Biosecure shrimp feeds & feeding strategies of the future

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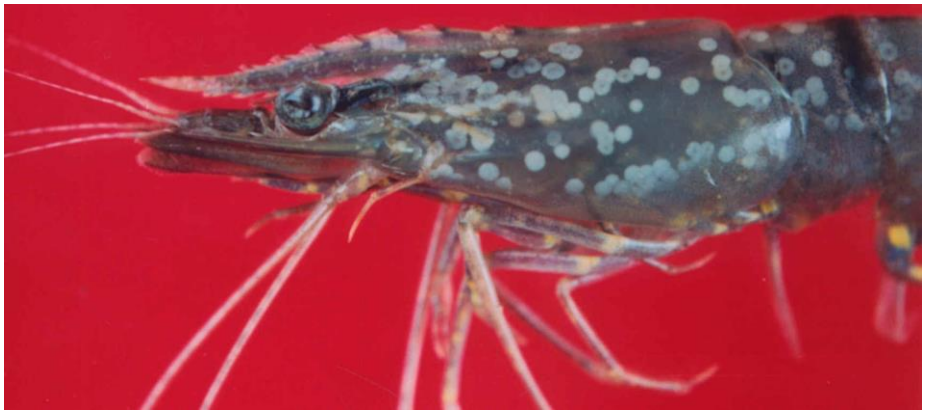
AQUAHANA

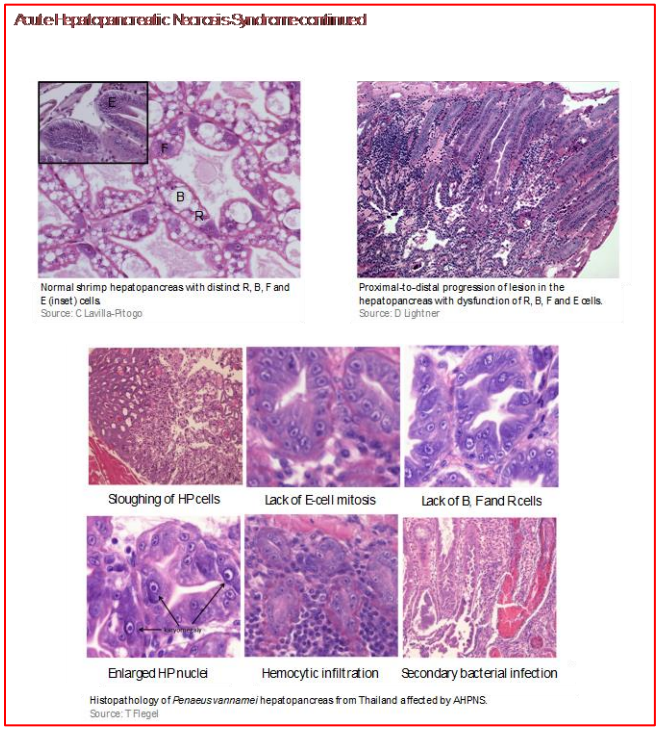
A'ohe hana nui ke kālulu'ia – *No task is too big when done together*

Presentation outline

- Importance of biosecurity & definitions
- Feed biosecurity risks associated with viable pathogens, feed formulation, feed processing & on-farm feed management
- Future role of nutrition, genetics & environmental control in improving shrimp health management & the need for a new generation improved biosecure shrimp feeds & feed management systems
- Future roles & responsibilities of feed companies, farmers & government authorities



