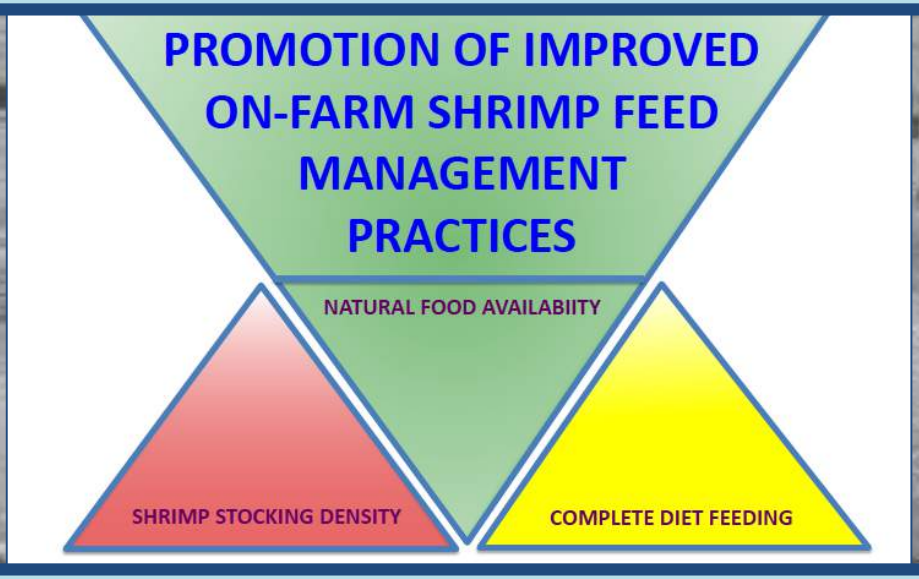
Recent developments in shrimp feeds & feeding

a practical perspective



Albert G.J. Tacon

Aquatic Farms Ltd

Kaneohe, HI 96744 USA

agjtacon@aquahana.com

TOP FED AQUACULTURE SPECIES IN 2013

Top fed species	Tonnes	APR 20-13	$ billion	Feed Tonnes
1. Chinese fed carp	13,158,580	5.2 %	17.7	11,855,881
2. Tilapia	4,823,160	11.3%	8.2	7,215,447
3. Shrimp 	**4,454,602**	**11.1 %**	**22.7**	**6,361,172**
4. Catfishes	4,274,110	10.1 %	6.8	4,727,166
5. Marine fish	2,283,456	8.1%	9.5	3,164,870
6. Salmon	2,283,093	12.5 %	13.8	2,968,021
7. Misc FW/D fish **	2,206,437	10.5%	4.9	1,390,055
8. FW crustaceans	1,953,773	4.9 %	11.1	1,967,449
9. Milkfish	1,043,936	8.9 %	1.8	1,002,178
10. Trout	836,569	2.7 %	3.6	1,087,540
11. Eel	231,682	-5.1 %	1.3	355,863
TOTAL	**37,549,398**	**7.3 %**	**101.4**	**42,095,642**

* Calculated from FAO (2015); ** Miscellaneous freshwater & diadromous fish

Farmed shrimp: global statistics for 2013

Total farmed shrimp production - 4.45 million tonnes

***Litopenaeus vannamei* - 3.31 million tonnes or 74.4% total**

***Penaeus mondon* - 803,783 tonnes or 18.0% total**

Growth rate since 2000 – 11.1 % per year (26.6%/1.88% LV/PM)

Major country producers - China 38.1%, Indonesia 14.0%, Vietnam 12.1%, Thailand 7.4%, Ecuador 6.8%, India 6.5% & Mexico 2.7%

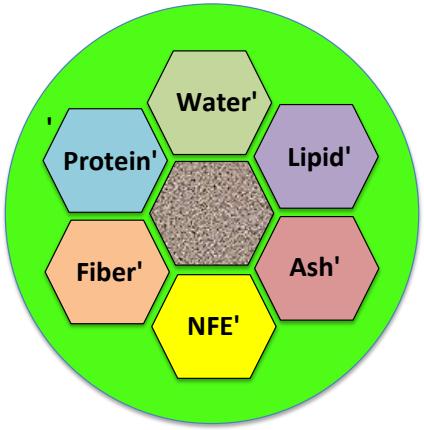
Percent total production on feeds - 84%

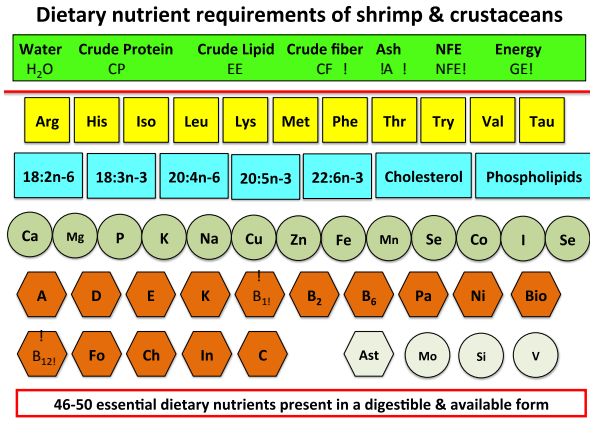
Calculated Economic FCR - 1.7

Total shrimp aquafeed production - 6.36 million tonnes

Recent developments in shrimp feeds & feeding

- **Improved labeling & reporting of nutrient levels within feed ingredients & shrimp feeds**
- **Improved feed formulation & reduced use of wild fish in shrimp feeds**
- **Improved on-farm feed management practices tailored to the needs of small-scale shrimp farmers**





Recent developments in shrimp feeds & feeding

FISH MEAL, SHRIMP MEAL, SQUID MEAL,
FISH OIL, WHEAT FLOUR, SOYABEAN MEAL,
CHOLESTEROL, PHOSPHOLIPID,
VITAMINS AND MINERALS

FEEDING PROGRAM

- **Improved labeling & reporting of nutrient levels within feed ingredients & shrimp feeds**

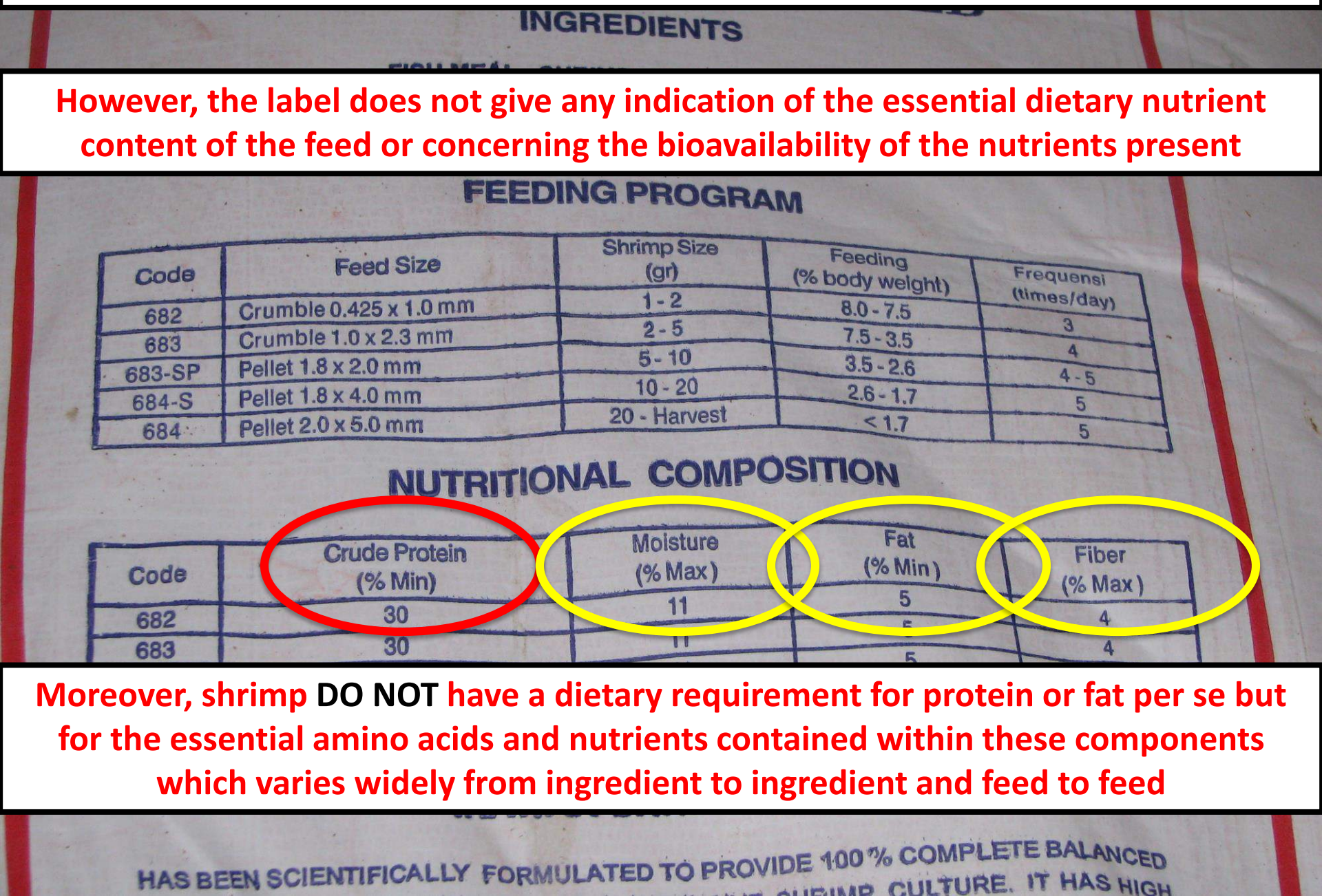
NUTRITIONAL COMPOSITION

Code	Crude Protein (% Min)	Moisture (% Max)	Fat (% Min)	Fiber (% Max)
682	30	11	5	4
683	30	11	5	4
683-SP	30	11	5	4
684-S	28	11	5	4
684	28	11	5	4

IRAWAN SHRIMP FEED

HAS BEEN SCIENTIFICALLY FORMULATED TO PROVIDE 100% COMPLETE BALANCED

The label just complies with national feed manufacturing laws & proximate composition guarantees for the farmer



INGREDIENTS

However, the label does not give any indication of the essential dietary nutrient content of the feed or concerning the bioavailability of the nutrients present

FEEDING PROGRAM

Code	Feed Size	Shrimp Size (gr)	Feeding (% body weight)	Frequensi (times/day)
682	Crumble 0.425 x 1.0 mm	1 - 2	8.0 - 7.5	3
683	Crumble 1.0 x 2.3 mm	2 - 5	7.5 - 3.5	4
683-SP	Pellet 1.8 x 2.0 mm	5 - 10	3.5 - 2.6	4 - 5
684-S	Pellet 1.8 x 4.0 mm	10 - 20	2.6 - 1.7	5
684	Pellet 2.0 x 5.0 mm	20 - Harvest	< 1.7	5

NUTRITIONAL COMPOSITION

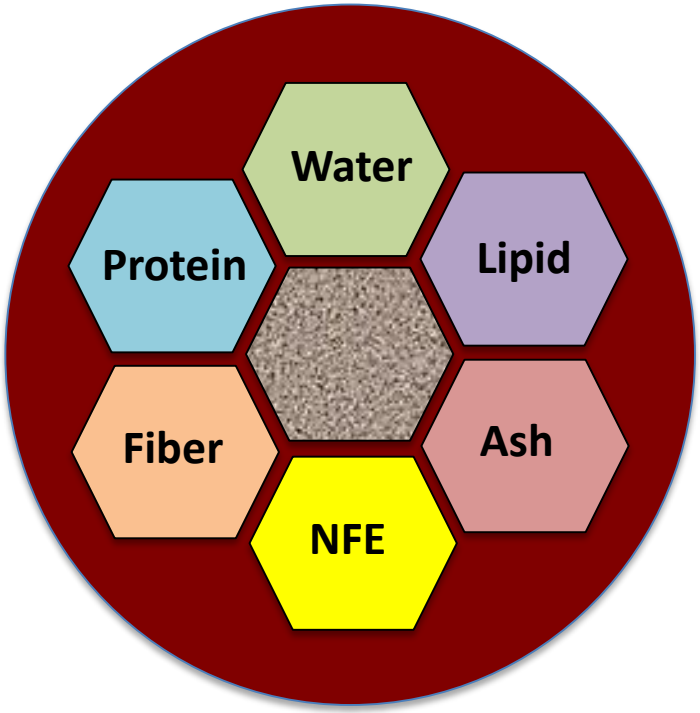
Code	Crude Protein (% Min)	Moisture (% Max)	Fat (% Min)	Fiber (% Max)
682	30	11	5	4
683	30	11	5	4

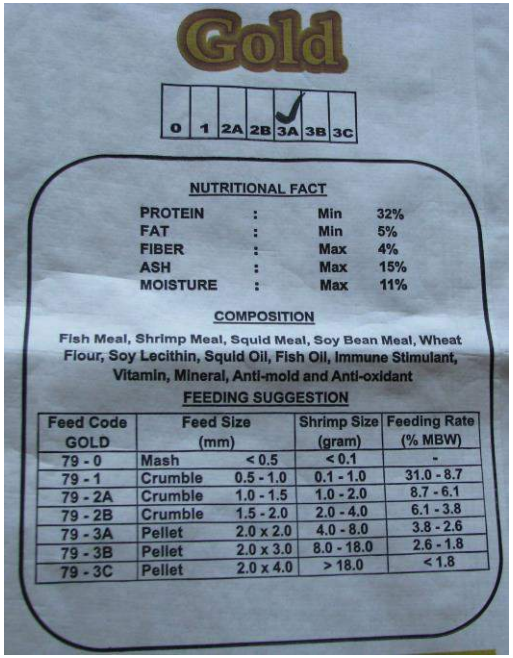
Moreover, shrimp DO NOT have a dietary requirement for protein or fat per se but for the essential amino acids and nutrients contained within these components which varies widely from ingredient to ingredient and feed to feed

