic wild fish. Catching the fish at different fishing seasons and areas is strongly recommended to keep the sustainability of catch fisheries resource. More utilisation of by-catch products to supply fish for aquafeeds will also assist keeping sustainability of fish meal and fish oil.

Some conclusions that could be withdrawn in the study were that commercial pelleted shrimp aquafeeds (*Litopenaeus vanname* and *Penaeus monodon*) vailable in Indonesia contain high fish meal and fish oil levels with a range of 20–30% fish meal and 1–3% fish oil, respectively. An average of feed fish equivalence ratios (FFERs) for *Litopenaeus vanname* and *Penaeus monodon* is 1.7:1, and 2.4:1, respectively. In general, traceability of raw materials (fish meal) in shrimp feeds is 60.1% from imported fish meal (Peruvian anchovy origin; certified by Global G.A.P) and 39.9% from domistic fish meal (Bali sardine and by-catch products origin; no Global G.A.P certification). All marine, terrestrial plant, and terrestrial animal ingredients used >1% (shrimp waste meal, soybean meal, meat and bone meal (MBM), corn meal, squid oil) in commercial shrimp was imported and from sources certified (Global G.A.P; ISO 22000:2005). In addition, the aquafeed manufacturers do not know whether they used genetically modified ingredients in feeds or not and was sure that no vegetable ingredients used come from the Amazon Biome.

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