HAS BEEN SCIENTIFICALLY FORMULATED TO PROVIDE 100% COMPLETE BALANCED

PROXIMATE CHEMICAL ANALYSIS of feed ingredients and formulated feeds

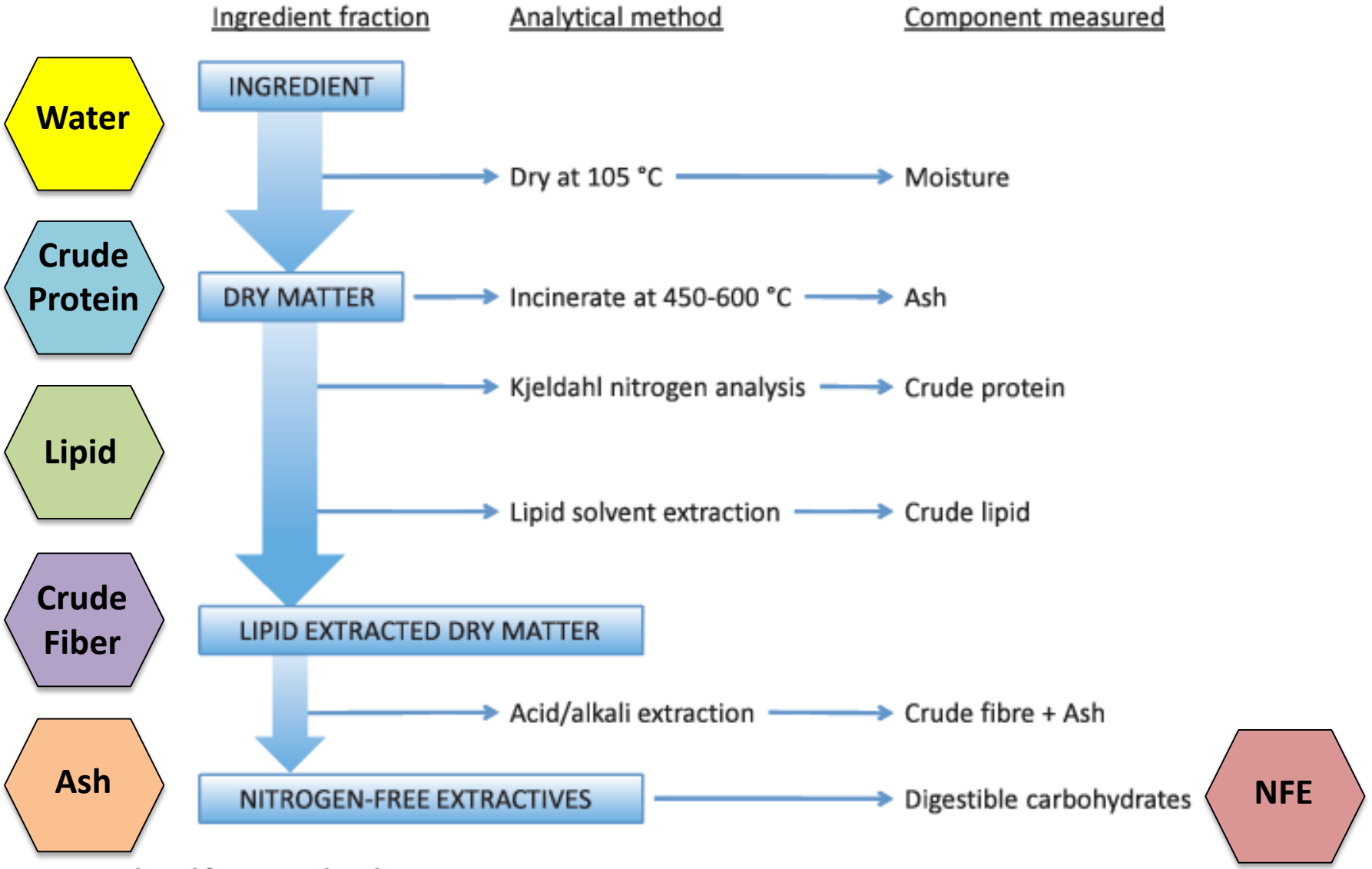
SOYBEAN MEAL "HIGH PRO"	
Nutrient	**%**
Protein	46.0 - 48.0
Fat	0.5 - 1.5
Fiber	3.0 - 3.5
Ash	5.5 - 6.0
Moisture	< 12.0





USE: Legal compliance for the declared proximate chemical composition of a feed ingredient or a formulated feed for the purposes of ingredient or feed registration, trade & sales

Proximate chemical analysis of feed ingredients & finished feeds



Source: adapted from Tacon (1987).

Proximate chemical analysis of feed ingredients & finished feeds

- Water
- Crude Protein
- Lipid
- Crude Fiber
- Ash

WATER

Heating a sample in a drying oven at a temperature above the boiling point of water (100 to 105°C) to constant weight - the loss in weight being calculated as percent moisture

Comment: Indirect method calculated as loss in sample weight on drying – includes water & other low boiling point volatiles

Proximate chemical analysis of feed ingredients & finished feeds

Water

Crude Protein

Lipid

Crude Fiber

Ash

CRUDE PROTEIN

Determined using the Kjeldahl method by measuring the total nitrogen content within the sample and then converting this figure to a total crude protein value by multiplication with the empirical factor

6.25

Comment: Indirect method which assumes protein contains 16% nitrogen by weight (16 x 6.25 = 100), reality is 12 to 19%

Proximate chemical analysis of feed ingredients & finished feeds

**/ Mariotti, Tome & Mirand (2008)*

- Water
- Crude Protein
- Lipid
- Crude Fiber
- Ash

CRUDE PROTEIN

Nitrogen conversion factors*

Wheat bran	4.96
Rice	5.34
Rapeseed	5.35
Wheat	5.49
Soybean meal	5.50
Gelatin	5.50
Fish	5.58
Corn	5.62
Milk	5.85
Casein	6.15

Comment: method does not distinguish between protein and non-protein nitrogen compounds such as nucleic acids, amines, uric acid, urea, ammonia, ammonium salts, nitrates, adulterants

Useful publications regarding chemical methods for protein & adulterants

Mariotti, F., D. Tome & P.P. Mirand. (2008). Converting nitrogen into protein – beyond 6.25 and Jones factors. Critical Reviews in Food Science & Nutrition, 48:177-184.

Moore, J.C., J.W. DeVries, M. Lipp, J.C. Griffiths & D.R. Abernethy. (2010). Total protein methods and their potential utility to reduce the risk of food protein adulteration. Comprehensive Reviews in Food Science & Food Safety, 9(4):330–357.

Haughey, S.A., Graham, S.F., Cancouët, E. & C.T. Elliott. (2013). The application of near-infrared reflectance spectroscopy (NIRS) to detect melamine adulteration in soybean meal. Food Chemistry, 136(3-4):1557-1561

ADULTERATION

Adulteration is the intentional addition of melamine and/or analogues directly to food, food ingredients, animal feed, feed ingredients or pelletizing agents. It may also be present indirectly in foods of animal origin as a result of carryover from the intentional addition to animal feed.

Adulterants may include rice hulls, oyster shell, feather meal, leather meal, ground limestone, non-protein nitrogen such as ammonium nitrate, urea, melamine & others

LC-MS/MS Analysis of Emerging Food Contaminants

Quantitation and Identification of Dicyandiamide in Milk and other Protein-Rich Foods

Fanny Fu[1] and André Schreiber[2]
[1]AB SCIEX Taipei (Taiwan), [2]AB SCIEX Concord, Ontario (Canada)

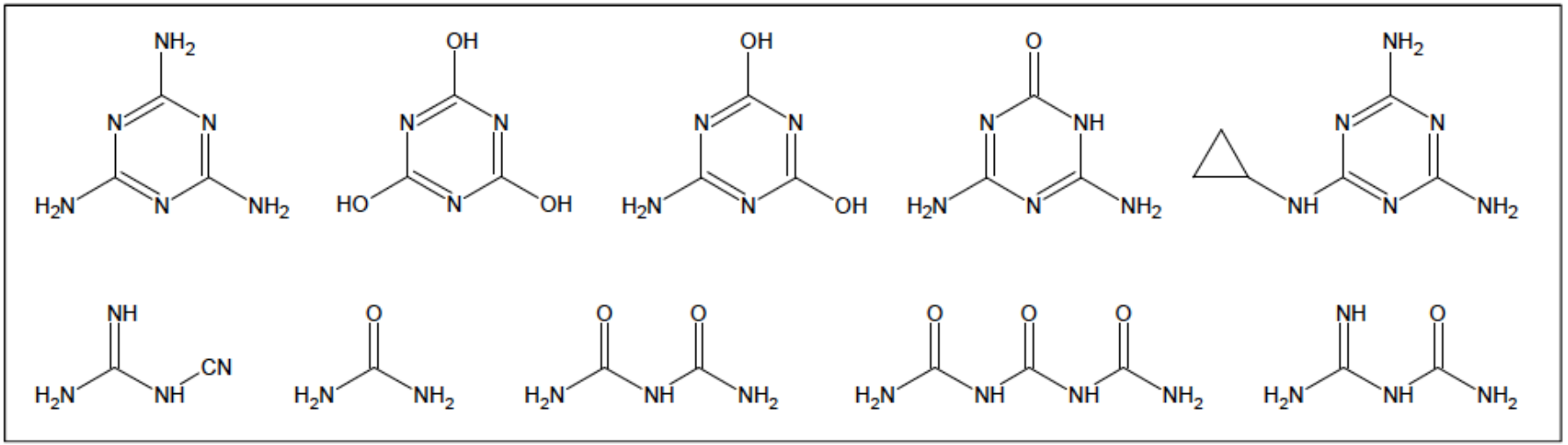


Figure 1. Potential adulterants (non-protein nitrogen sources), including melamine, cyanuric acid, ammelide, ammeline, cyromazine, dicyandiamide, urea, biuret, triuret, amidinourea, (top left to bottom right)

For Research Use Only. Not for use in diagnostic procedures.

Publication number: 7170213-01

AB SCIEX

Headquarters
500 Old Connecticut Path, Framingham, MA 01701 USA
Phone 508-383-7700
www.absciex.com

International Sales
For our office locations please call the division headquarters or refer to our website at
www.absciex.com/offices

APPLICATION NOTE

GC/MS Spectrometry

Authors

James Neal-Kababick

Flora Research Laboratories
Grants Pass, OR USA

William Goodman

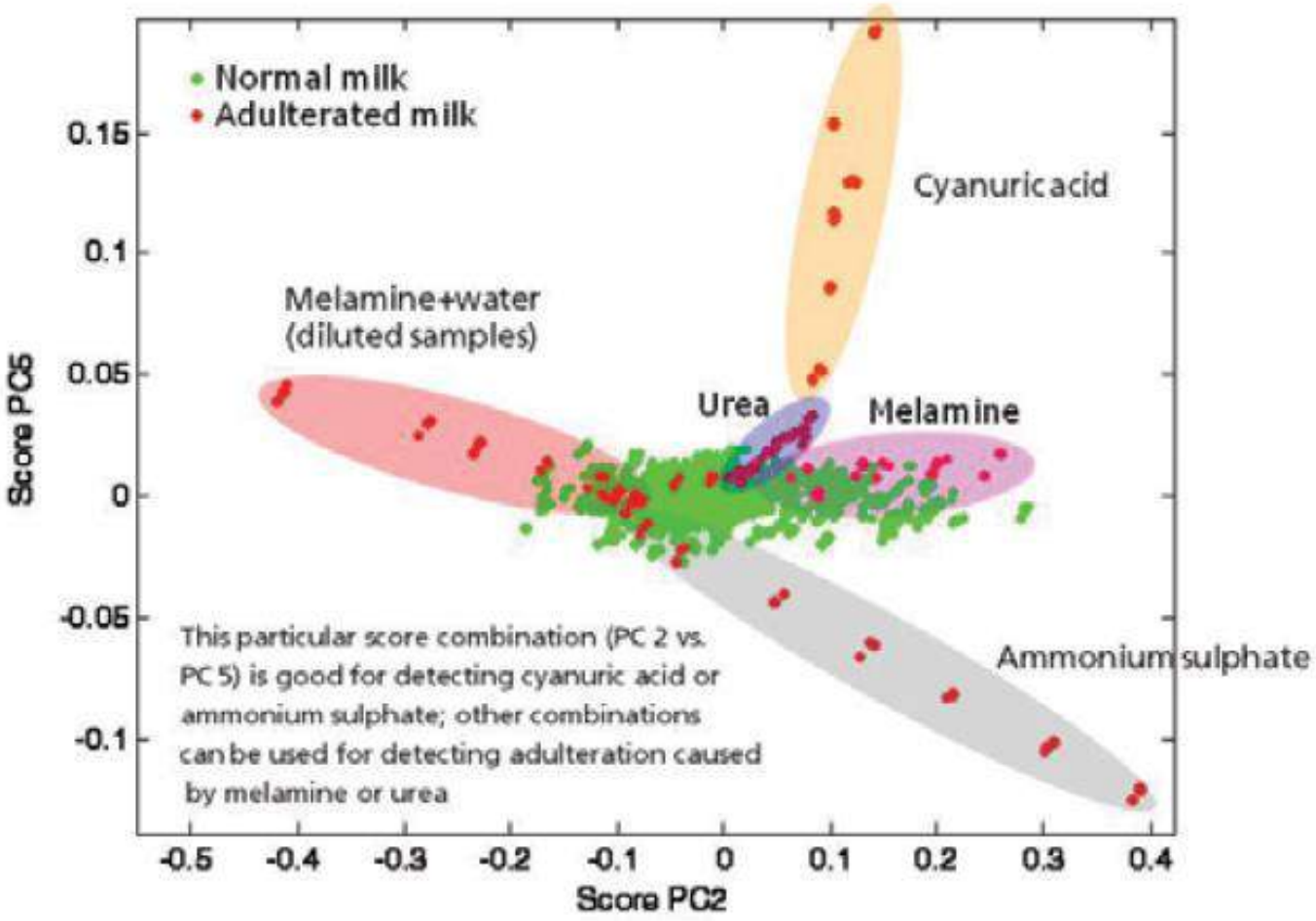
PerkinElmer, Inc.
Shelton, CT USA

Screening for Melamine Adulteration in Protein-based Foods by GC/MS

PerkinElmer
For the Better

Protein Analysis revisited*

Deficiencies of traditional nitrogen-based methods for detection of adulteration of food and feed have led to a search for alternative methods and an attempted redefinition of the term 'Protein'. Can traditional methods like Kjeldahl still be used? What about calibrations for indirect NIR and FTIR methods – and what are the alternatives?



by Jürgen Möller, FOSS (jmr@foss.dk)

In Focus, Vol. 34, No 2, 2010

Best Practices in Aquaculture Supply Chain Management

Dan Fegan, Cargill

Food Safety Case Study 2

- Melamine in feed ingredients
  - Some high value feed ingredients are priced based on crude protein
  - This is typically estimated from the nitrogen content
  - Adulterants high in N can increase the apparent protein content
  - Inorganic N (eg urea) is easy to test, organic N (eg melamine) is much more difficult and time consuming
  - Cargill scientists worked to develop a simple, cheap, real time test
  - This test has been widely shared to improve surveillance and monitoring of melamine adulteration

Proximate chemical analysis of feed ingredients & finished feeds

Water

Crude Protein

Lipid

Crude Fiber

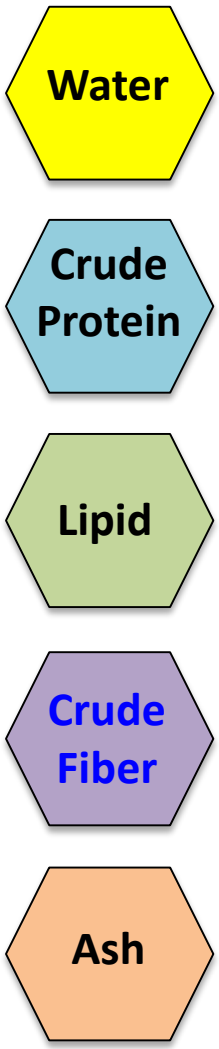
Ash

LIPID

Crude lipid content of an ingredient or ration is usually determined by solvent extraction with petroleum ether using a Soxhlet extractor & weighing the lipid fraction after solvent evaporation

Comment: Direct method which usually readily extracts triglyceride fats & oils, but requires prior acid hydrolysis for complex lipids

Proximate chemical analysis of feed ingredients & finished feeds

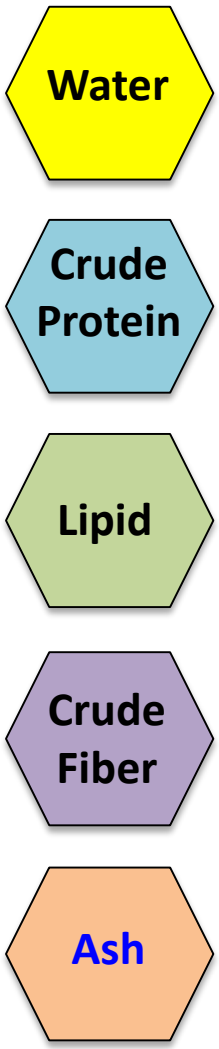


CRUDE FIBRE

Determined as the organic residue remaining after extracting a lipid extracted ingredient with dilute acid & alkali under controlled conditions

Comment: Based on insoluble organic residue remaining after lipid extraction & digestion with dliute acid & alkali

Proximate chemical analysis of feed ingredients & finished feeds



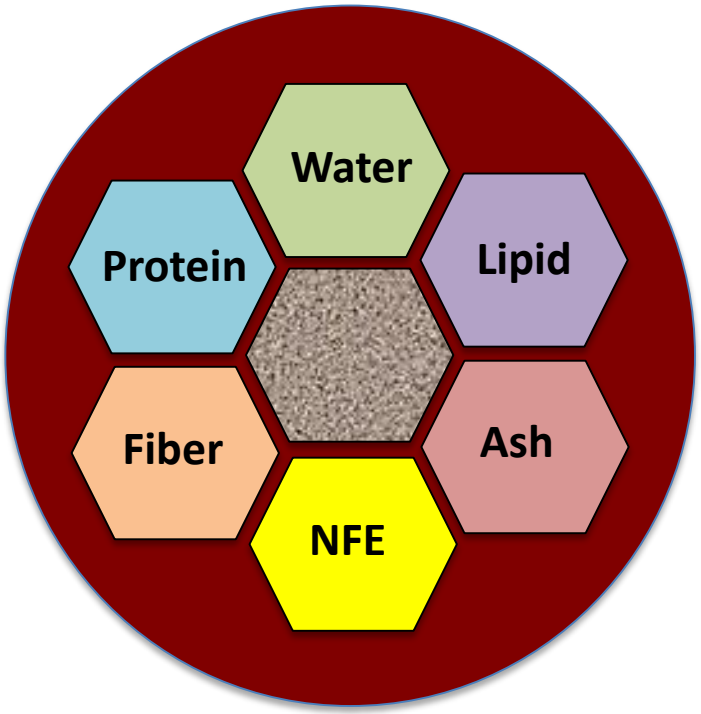
ASH

Determined by oxidative combustion in a muffle furnace at 550 to 600°C - the inorganic residue remaining being calculated as percent ash

Comment: Some minerals may be lost through volatilization at high temperatures, including K, Na, Cl & P

PROXIMATE CHEMICAL ANALYSIS of feed ingredients and formulated feeds

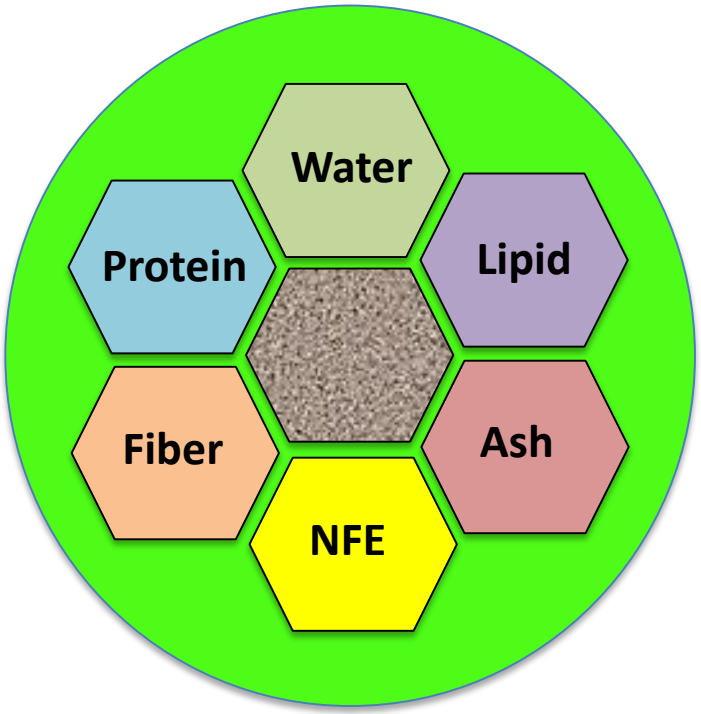
SOYBEAN MEAL "HIGH PRO"	
Nutrient	**%**
Protein	46.0 - 48.0
Fat	0.5 - 1.5
Fiber	3.0 - 3.5
Ash	5.5 - 6.0
Moisture	< 12.0



In summary, although proximate chemical analysis is routinely used by feed laboratories for monitoring the composition of feed ingredients & finished feeds, the results have little practical value due to the non-specific nature of the methods used & the fact that no information is provided on the nutrients present or concerning their bioavailability

PROXIMATE CHEMICAL ANALYSIS of feed ingredients and formulated feeds

SOYBEAN MEAL "HIGH PRO"	
Nutrient	**%**
Protein	46.0 - 48.0
Fat	0.5 - 1.5
Fiber	3.0 - 3.5
Ash	5.5 - 6.0
Moisture	< 12.0

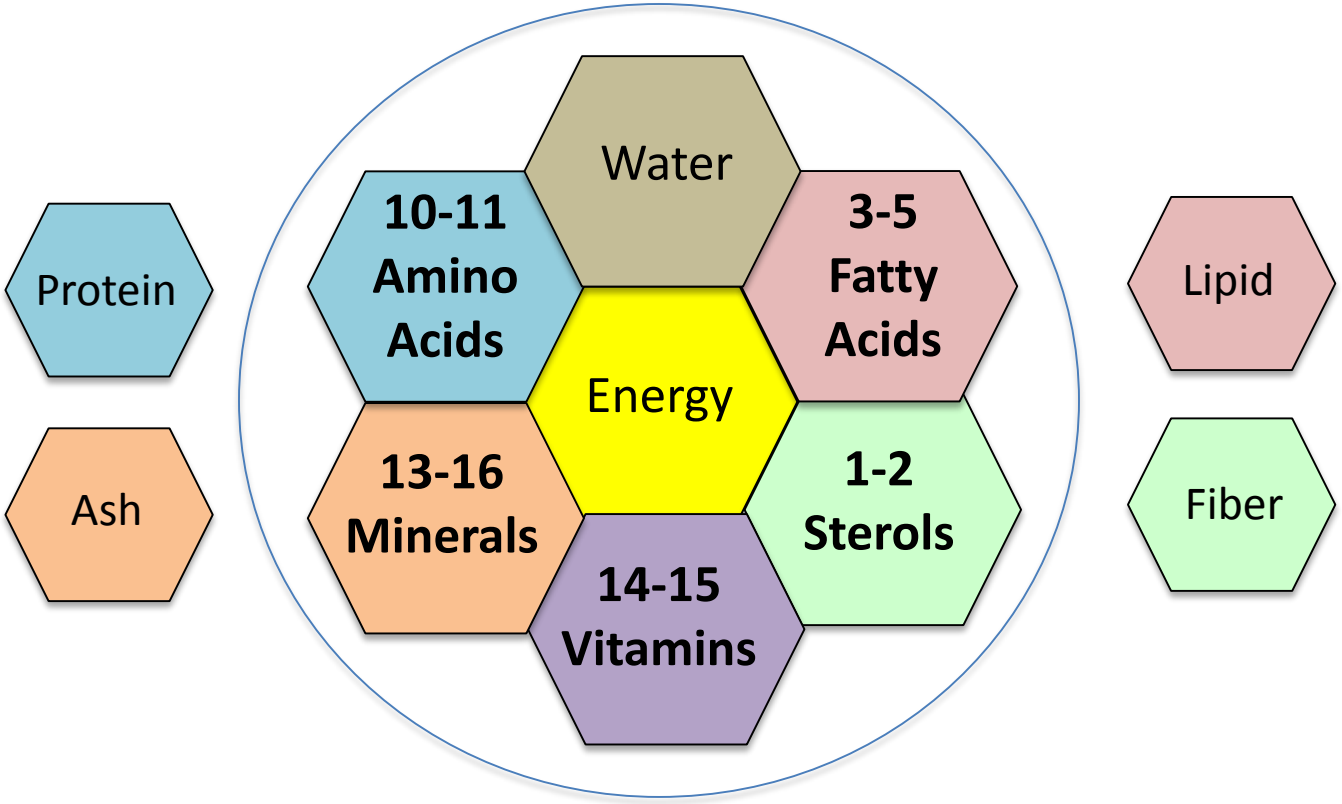


We need to look at the specific nutrients present within these proximate components

Water	Crude Protein	Crude Lipid	Crude fiber	Ash	NFE	Energy
H_2O	CP	EE	CF	A	NFE	GE

Dietary nutrient requirements of shrimp & crustaceans

Water	Crude Protein	Crude Lipid	Crude fiber	Ash	NFE	Energy
H_2O	CP	EE	CF	A	NFE	GE



Dietary requirement for over 46-50 bioavailable essential nutrients

Dietary nutrient requirements of shrimp & crustaceans

Water	Crude Protein	Crude Lipid	Crude fiber	Ash	NFE	Energy
H_2O	CP	EE	CF	A	NFE	GE

Arg | His | Iso | Leu | Lys | Met | Phe | Thr | Try | Val | Tau

18:2n-6 | 18:3n-3 | 20:4n-6 | 20:5n-3 | 22:6n-3 | Cholesterol | Phospholipids

Ca | Mg | P | K | Na | Cu | Zn | Fe | Mn | Se | Co | I | Se

A | D | E | K | B_1 | B_2 | B_6 | Pa | Ni | Bio

B_{12} | Fo | Ch | In | C | Ast | Mo | Si | V

46-50 essential dietary nutrients present in a digestible & available form

The future – full nutrient declaration?

THẮNG LONG

TIGER

THỨC ĂN NUÔI TÔM THẺ

L. VANNAMEI SHRIMP FEED

ISO 22000 : 2005

HACCP

KHỐI LƯỢNG TỊNH

20 kg

SỐ CÔNG BỐ: TCCS-TL 01:2011/05

SẢN PHẨM CỦA:

CÔNG TY TNHH KHOA KỸ SINH VẬT THĂNG LONG

SHENG LONG BIO-TECH INTERNATIONAL CO., LTD

Lô A-5, KCN Đức Hòa 1, Hạnh Phúc, Ấp 5 Đức Hòa Đông, Huyện Đức Hòa, Tỉnh Long An, Việt Nam

ĐT: (84-72) 3761358 - 3779741 - Fax: (84-72) 3761359

CÔNG TY TNHH QUỐC TẾ LONG THĂNG

KCN Suối Dầu - Cam Lâm - Khánh Hòa, Việt Nam - ĐT: (84-58) 3743191 - Fax: (84-58) 3743192

THỨC ĂN NUÔI TÔM THẺ

chuyên dụng cho tôm thẻ

và kinh tế trong sản xuất.

We develop an excellent and cost-effective *Vannamei* nutrition to shrimp farmers for sustainable and economic production.

THÀNH PHẦN NGUYÊN LIỆU

Bột cá cao cấp, Dầu cá, Bột nội tạng mực, Bột mì, Bột đậu nành, Lecithin, Cholesterol, Vitamin và Khoáng chất.

FEED INGREDIENTS

Fish meal, Fish oil, Squid visceral meal, Wheat flour, Soybean meal, Lecithin, Cholesterol, Vitamins and Minerals.

THÀNH PHẦN DINH DƯỠNG

ĐỘ ẨM TỐI ĐA	11%
PROTEIN THÔ TỐI THIỂU	40%
PROTEIN TIÊU HÓA TỐI THIỂU	38%
XƠ THÔ TỐI ĐA	4%
CANXI TỐI ĐA	2.3%
PHOSPHO TRONG KHOÁNG	1.0 - 3.5%
LYSINE TỐI THIỂU	1.6%
METHIONINE + CYSTINE TỐI THIỂU	0.7%

COMPOSITION

Moisture (max)	11%
Crude protein (min)	40%
Digestible crude protein (min)	38%
Crude fiber (max)	4%
Canxi (max)	2.3%
Phospho	1.0 - 3.5%
Lysine (min)	1.6%
Methionine + Cystine (min)	0.7%

HƯỚNG DẪN CHO ĂN

HÌNH DẠNG	Viên
TRỌNG LƯỢNG TÔM NUÔI (G)	3 - 7
TỶ LỆ CHO ĂN (%)	6 - 5
SỐ LẦN CHO ĂN/NGÀY	3 - 4
% THỨC ĂN TRONG SÀNG	3.5
THỜI GIAN KIỂM TRA (GIỜ)	1.0 - 1.5

RECOMMENDED FEEDING GUIDE

Shape	Pellet
Shrimp body weight (g)	3 - 7
% of feeding	6 - 5
Daily feeding frequency	3 - 4
% feed in trays	3.5
Monitoring time (hrs)	1.0 - 1.5

CÁCH BẢO QUẢN

- Thời hạn sử dụng 3 tháng, ngày sản xuất và hạn sử dụng được in trên bao bì.
- Để nơi thoáng mát, khô ráo, tốt nhất nên sử dụng ngay sau khi mở bao.

nội tạng mực,
n, Cholesterol,

flour, Soybean meal, Lecithin, Cholesterol,
Vitamins and Minerals.

	11%
	40%
	38%
	4%
	2.3%
	1.0 - 3.5%
	1.6%
HIỂU	0.7%

COMPOSITION

Moisture (max)	11%
Crude protein (min)	40%
Digestible crude protein (min)	38%
Crude fiber (max)	4%
Canxi (max)	2.3%
Phospho	1.0 - 3.5%
Lysine (min)	1.6%
Methionine + Cystine (min)	0.7%

RECOMMENDED FEEDING GUIDE

	Pellet

6151 LAGUNA TILAPIA TANQUE – REDE 32

Ração para peixes

- INDICAÇÃO DE USO: Ração para tilápias e outras espécie onívoras de peixes cultivadas em tanques-rede.
- COMPOSIÇÃO BÁSICA: Farelo de soja*, milho integral moído, farelo de trigo, farinha de carne, farelo de arroz, farinha de penas hidrolisadas, farelo de glúten de milho - 21**, farelo de algodão* **, farinha de sangue, farinha de vísceras, óleo de soja degomado, calcário calcítico, cloreto de sódio (sal comum), monóxido de manganês, sulfato de ferro, óxido de zinco, iodato de cálcio, sulfato de cobre, selenito de sódio, sulfato de cobalto, vitamina A, vitamina D3, vitamina E, vitamina K3, vitamina B1, vitamina B2, niacina, ácido pantotênico, vitamina B6, ácido fólico, biotina, vitamina B12, cloreto de colina, vitamina C, lisina, metionina, ácido propiônico, silimarina, etoxiquin, hidróxido de anizola butilado (BHA).. Espécies doadoras do gene: *Agrobacterium tumefaciens **Bacillus thuringiensis.
- EVENTUAIS SUBSTITUTIVOS: Farinha de trigo, farelo de glúten de milho - 60, farelo de milho, fosfato bicalcico, proteína concentrada de soja, óleo de salmão, levedura seca de cana de açúcar, gérmen de milho, soja integral extrusada, farinha de peixe salmão, óleo de peixe refinado, lecitina de soja, hidróxido de tolueno butilado (BHT).
- NÍVEIS DE GARANTIA: Umidade (máx) 80,00 g/kg; proteína bruta (mín) 320,00 g/kg; extrato etéreo (mín) 60,00 g/kg; fibra bruta (máx) 60,00 g/kg; matéria mineral (máx) 105,00 g/kg; cálcio (mín) 10,00 g/kg; cálcio (máx) 20,00 g/kg; fósforo (mín) 6.000,00 mg/kg; sódio (mín) 2.200,00 mg/kg; ferro (mín) 30,00 mg/kg; cobre (mín) 5,00 mg/kg; manganês (mín) 30,00 mg/kg; zinco (mín) 60,00 mg/kg; iodo (mín) 1,00 mg/kg; cobalto (mín) 0,10 mg/kg; selênio (mín) 0,30 mg/kg; vitamina A (mín) 12.000,00 UI/kg; vitamina D3 (mín) 2.400,00 UI/kg; vitamina E (mín) 50,00 UI/kg; vitamina K3 (mín) 5,00 mg/kg; vitamina B1 (mín) 10,00 mg/kg; vitamina B2 (mín) 20,00 mg/kg; niacina (mín) 100,00 mg/kg; acido pantotênico (mín) 50,00 mg/kg; vitamina B6 (mín) 10,00 mg/kg; acido fólico (mín) 4,00 mg/kg; biotina (mín) 0,24 mg/kg; vitamina B12 (mín) 40,00 mcg/kg; colina (mín) 500,00 mg/kg; vitamina C (mín) 350,00 mg/kg; lisina (mín) 18,50 g/kg; metionina (mín) 6.500,00 mg/kg.
- MODO DE USAR: Distribuir aos peixes acima de 260 gramas de peso. A quantidade diária oferecida deve variar de 4 a 5% da biomassa dividida em 2 porções. Uso proibido na alimentação de ruminantes.
- PRODUTO ISENTO DE REGISTRO NO MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO.

LOTE: 05EX120028748 FAB: 30/10/2012 B
COD: 01.6151.40.25 v02 VAL: 28/04/2013

7 896642 904966

Peso Liq.: 25 kg

Vitalis 2.5

Alimento para Reproductores de Camarão

COMPOSIÇÃO BÁSICA DO PRODUTO :

FARINHA DE PEIXE, GLÚTEN DE TRIGO, ALGAS MARINHAS CALCARIAS, AMIDO DE MILHO, OLEO DE PEIXE REFINADO, LECITINA DE SOJA, VITAMINAS, MINERALES

EVENTUAIS SUBSTITUVOS :

ASTAXANTINA

NÍVEIS DE GARANTIA POR QUILOGRAMA DO PRODUTO :

UMIDADE (MÁXIMO) :	75g	MANGANÊS (MÍNIMO) :	35,00 mg
PROTEÍNA BRUTA (MÍNIMO) :	590,00g	SELÊNIO (MÍNIMO) :	0,20 mg
EXTRATO ETÉREO (MÍNIMO) :	110,00g	VITAMINA A (MÍNIMO) :	20.000,00 U.I
MATERIAL MINERAL (MÁXIMO) :	110,50g	VITAMINA D3 (MÍNIMO) :	2.500,00 U.I
MATÉRIA FIBROSA (MÁXIMO) :	3.000,00 mg	ZINCO (MÍNIMO) :	100,00 mg
CÁLCIO (MÍNIMO) :	15,00g	FERRO (MÍNIMO) :	75,00 mg
CÁLCIO (MÁXIMO) :	25,00g	VITAMINA E (MÍNIMO) :	600,00 UI
FÓSFORO (MÍNIMO) :	13,00g	VITAMINA C (MÍNIMO) :	1.000,00 mg
IODO (MÍNIMO) :	3,00 mg	COBRE (MÍNIMO) :	10,00 mg

INDICAÇÃO DE USO/ESPÉCIE A QUE SE DESTINA : INDICADO COMO ALIMENTO PARA MATURAÇÃO DE REPRODUTORES DE CAMARÃO.

MODO DE USAR : ALIMENTAR A VONTADE ATÉ APROXIMADAMENTE 5% DA BIOMASSA/DIA.

USO PROIBIDO NA ALIMENTAÇÃO DE RUMINANTES.

CONDIÇÕES DE CONSERVAÇÃO : ARMAZENAR EM LOCAL SECO E FRESCO.

PESO LÍQUIDO : 10 KG

PRODUTO FABRICADO 24 MESES ANTES DA DATA DE EXPIRAÇÃO.

CONSUMIR DE PREFERÊNCIA ANTES : 06-11-15

NUMERO DE LOTE : 7190032

PRODUTO IMPORTADO ISENTO DE REGISTRO NO MINISTERIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO

IMPORTADOR/DISTRIBUIDOR : NUTRECO BRASIL NUTRIÇÃO ANIMAL LTDA
Endereço :Via Ligaçao I, No 900 / Distrito Industrial III / Maracanau- Ceará - Brasil
CEP. 61.921.520 / SIF : CE-06479 / CNPJ- 03.022.008/0007-32 / INSCRIÇÃO ESTADUAL - 06.624.778-0

FABRICANTE / EXPORTADOR : TROUW FRANCE S.A.
Spécialités Alimentaires pour l'Aquaculture
02140 VERVINS - TEL : 03 23 91 34 34 - R.C.835.680.125 B / N° AGREMENT : Alpha FR 02 321 001

National standard vannamei feeds **Vietnam** 2014

Source: Ministry of Agriculture Vietnam

1. Physical parameters
   - Pellet size
   - fines
   - Water stability
2. Nutritional specifications
   - Proximate composition
   - Lys/Met
   - Ca/P
3. Ingredient quality
   - NaCl
   - sand
4. Feed/food safety
   - Microbiology
   - Melamine
   - Antibiotics

No.	Item	Vannamei					
		No.1	No.2	No.3	No.4	No.5	No.6
	Approval						
1	Size/Shape	Crumble or Pellet	Crumble or Pellet	Crumble or Pellet	Pellet	Pellet	Pellet
	- Diameter	0.6	0.8	1.2	1.8	2.2	2.5
	- Length **Standard: Length / Diameter**	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2
	Crumble rate (%), max	1	1	1	1	1	1
2	Weight of shrimp/fish (g/pc)	0.1-1	1-3	3-8	8-12	12-20	> 20
3	Stability (hrs, min)	1-2	1-2	1-2	1-2	1-2	1-2
4	Metabolizable energy (Kcal/kg)						
6	Moisture (max)	11	11	11	11	11	11
7	Protein (min)	38	36	34	34	33	32
8	Digestible protein (min)						
9	Crude fat (min)	5-7	5-7	5-7	4-6	4-6	4-6
10	Crude fiber (max)	3	4	4	4	4	4
11	Ash (max)	14	14	15	15	16	16
12	Sand (Max)	1	1.2	1.3	1.5	1.5	1.7
13	Calcium (max)	2.3	2.3	2.3	2.3	2.3	2.3
14	Total phosphorus (max)						
15	Ca/P	1-1.5	1-1.5	1-1.5	1-1.5	1-1.5	1-1.5
16	NaCl	2	2	2	2	2	2
17	Lysin (min)	1.8	1.8	1.7	1.6	1.5	1.5
18	Methionine (min)	0.8	0.8	0.7	0.7	0.6	0.6
19	Insect	ND					
20	Salmonella	ND					
21	Aspergillus flavus	ND					
22	Aflatoxin B1 (ppb) (max)	10					
23	Melamine (ppm) (max)	2.5					
24	Antibiotic	ND					

Source: Coutteau & Wu (2015)

Recent developments in shrimp feeds & feeding

1 - Improved labeling & reporting of nutrient levels within feed ingredients & shrimp feeds for the benefit of the feed compounder, farmer & consumer - including (total or added)

including

Amino acids: Methionine, Lysine, Threonine, Histidine, Taurine etc

Fatty acids: 18:2n-6, 18:3n-3, 20:4n-6, 20:5n-3, 22:6n-3

Vitamins: A, D, E, K, C, B^1, B^2, B^6, B^{12}, Biotin, Choline, Inositol etc

Minerals: Ca, P, Mg, K, NaCl, Fe, Zn, Mn, Cu, Co, I, Se, Cr, Mo etc

Feed additives: Enzymes, Antioxidants, Binders, Probiotics etc

Energy: Gross & estimated digestible or metabolizable energy

- Use of specific controlled feed ingredients (GMO, ruminant etc)

- Estimated bioavailability of key nutrients – pepsin digestibility

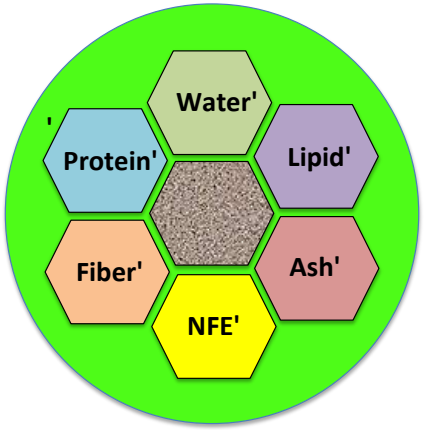
- Absence of specific adulterants – melamine, urea, mycotoxins

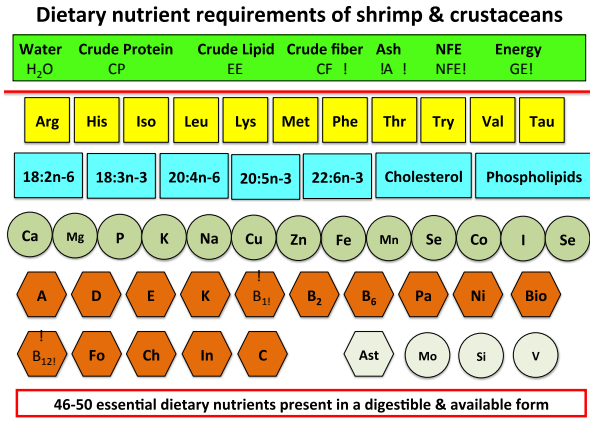
Recent developments in shrimp feeds & feeding

- Improved labeling & reporting of nutrient levels within feed ingredients & shrimp feeds

- **Improved feed formulation & reduced use of wild fish in shrimp feeds**

- Improved on-farm feed management practices tailored to the needs of small-scale shrimp farmers





Recent developments in shrimp feeds & feeding

2 - Improved feed formulation and reduced use of wild fish in shrimp feeds through:

- **the blending of different animal & plant feed ingredients with complementary dietary EAA profiles tailored to the EAA requirements of shrimp;**
- **the use of specific feed additives to make up the nutrient deficiencies within existing fishmeal replacers, including use of limiting EAA, trace minerals, sterols, emulsifiers, enzymes & feeding attractants;**
- **the determination of EAA bioavailability within feed ingredients & finished feeds using a combination of in-vivo digestibility techniques (through fecal collection) and in-vitro digestibility/hydrolysis techniques (through NIRs or pepsin digestibility);**

Shrimp & fish do not have a dietary requirement for protein *per se* but for the essential amino acids contained in the protein

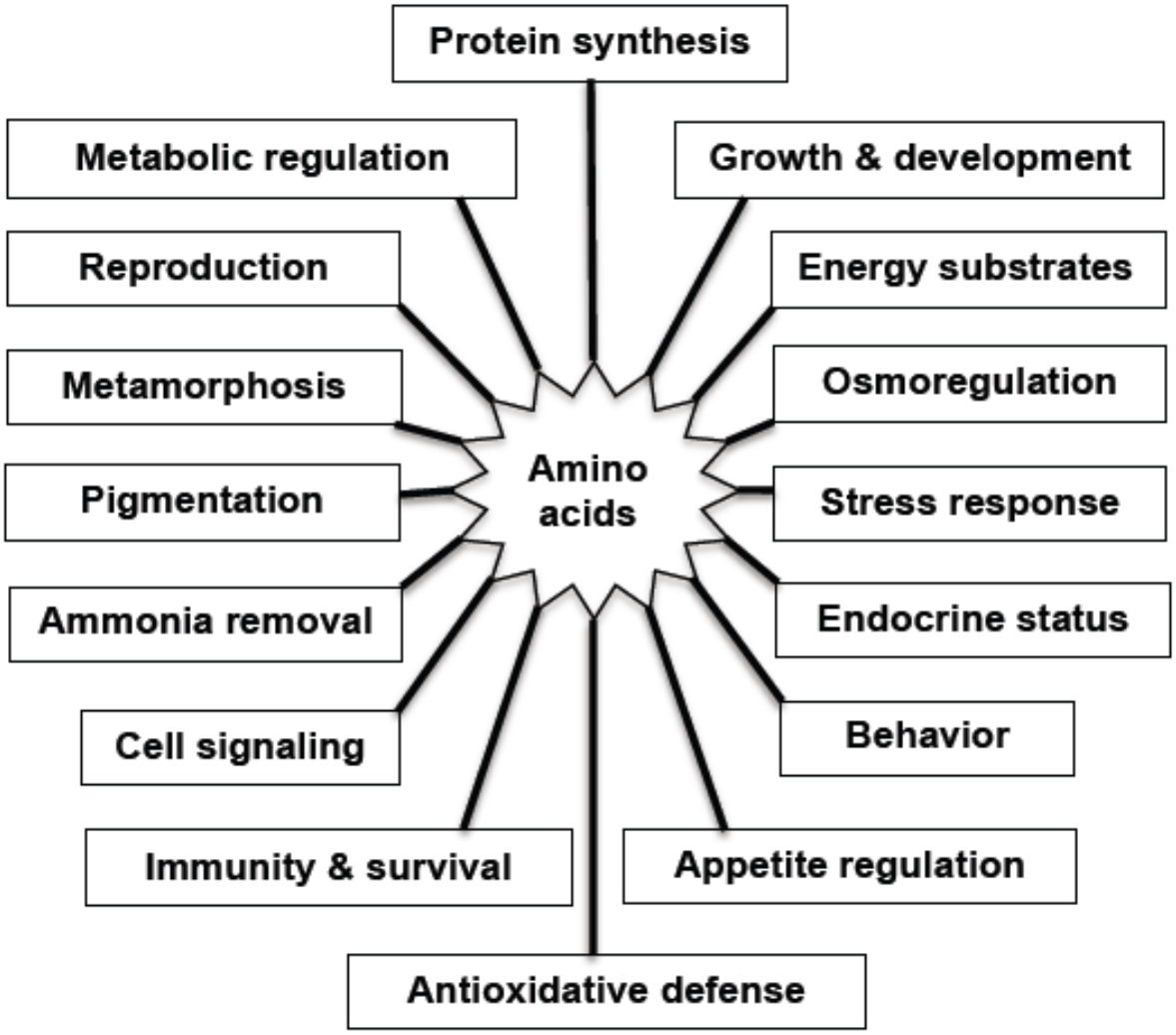
In general the nutritive value and ultimate biological value of a dietary protein source, whether it be fishmeal or soybean meal, will largely be determined by its amino acid composition, and in particular by its essential amino acid (EAA) profile, and their consequent biological availability to the animal – the closest that the EAA profile of the feed ingredient approximates to the EAA requirements of shrimp, the higher will be its nutritional value;

Essential amino acids can be defined as those amino acids that cannot be synthesized within the animal body or at a rate sufficient to meet the physiological needs of the growing animal, and must therefore be supplied in a ready made form in the diet.

Reported dietary essential & non-essential amino acids for fish & crustaceans (modified after Li et al. 2008; Wu, 2009)

Essential amino acids - EAA	Conditionally essential amino acids	Non-essential amino acids
Arginine (Arg) Histidine (His) Isoleucine (Iso) Leucine (Leu) Lysine (Lys) Methionine (Met) Phenylalanine (Phe) Threonine (Thr) Tryptophan (Trp) Valine (Val)	Cysteine (Cys) Glutamine (Gln) Glycine (Gly) Hydroxyproline (Hyp) Proline (Pro) Taurine[1/]	Alanine (Ala) Asparagine (Asn), Aspartate (Asp) Glutamate (Glu) Serine (Ser) Tyrosine (Tyr)

[1/] Taurine or 2-aminoethanesulfonic acid is a derivative of cysteine



Reported roles of amino acids in the growth, development and health of fish (modified after Li et al. 2008)

Reported major functions & metabolites produced from amino acids (modified after Li et al. 2008 & Wu, 2009).

Functions

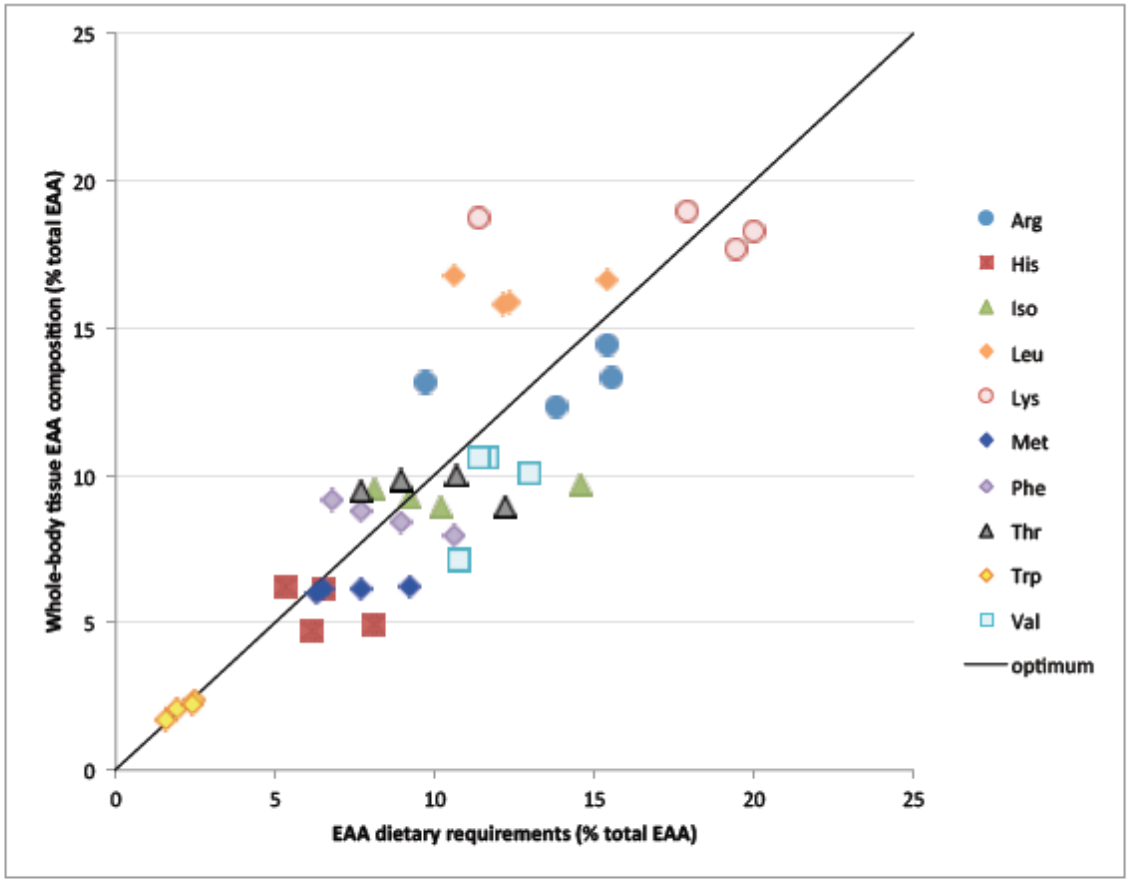
- Ammonia detoxification (glutamate, glutamine, citrulline);
- Antioxidative defense (glutathione, cysteine, glutamine, glycine, taurine);
- Appetite stimulation (Alanine, glutamate, proline, serine);
- Cell signaling (nitric oxide, arginine, glutamine, leucine, proline, polyamines);
- Energy utilization (nitric oxide, thyroxine, carnitine);
- Growth regulation (arginine, glutamine, hydroxyproline, leucine, thyroxine);
- Gut development (taurine, glutamine, arginine, threonine, polyamines);
- Immunity (nitric oxide, arginine, glutamine, dopamine);
- Metamorphosis (tyrosine, thyroxine, γ-Aminobutyrate);
- Neural development (nitric oxide, arginine, taurine, creatine);
- Osmoregulation (glycine, taurine, β-Alanine, arginine);
- Pigmentation (thyroxine, melanin);
- Reproduction (nitric oxide, polyamines, arginine, melatonin, hydroxyproline);
- Stress responses (tryptophan, serotonin, leucine, isoleucine, valine, glutamine);
- Suppression of aggressive behavior (tryptophan, serotonin)

Reported major functions & metabolites produced from amino acids (modified after Li et al. 2008 & Wu, 2009).

Metabolites
• **β-Alanine:** Dipeptides (carnosine, carcinine, anserine, balenine), component of coenzyme A and pantothenic acid; • **Arginine:** Nitric oxide, citrulline, ornithine, proline, glutamate, polyamines, creatine; • **Aspartate:** Purine, pyrimidine, asparagine, arginine, inositol, β-Alanine; • **Cysteine:** Taurine, glutathione, SO_4, H_2S; • **Glutamate:** Glutamine, citrulline, argine, γ-Aminobutyrate, glutathione; • **Glutamine:** Purine, pyrimidine, ornithine, citrulline, arginine, proline, asparagines, amino sugars (glucosamine), ammonia; • **Glycine:** Creatine, glutathione, purines, porphyrins, heme (hemoproteins); • **Histidine:** Histamine, carnosine, anserine, balenine, 3-methylhistidine, urocanic acid; • **Isoleucine:** Glutamine, alanine; • **Leucine:** Glutamine, alanine, hydroxyl-β-methyl-butyrate; • **Lysine:** Cadaverine (polyamine), carnitine, trimethyllysine, OH-lysine;

Reported major functions & metabolites produced from amino acids (modified after Li et al. 2008 & Wu, 2009).

Metabolites
• **Methionine (EAA):** Homocysteine, betaine, choline, cysteine, S-Adenosyl methionine (the source of methyl groups for methylations), creatine, polyamines (spermine and spermidine), taurine, phospholipids, carnatine; • **Phenylalanine (EAA):** Tyrosine, melatonin; • **Proline (cEAA):** H_2O_2; P5C (Pyrroline-5-carboxylate), hyroxyproline; • **Serine (NEAA):** Cysteine, purine, pyrimidine, ceramide, lipoproteins (Phosphatidyl-serine, phosphatidyl-ethanolamine), glycine, carnitine; • **Threonine (EAA):** Glycine, mucin protein; • **Tryptophan (EAA):** Niacin, serotonin, tryptamine, N-acetylserotonin, anthranilic acid; • **Tyrosine (NEAA):** Dopa (3,4 dihydroxyphenylanaine), dopamine, norepinephrine, epinephrine, melanin, triiodothyroxine, thyroxine); and • **Valine (EAA):** Glutamine, alanine.



Relationship between pattern of essential amino acid (EAA) requirements of four major cultured fish species and the profile of the same amino acids in the whole-body fish carcass of the same species. The line represents coincidence of requirement and tissue pattern.

(data expressed as % total EAA for Rainbow trout, Channel catfish, Common carp and Tilapia)

Reported whole-body AA composition (g AA/100g total AA) of different fish & shrimp

Amino acid (AA)	RaT[1]	AtS[1]	ChC[1]	LaB[1]	CoC[2]	Til[2]	StB[2]	Mil[2]	Fish[3]	Shrimp[3]	WhS[4]
Alanine (NEAA	6.6	6.5	6.3	6.0	6.3	6.2	6.3	6.3	6.6	6.1	5.6
Arginine (EAA)	6.4	6.6	6.7	8.5	6.2	6.4	6.2	6.2	6.6	8.3	8.9
Aspartate (NEAA)	9.9	9.9	9.7	11.8	10.6	11.6	10.6	10.6	9.8	10.5	9.9
Cystei`ne (cEAA)	0.8	1.0	0.9	0.8	1.1	1.1	1.1	1.1	1.0	1.0	1.0
Glutamate (NEAA)	14.2	14.3	14.4	13.3	15.5	16.2	15.5	15.4	15.3	15.8	14.9
Glycine (cEAA)	7.8	7.4	8.1	7.8	5.0	5.2	5.0	5.0	7.3	6.3	7.5
Histidine	3.0	3.0	2.2	2.1	3.1	2.4	3.1	3.1	2.6	2.3	2.2
Isoleucine	4.3	4.4	4.3	4.0	4.8	4.7	4.8	4.8	4.6	4.5	4.1
Leucine	7.6	7.7	7.4	8.0	8.4	8.1	8.4	8.4	7.7	7.7	7.2
Lysine	8.5	9.3	8.5	8.1	9.5	9.1	9.5	9.5	7.9	8.1	5.3
Methionine	2.9	1.8	2.9	2.6	3.1	3.0	3.1	3.1	2.9	2.7	2.1
Phenylalanine	4.4	4.4	4.1	4.0	4.0	4.1	4.0	4.1	4.4	4.3	5.5
Proline (cEAA)	4.9	4.6	6.0	6.0	3.7	3.8	3.7	3.7	4.7	3.9	7.0
Serine (NEAA)	4.7	4.6	4.9	4.2	4.2	4.1	4.2	4.2	4.4	4.1	4.2
Threonine	4.8	5.0	4.4	4.4	4.5	4.8	4.5	4.5	4.7	4.0	4.1
Tryptophan	1.0	0.9	0.8	0.9	1.2	1.1	1.2	1.2	1.1	1.1	0.9
Tyrosine (NEAA)	3.4	3.5	3.3	2.8	3.5	3.4	3.5	3.5	3.2	4.1	4.2
Valine	5.1	5.1	5.2	4.6	5.3	4.9	5.3	5.3	5.1	5.0	4.5
Sum EAA	48.0	48.2	46.5	47.2	50.1	48.6	50.1	50.2	47.6	48.0	44.8

[1] NRC (2011) where RT is Rainbow trout, AS is Atlantic salmon, CC is Channel catfish, LB is Largemouth bass; [2] USDA/ARS (2011) where CoC is Common carp, Til is Tilapia, StB is Striped bass, and Mil is Milkfish – all data is for 100g edible portion; [3] Kaushik & Seiliez (2010) where Fish & Shrimp represent means for numerous published analyses for cultured fish and Penaeid shrimp species; [4] WhS – Pacific white shrimp – whole (Tacon et al. 2002)

Calculated essential amino acid score of different feed ingredients compared with the estimated EAA requirement profile of shrimp

Essential amino acids	Arg	Cys	Met	Thr	Iso	Leu	Lys	Val	Tyr	Try	Phe	His
Fishery products	*Methionine: 90-209, Lysine 107-146, Threonine 87-107, Histidine 95-272*											
Anchovy fishmeal	59	95	140	106	112	106	143	116	82	128	83	112
Menhaden fishmeal	63	90	138	101	115	106	146	118	78	122	81	109
Herring fishmeal	64	100	140	104	107	104	143	127	76	122	78	109
Tuna fishmeal	66	85	129	107	110	99	143	113	77	117	81	151
White fishmeal	72	110	138	107	107	103	145	111	76	117	77	105
Fish solubles, condensed	65	100	136	87	96	106	136	111	40	128	78	272
Fish soluble, dehydrated	66	140	117	105	105	95	145	102	49	261	70	198
Shrimp meal (process residue)	86	125	102	106	111	101	107	112	79	100	99	112
Shrimp head meal	63	85	209	96	93	87	110	108	98	117	136	100
Krill meal	64	122	137	102	117	103	135	107	94	121	90	95
Squat lobster/langostilla meal	58	100	90	104	102	91	122	122	117	150	87	188
Squid meal	65	140	107	106	96	98	125	102	100	178	85	172
Squid liver meal	63	120	112	96	121	91	112	99	76	244	86	230

Ingredient scores calculated against the estimated EAA dietary requirement profile of White shrimp expressed as % total amino acids: Arg 9.70%, Cys 1.03%, Met 2.13%, Thr 4.0%, Iso 4.13%, Leu 7.13%, Lys 5.35%, Val 4.57%, Tyr 4.13%, Tryp 0.91%, Phe 4.97%, His 2.16% & Tau 0.75%; Source: Tacon et al. (2002) – Aquaculture Nutrition 8:121-137).

Calculated essential amino acid score of different feed ingredients compared with the estimated EAA requirement profile of shrimp

Essential amino acids	Arg	Cys	Met	Thr	Iso	Leu	Lys	Val	Tyr	Try	Phe	His
Livestock products	*Methionine: 33-99, Lysine 49-138, Threonine 94-105, Histidine 46-209*											
Blood meal, spray dried (BM)	37	83	38	94	23	158	135	167	55	127	122	209
Feather meal, hydrolyzed (HFM)	79	424	33	119	117	122	49	166	72	83	85	46
Meat and bone meal (MBM)	85	122	82	104	93	110	125	127	69	94	87	119
Meat meal (MM)	86	146	80	97	100	106	138	129	53	100	85	107
Poultry byproduct meal (PBM)	80	171	99	104	109	114	114	122	63	99	84	109
BM:HFM (1:1 ∑AA basis) – blend A	58	253	35	106	70	140	92	166	63	105	103	127
A:PBM (1:1) – blend B	98	212	67	105	89	127	103	144	63	102	93	118
Invertebrate products	*Methionine: 61-93, Lysine 118-140, Threonine 27-125, Histidine 98-194*											
Soldier fly larvae	50	21	93	27	107	108	140	164	134	48	97	194
Earthworm meal	85	122	82	104	93	110	125	127	69	94	87	119
Marine polychaete meal	84	102	61	125	108	114	118	115	89	88	79	98

Ingredient scores calculated against the estimated EAA dietary requirement profile of White shrimp expressed as % total amino acids: Arg 9.70%, Cys 1.03%, Met 2.13%, Thr 4.0%, Iso 4.13%, Leu 7.13%, Lys 5.35%, Val 4.57%, Tyr 4.13%, Tryp 0.91%, Phe 4.97%, His 2.16% & Tau 0.75%; Source: Tacon et al. (2002) – Aquaculture Nutrition 8:121-137).

Calculated essential amino acid score of different feed ingredients compared with the estimated EAA requirement profile of shrimp

Essential amino acids	Arg	Cys	Met	Thr	Iso	Leu	Lys	Val	Tyr	Try	Phe	His
Protein-rich cereal products *Methionine: 75-120, Lysine 30-128, Threonine 82-135, Histidine 70-163*												
Brewers grains (5-02-141)	49	127	80	89	143	137	64	133	113	155	112	93
Corn gluten feed	49	249	116	107	91	155	59	125	97	99	87	158
Corn gluten meal (60% protein)	32	166	120	82	93	221	30	100	123	61	122	93
Corn DDGS	45	156	99	102	132	196	53	140	81	66	124	126
Corn germ meal	64	249	139	135	85	110	80	131	67	121	82	163
Leaf protein concentrate	60	78	75	112	108	120	111	127	89	149	113	95
Potato protein concentrate	41	146	106	114	123	115	121	107	125	110	109	70
Wheat germ meal	85	190	87	108	92	87	128	116	80	144	86	128
Wheat gluten meal	48	283	99	85	115	131	41	113	112	133	140	128
Rice protein concentrate	78	200	116	94	94	113	57	119	128	144	104	100

Ingredient scores calculated against the estimated EAA dietary requirement profile of White shrimp expressed as % total amino acids: Arg 9.70%, Cys 1.03%, Met 2.13%, Thr 4.0%, Iso 4.13%, Leu 7.13%, Lys 5.35%, Val 4.57%, Tyr 4.13%, Tryp 0.91%, Phe 4.97%, His 2.16% & Tau 0.75%; Source: Tacon et al. (2002) – Aquaculture Nutrition 8:121-137).

Essential amino acids	Arg	Cys	Met	Thr	Iso	Leu	Lys	Val	Tyr	Try	Phe	His
Oilseed protein products	*Methionine: 47-137, Lysine: 49-119, Threonine: 73-124, Histidine: 86-149*											
Canola meal, solvent extracted	66	195	199	115	102	103	116	115	69	144	89	149
Canola protein concentrate	71	219	104	110	100	111	113	113	69	149	85	123
Rapeseed meal, mech. extracted	66	102	104	124	109	110	102	127	67	160	92	137
Rapeseed meal, solv. extracted	67	112	101	123	103	110	119	123	60	149	89	142
Coconut kernel (endosperm) dry	138	112	92	84	97	95	66	120	66	116	92	98
Copra meal, mech. extracted	131	136	82	89	107	103	60	121	67	116	91	88
Copra meal, solv.extracted	130	127	78	87	106	106	59	120	73	116	91	93
Cotton seed (kernel), whole	122	156	64	87	84	87	86	106	74	144	110	132
Cottonseed meal, mech.extract.	113	185	71	88	92	88	79	115	67	155	114	126
Cottonseed meal, solv.extract.	118	176	71	85	89	82	89	109	61	149	121	128
Cottonseed meal (dehul solv. ext)	118	239	85	98	88	76	75	112	46	160	125	132
Linseed/flax (kernel)	103	195	97	99	109	89	74	123	69	177	101	100
Linseed meal, mech.extracted	98	180	87	97	135	91	73	120	73	188	95	98
Linseed meal, solv.extracted	96	185	78	98	134	91	68	120	85	177	95	102
Oil palm seed (kernel)	143	176	113	81	87	87	67	123	67	105	77	100
Oil palm (kernel), solv. extracted	143	161	92	89	91	98	59	105	67	127	93	86
Peanut meal, mechan.extracted	123	171	54	73	96	99	66	106	95	121	110	116
Peanut meal, solvent extracted	121	151	47	79	101	98	75	100	98	121	105	119
Sesame seed (kernel)	127	180	134	90	89	96	52	102	78	149	91	114
Sesame oilcake, mech. extract.	116	176	137	90	98	97	49	105	92	149	92	112
Soybean seed, heat processed	74	122	64	105	126	99	116	116	76	149	105	116
Soybean meal, undec.mech.extr.	70	122	66	94	142	113	113	109	83	149	96	114
Soybean meal, undec.solv.extr.	79	161	61	98	115	106	119	105	79	160	98	121
Soybean meal, dehulled,solv.extr.	77	146	66	97	113	105	118	112	85	149	101	114
Soybean protein concentrate	79	132	68	99	117	104	117	109	84	133	100	123
Sunflower seed (k ernel) withhulls	93	161	99	104	118	101	77	124	51	166	101	123
Sunflower seed, decor. mech.extr	97	180	130	93	120	91	80	119	64	149	101	116
Sunflower seed, decor. solv.extr.	92	156	115	98	115	102	75	125	64	144	101	114

Calculated essential amino acid score of different feed ingredients compared with the estimated EAA requirement profile of shrimp

Essential amino acids	Arg	Cys	Met	Thr	Iso	Leu	Lys	Val	Tyr	Try	Phe	His
Pulse/grain legume products *Methionine: 28-82, Lysine 105-162, Threonine 81-122, Histidine 119-195*												
Pigeon pea	56	102	28	81	85	100	162	88	55	72	188	195
Jack bean	53	127	68	122	107	112	113	111	93	144	114	137
Chickpea	96	112	47	93	106	104	127	98	70	94	113	121
Egyptian bean	70	97	28	89	107	120	142	111	83	83	104	149
Lentil	88	88	35	98	103	106	133	109	78	105	104	126
Lupin	104	141	38	98	113	108	105	94	91	116	98	128
African locust bean	71	127	49	87	106	106	133	114	96	110	105	137
Lima bean	59	97	59	102	117	111	136	109	76	110	118	142
Kidney bean	62	97	54	107	109	114	144	108	66	121	112	142
Pea/field pea	74	88	52	103	115	107	123	114	84	99	105	126
Pea protein concentrate	97	117	38	90	102	38	137	101	75	105	101	119
Urd	59	73	26	87	198	103	157	93	63	88	102	139
Broad bean	96	68	45	99	104	103	127	111	89	110	90	121
Cowpea	71	112	59	97	100	106	138	107	68	127	112	163
Bambarra groundnut	66	97	82	88	107	111	122	117	85	121	114	139
Ground bean	66	93	66	95	108	106	123	136	84	83	115	128

Ingredient scores calculated against the estimated EAA dietary requirement profile of White shrimp expressed as % total amino acids: Arg 9.70%, Cys 1.03%, Met 2.13%, Thr 4.0%, Iso 4.13%, Leu 7.13%, Lys 5.35%, Val 4.57%, Tyr 4.13%, Tryp 0.91%, Phe 4.97%, His 2.16% & Tau 0.75%; Source: Tacon et al. (2002) – Aquaculture Nutrition 8:121-137).

Calculated essential amino acid score of different feed ingredients compared with the estimated EAA requirement profile of shrimp

Essential amino acids	Arg	Cys	Met	Thr	Iso	Leu	Lys	Val	Tyr	Try	Phe	His
Single cell proteins												
Pseudomonas/Methylophilus sp	55	58	120	120	118	111	117	133	95	127	90	102
Mixed bacterial SCP	73	68	130	113	108	110	106	127	86	149	84	102
Brewers yeast (*S. cerevisiae*)	53	122	82	127	121	102	137	123	85	144	85	121
Extracted yeast (*S. cerevisiae*)	48	122	85	118	114	123	124	131	87	133	91	109
Torula yeast (*T. utilis*)	51	112	68	124	131	94	133	122	92	105	110	119
Candida spp. (alkane substrate)	44	112	97	137	124	113	126	125	93	155	86	95
Aspergillus oryzae (waste starch)	58	98	58	117	111	106	108	122	154	160	72	114
Rhodotorula pilimanae	78	24	118	134	103	99	163	118	66	33	69	123
Spirulina maxima	68	54	82	115	145	115	86	135	103	155	88	77
Activated bacterial SCP (brewery)	55	78	99	117	123	106	121	115	102	160	99	100
Fermamino bacterial SCP	62	72	110	465	113	104	101	132	81	81	79	171

Ingredient scores calculated against the estimated EAA dietary requirement profile of White shrimp expressed as % total amino acids: Arg 9.70%, Cys 1.03%, Met 2.13%, Thr 4.0%, Iso 4.13%, Leu 7.13%, Lys 5.35%, Val 4.57%, Tyr 4.13%, Tryp 0.91%, Phe 4.97%, His 2.16% & Tau 0.75%; Source: Tacon et al. (2002) – Aquaculture Nutrition 8:121-137).

Observed variations in key EAA within commercial shrimp feeds in selected Asian Countries

Total levels not available levels

Thailand	CP	MET	CYS	M+C	LYS	THR
Average	35.82	0.77	0.48	1.25	1.96	1.32
Min	30.71	0.52	0.40	0.97	1.72	1.15
Max	41.05	1.61	0.58	2.18	2.33	1.58
Stdev	2.83	0.27	0.06	0.30	0.15	0.11
Malaysia						
Average	40.43	0.82	0.59	1.41	2.25	1.49
Min	40.06	0.81	0.59	1.41	2.09	1.48
Max	40.80	0.82	0.60	1.41	2.40	1.50
Stdev	0.52	0.01	0.00	0.00	0.22	0.01
Vietnam						
Average	40.99	0.77	0.48	1.25	2.31	1.48
Min	40.64	0.72	0.46	1.20	2.19	1.45
Max	41.90	0.81	0.47	1.27	2.34	1.49
Stdev	0.52	0.04	0.00	0.03	0.07	0.02
India						
Average	35.28	0.61	0.43	1.04	2.00	1.31
Min	32.08	0.47	0.39	0.88	1.71	1.16
Max	39.42	0.81	0.50	1.21	2.37	1.46
Stdev	2.01	0.09	0.03	0.10	0.20	0.09
Indonesia						
Average	34.92	0.63	0.51	1.14	1.89	1.27
Min	30.65	0.49	0.42	0.98	1.51	1.12
Max	37.98	0.81	0.60	1.28	2.30	1.42
Stdev	3.04	0.12	0.08	0.12	0.32	0.13

SHRIMP NUTRITION & FEEDING

A SELECTED ANNOTATED BIBLIOGRAPY

1971 - 2014

compiled by

Albert G.J. Tacon, Thiago Raggi & Daniel Lemos

Laboratório de Aquicultura
Instituto Oceanográfico
Universidade de São Paulo
São Paulo, Brasil

for

The CNPq Research Project

Feeding Tomorrow's Fish:
Environmental and Economically Sustainable
Aquafeeds and Feeding Regimes for
Marine Aquaculture

AquaMar

São Paulo, April 2014

SUBJECT INDEX

789 pages, excluding index

166 refs
30 C J Refs

Huang, K., Wang, W., & Li, C. (2003). Requirement of essential amino acids for *Penaeus vannamei*. Journal of Fisheries of China/Shuichan Xuebao, 27(5), 456-461.

Feeding experiments were conducted with protein diets (PD) and protein-free diets (FPD) for juvenile Penaeus vannamei (average body weights, 0.2627-0.2715 g). The diets (PD) are prepared by casein and gelatin as protein source with high biological values. The requirements of juvenile *Penaeus vannamei* for essential amino acids (EAA) were determined based on the daily deposition and changes of each EAA in shrimp body.

Xiamen,12-16 Nov 2013

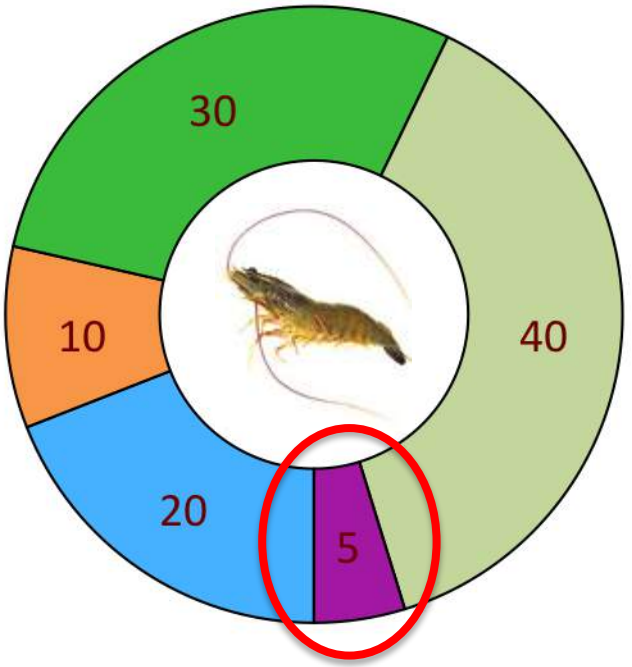
Ingredients commonly used in feeds for PENAEID SHRIMP SPECIES

Aquatic protein meals & oils	5-20%
Fishmeals & oil: wild & farmed	5-20
Squid meal, krill meal	2-10
Seaweed meals & products	1-5
Cultured microbial biomass	1-5

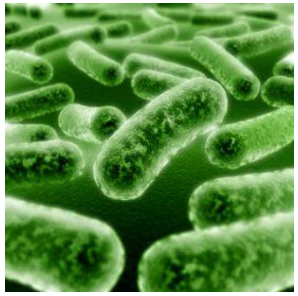
Terrestrial animal proteins & oils	5-10%
Poultry by-products	5-10
Porcine by-products	2-5
Ruminant by-products	2-5
Terrestrial invertebrates	1-5

Terrestrial plant proteins & oils	10-30%
Oilseed protein by-products	10-30
Cereal protein by-products	5-15
Pulse protein by-products	5-15
Other plant proteins	5-15

Other plant meals & fillers	25-40%
Cereal meals & by-products	15-50
Root meals & extracts	2-10
Fruit meals & by-products	1-5
Forage & leaf meals	1-5



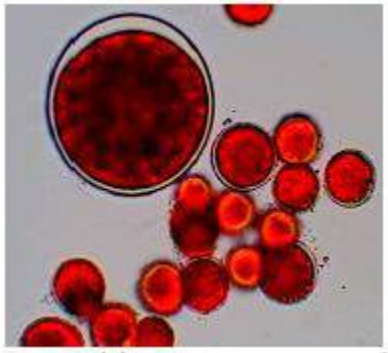
Feed additives	0-5%
Vitamins, antioxidants, emulsifiers & pigments	
Minerals, trace elements, salt	
Amino acids, **nucleotides, feeding attractants, enzymes**	
Gut modifiers, prebiotics, probiotics, acidifiers	
Immune enhancers, anti-fungal, anti-viral, anti-parasitical	
Binders, growth promoters, hormones, antibiotics	



Feed Additives

these are usually mixed with the diet when it is manufactured

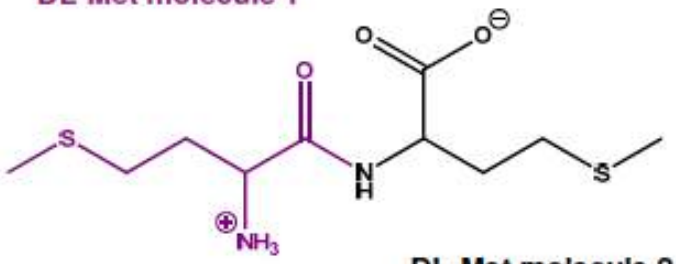
Vitamins, pigments, antioxidants & emulsifiers
Minerals, trace elements, salt, limestone, zeolite
Amino acids, nucleotides, feeding attractants
Enzymes, gut modifiers, prebiotics, probiotics, acidifiers
Immune enhancers, anti-fungal, anti-viral, anti-parasitical
Binders, growth promoters, hormones, antibiotics



AQUAVI® Met-Met: the second generation methionine source for crustaceans

Coming soon

DL-Met molecule 1



DL-Met molecule 2

Amino acids and more.

AQUAVI® Met-Met

is the first **dipeptide** designed for the crustaceans' industry.

Minimized **leaching** and optimized **nutrients' syncronicity:** – a new era in the aqua feed industry.

Improving the utilization of feed ingredients

Use of renewable nutrient sources

EXOGENOUS ENZYMES

- **Releasing nutrient trapped in complex biopolymers**
- **Breakdown of anti-nutrients**
- **Reducing residues from farming operations (environment)**
- **Assisting in gut health**
- **Improving feed consistency**

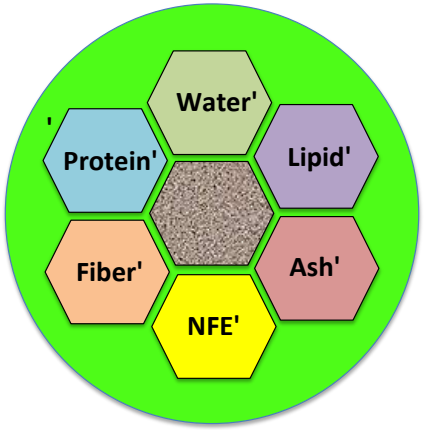
Phytase	β – glucanase	Amylase	Lipase	Mannanase
Xylanase	Cellulase	Protease	Micotoxinase	α - galactosidase

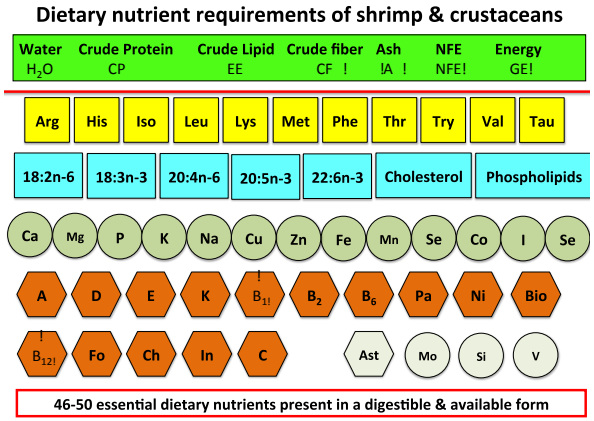
Recent developments in shrimp feeds & feeding

- Improved labeling & reporting of nutrient levels within feed ingredients & shrimp feeds

- Improved feed formulation & reduced use of wild fish in shrimp feeds

- **Improved on-farm feed management practices tailored to the needs of small-scale shrimp farmers**





Recent developments in shrimp feeds & feeding

3 - Development of improved on-farm feed management practices tailored to individual farm conditions & the needs of small-scale shrimp farmers through;

- **the use of improved feed transportation & storage techniques;**
- **the use of improved record keeping & financial control;**
- **the use of improved on-farm feed & water management, including natural food production & control.**

USAID
FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

TRAINING WORKSHOP ON THE PROMOTION OF IMPROVED ON-FARM SHRIMP FEED MANAGEMENT PRACTICES

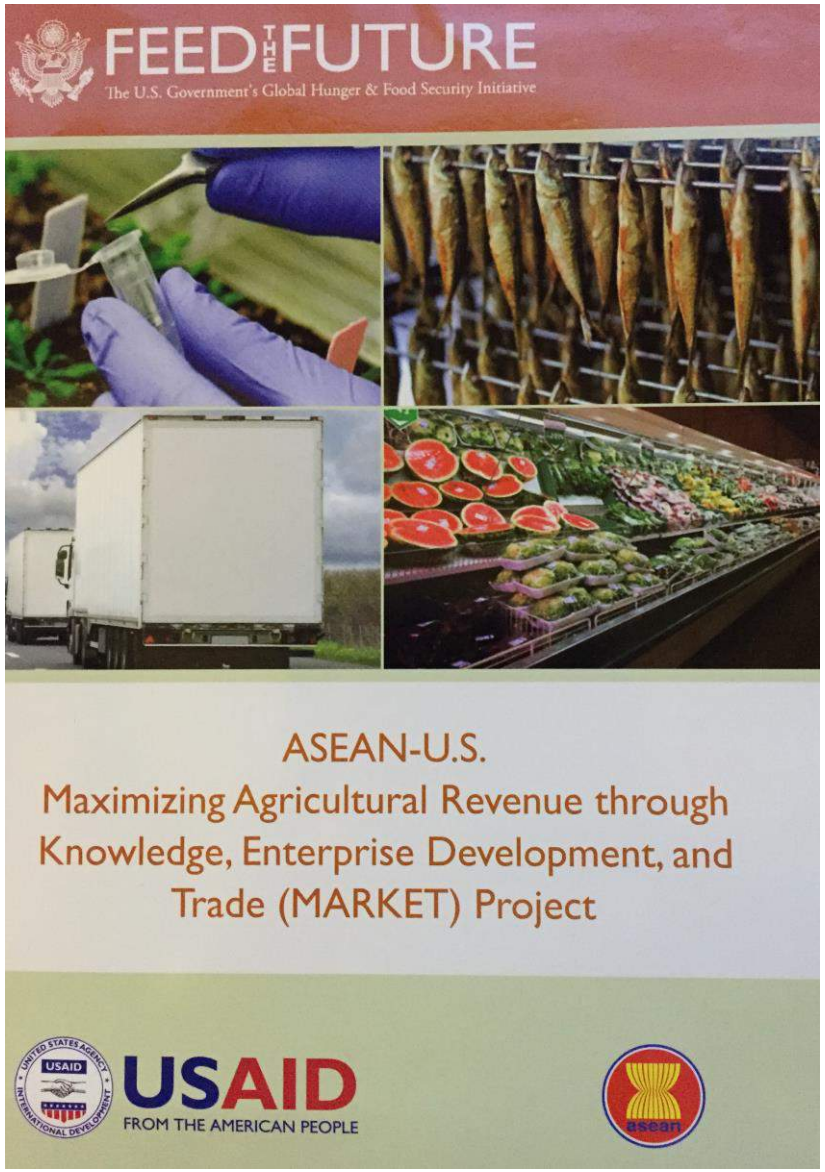
USAID – MARKET: Project & Background

The Maximizing Agricultural Revenue through Knowledge, Enterprise Development and Trade Project

Promotes more sustainable and efficient use of aquaculture & fishery resources in ASEAN region

The three and half year project began in late 2011, is implemented by Nathan Associates Inc. in partnership with ASEAN, and is part of

The US Feed the Future Global Hunger & Food Security Initiative



USAID-MARKET Project & Background

Long-term objective of USAID – MARKET Project:

- **Improved practices adopted by small-holder producers in the aquaculture & fishery industry in the ASEAN region.**
- **Increased public-private coordination & partnerships addressing key sustainable aquaculture & fishery sector issues in the ASEAN region.**
- **Improved policy & regulatory environment for sustainable & inclusive aquatic resources management within ASEAN.**

SMALL-SCALE FARMERS – the weakest link

- Need for the resident feed industry, government extension services, & farmer associations to closely monitor & support small-scale farmers, which currently represents the weakest link within most ASEAN countries, and the sector most vulnerable to the possible use of unsustainable farming practices & potential disease risks;

- Estimated that up to 80% of Asia's aquaculture farms are small-scale operations that contribute significantly to development of rural livelihoods. Disease outbreaks, poor production practices and market pressures threaten the livelihoods of local operators. In ASEAN, public sector extension services exist, yet rarely focus or target the typical farmer smallholder, particularly in aquaculture'.

March 5, 2015

United States: Washington DC—FDA Crackdown on Imported Shrimp with Antibiotics

New data released by the USA Food and Drug Administration (FDA) indicates that of the 114 seafood shipments (called "entry lines" in FDA's reports) were refused in January 2015, 24 were of imported shrimp with veterinary drug residues.

The FDA's report for February continues to provide evidence of a crackdown on shrimp imports contaminated with banned antibiotics. The report also demonstrates that problems with banned antibiotics in shrimp aquaculture have been limited to a small number of countries. In particular, of the 1,025 shipments of shrimp refused for reasons related to veterinary drug residues since 2002, over 90% (928) were shipped from just five countries: China, Malaysia, Vietnam, India & Indonesia.

Source:
https://www.shrimpnews.com/FreeReportsFolder/NewsReportsFolder/USAdcFDAcrackdownOnAntibiotics.html

USAID FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

PROJECT TRAINING APPROACH & IMPLEMENTATION

Focus: as recommended by the 2nd Taskforce meeting, training should be needs driven, and based on the perceived needs of the shrimp farm surveys conducted by the Project in May 2014 in Indonesia (Banyuwangi area), Thailand (Khon Kean area) & Vietnam (Soc Trang/Ca Mau area) – focus on small-scale shrimp farmers

PROJECT TRAINING APPROACH & IMPLEMENTATION

Common gaps & needs identified from the three shrimp farm surveys conducted were as follows:

- Knowledge & understanding on feed costs & record keeping
- Knowledge on feed characteristics: water stability, proximate composition & nutrient content, labeling, shelf life etc
- Knowledge & understanding on the use of feed additives
- Knowledge on optimum feeding time & feeding methods
- Knowledge on monitoring feed efficiency & shrimp performance
- Knowledge & use of suitable environmental monitoring methods
- Knowledge on disease identification & prevention methods

TRAINING PROGRAM APPROACH

Trainer Training workshops (TOT): Two-day TOTs to be held in Indonesia, Thailand and Vietnam for 20-25 trainers per country, with 1st day dedicated to lectures, and the day dedicated to shrimp farm visits and a group discussion of observed on-farm feed management practices with simultaneous translation

Farmer Training workshops: Farmer training workshops to be held in Indonesia, Philippines, Thailand & Vietnam for 50-100 farmers over a half to one day period in local language by selected trainers from the TOT program, and based on relevant materials presented during the TOT but adjusted to local farmer needs & conditions, aimed at assisting small-scale farmers how to improve and optimize their on-farm feed management practices

Special Regional Training workshop: Tailored more to the needs of the shrimp feed manufacturing sector within the region, and also to present the project results and findings, and discuss potential project follow-up activities

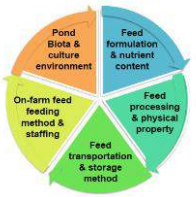
Workshop Approach – so facilitating active participation & discussion

The overall objective of the training is to help small-scale shrimp farmers within the region with the adoption of `Improved On-Farm Feed Management Practices', through

- **The use of improved record keeping & understanding of shrimp feed & feeding costs,**
- **The use of improved feed transportation and on-farm feed storage methods,**
- **The use of improved on-farm shrimp feeding methods tailored to farmer needs and financial resources,**
- **The promotion of improved technical support by feed companies to meet small-scale shrimp farmer needs concerning on-farm feed management,**
- **The promotion of increased public-private partnerships addressing the special needs of small-scale shrimp farmers in the region**

TRAINING WORKSHOP ON THE PROMOTION OF IMPROVED ON-FARM SHRIMP FEED MANAGEMENT PRACTICES

ON-FARM SHRIMP FEED MANAGEMENT



Need for definition:

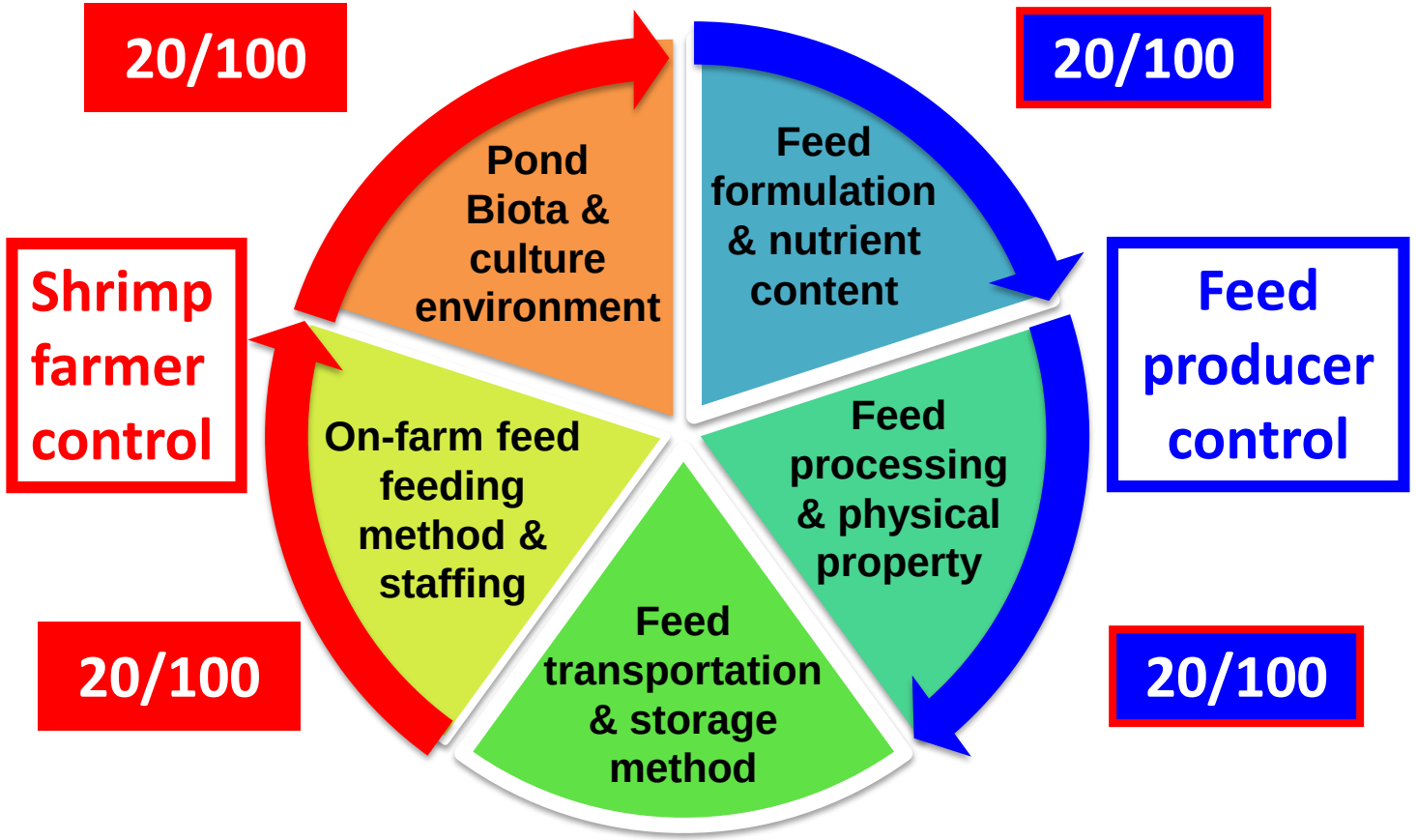
On-farm Feed Management

" covers all those activities conducted by the farmer & his or her staff concerning the handling, storage & use of shrimp feed on the farm "




Main Factors Influencing Shrimp Feed Performance

Training approach



20/100

20/100

Shrimp farmer control

Feed producer control

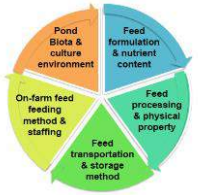
20/100

20/100

10/100

10/100

Trainer of Trainer TOT workshop schedule



Day 1:

- Objective of the workshop & introduction of participants (8)
- Main factors affecting feed performance & importance of feed management (41)
- Knowing your feed costs & importance of good record keeping (32)
- Feed types, feed labels & importance of national feed legislation (46)
- Feed transportation & on-farm feed storage: do's and dont's (53)
- Feed additives, top dressing feeds & potential feed biosecurity risks (62)
- Feeding habits, nutrient leaching & importance of natural foods (79)
- Feeding methods, feeding tables & choice of feeding method (167)
- Importance of good pond & water management, including nutrient recycling (92)

Day 2:

- Shrimp farm visits (2-3)
- Group discussion on observed on-farm shrimp feed management practices
- Group discussion on training needs of small-scale farmers, including follow-up
- Closing & presentation of TOT training certificates/thumb drive with presentations

USAID FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

VIETNAM:

Trainer Training workshops (TOT)

Date of TOT:	**January 15-16, 2015**	
Venue of TOT:	**Ngoc Suong Hotel, Soc Trang, Vietnam**	
Local MARKET support staff/consultants:	**Mr Lap Dinh Xuan (ICAFIS, Hanoi)** **Ms Tung Nguyen Thi Thanh (ICAFIS, Hanoi)** **Ms Thuy Cu Thi Le (MARKET staff, Hanoi)** **Dr Jesper Hedegaard (MARKET consultant, Bangkok)** **Dr Albert Tacon (MARKET consultant, USA)**	
Translator:	**Dr. Nguyen Nhu Tri (Nong Lam University, HCMC)**	
Participants + MARKET staff/consultants:	**Total participants + others**	**35 + 5**
	Shrimp farmers/representatives	**13**
	Government/extension staff	**10**
	University staff, including translator	**6**
	Feed company representatives	**4**
	NGOs (WWF, Can Tho)	**2**
	ICAFIS staff	**2**
	MARKET staff/consultants	**3**
Farm visit/s:	**My Thanh Shrimp Association shrimp farm/s, Soc Trang**	

USAID
FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

VIETNAM TOT

Dr Nguyen Nhu Tri


Thảo Phương
83B-006.56

USAID FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

NATIONAL FARMER TRAINING - VIETNAM

Three national training workshops held on 6th February in Soc Trang, Bac Lieu and Ben Tre by three different extension workers from extension centers of those three provinces, namely:

- **Mr. Vo Van Be - Extension Center of Soc Trang Province, will conduct the training in Soc Trang: 35 farmers trained**
- **Mr. Huynh Quoc Khoi - Extension Center of Bac Lieu Province, will conduct the training in Bac Lieu: 35 farmers trained**
- **Mr. Chau Huu Tri - Extension Center of Ben Tre Province, will conduct the training in Ben Tre: 36 farmers trained**

Total farmers trained to date: 106 farmers


THANH SHRIMP ASSOCIATION
FARMERS TRAINING/TẬP HUẤN CHO NÔNG DÂN

USAID FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

INDONESIA:

Triner Training workshops (TOT)

Date of TOT:	**January 21-22, 2015**	
Venue of TOT:	**Ketapang Indah Hotel, Banyuwangi, Indonesia**	
Local MARKET support staff/consultants:	**Dr Agus Suprayudi (MARKET feed consultant, Bogor)** **Ms Linny Ayunahati (MARKET staff, Jakarta)** **Ms Bellatrix Bogar (MARKET staff, Jakarta)** **Dr Albert Tacon (MARKET consultant, USA)**	
Translator:	**Dr. Julie Ekasari (Bogor Agricultural University, Bogor)**	
Participants + MARKET staff/consultants:	**Total participants + others**	**27 + 4**
	Shrimp farmers/representatives	**11**
	Government/extension staff	**7**
	University staff, including translator	**4**
	Feed company representatives	**5**
	NGOs (WWF, Jakarta; SFP -Banyuwangi)	**2**
	MARKET staff/consultants	**4**
Farm visit/s:	**Hadi Cahyono shrimp farm/s, Banyuwangi**	

INDONESIA TOT

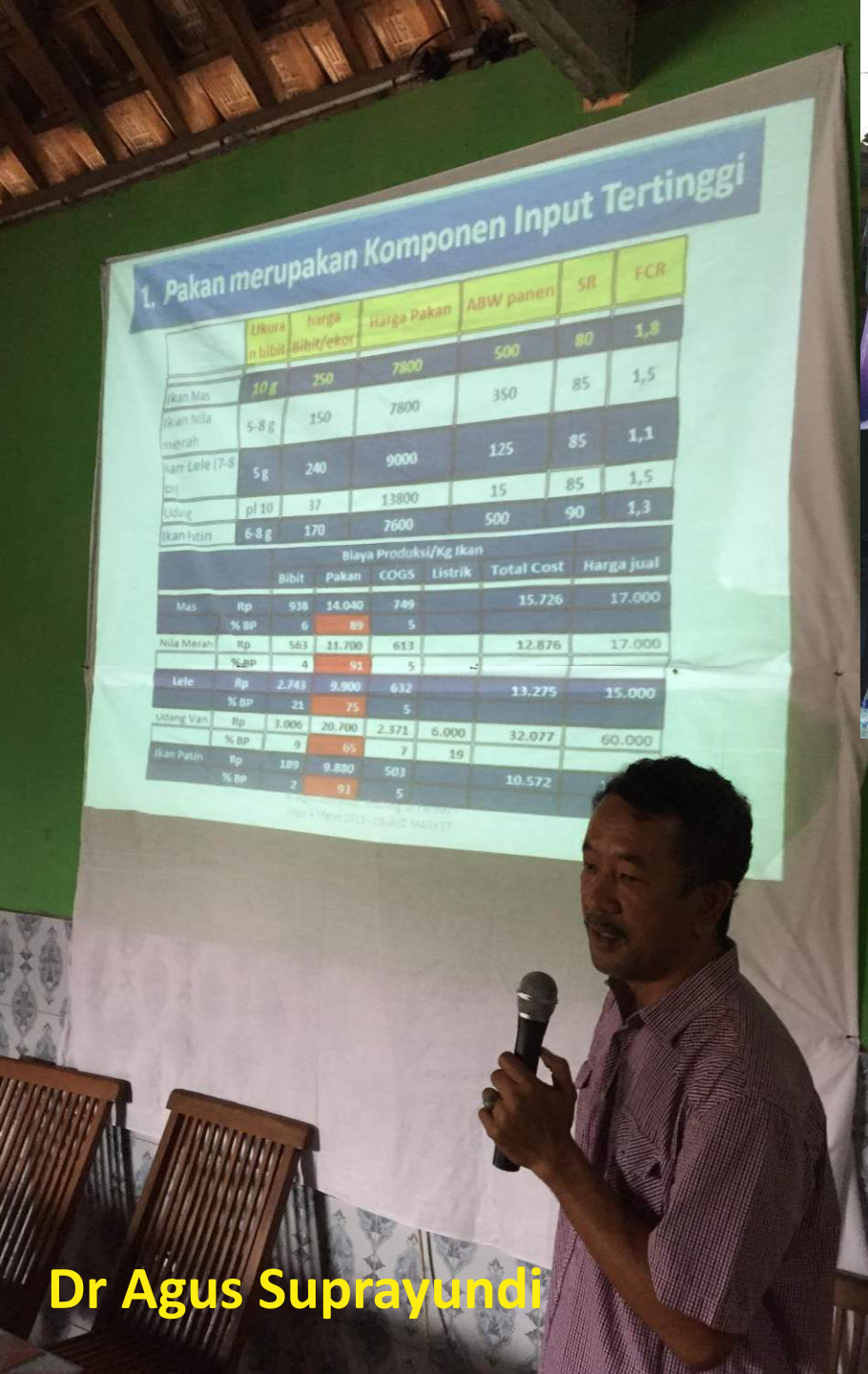
USAID
FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

NATIONAL FARMER TRAINING - INDONESIA

Four national training workshops have bee held to date in Indonesia, one by TOT trainee Mr Erik Sutikno in Jepara on 27th January, and three by Dr Agus Suprayudi in Jogyakarta province on 4 & 5 March 2015

Total farmers trained to date: 165 farmers



Dr Agus Suprayundi

Dr Agus Suprayundi

USAID FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

THAILAND:

Trainer Training workshops (TOT)

Date of TOT:	**January 27-28, 2015**	
Venue of TOT:	**Kasetsart University, Bangkok, Thailand**	
Local MARKET support staff/consultants:	**Ms Chonnikarn Phochanakij (Kenan Institute Asia)** **Ms Veena Cute-ngarmpring, Kenan Institute Asia)** **Mr Timothy Moore (MARKET staff, Jakarta)** **Ms Gladys Villacorta (MARKET staff, Jakarta)** **Dr Jesper Hedegaard (MARKET consultant, Bangkok)** **Dr Albert Tacon (MARKET consultant, USA)**	
Translator:	**Dr. Soranuth Sirisuay (Kasetsart University, Bangkok)**	
Participants + MARKET staff/consultants:	**Total participants + others**	**33 + 6**
	Shrimp farmers/representatives	**8**
	Government/extension staff	**7**
	Feed company representatives	**7**
	Observers	**6**
	University staff, including translator	**5**
	MARKET national staff/consultant	**6**
Farm visit/s:	**Boonlerd Fah Shrimp Farm, Don Tum, Nakorn Pathom Province**	

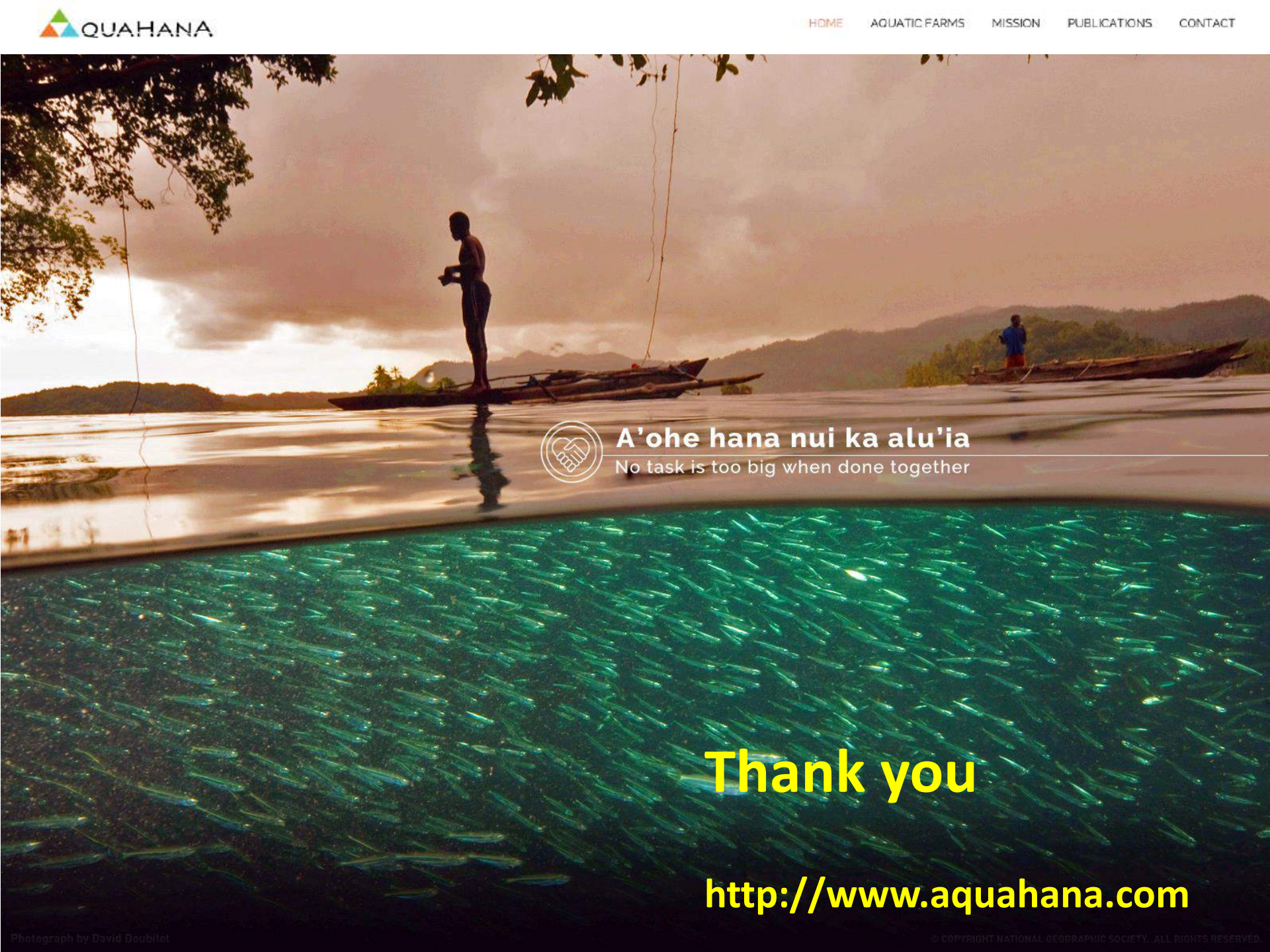
USAID
FROM THE AMERICAN PEOPLE

Maximizing Agricultural Revenue through Knowledge, Enterprise Development, and Trade Project

THAILAND TOT


Dr Soranuth Sirisuay

The importance of applied nutrition research in securing the future & long term sustainability of the aquaculture sector


QUAHANA
HOME
AQUATIC FARMS
MISSION
PUBLICATIONS
CONTACT
A'ohe hana nui ka alu'ia
No task is too big when done together
Thank you
http://www.aquahana.com
Photograph by David Doubilet
© COPYRIGHT NATIONAL GEOGRAPHIC SOCIETY. ALL RIGHTS RESERVED.