Increasing risk of disease outbreaks & losses



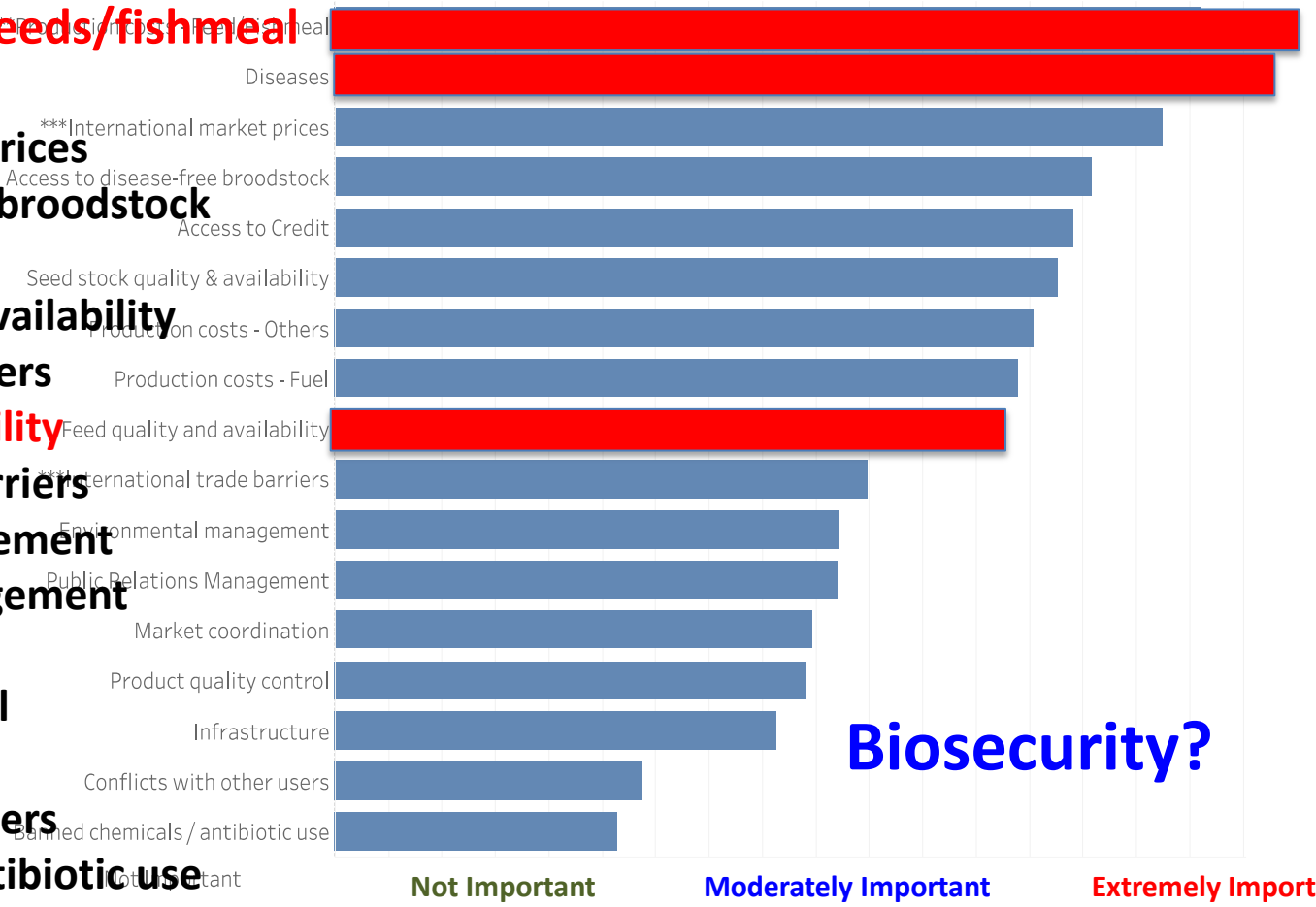
GOAL 2017 DUBLIN, IRELAND

Global Aquaculture Alliance

Major Issues & Challenges in Shrimp Aquaculture in Latin America

GOAL 2017 Survey – Anderson, Valderrama & Jory (2017)

1. **Production costs – feeds/fishmeal**
2. **Diseases**
3. **International market prices**
4. **Access to disease free broodstock**
5. **Access to credit**
6. **Seed stock quality & availability**
7. **Production costs – others**
8. **Feed quality & availability**
9. **International trade barriers**
10. **Environmental management**
11. **Public relations management**
12. **Market coordination**
13. **Product quality control**
14. **Infrastructure**
15. **Conflicts with other users**
16. **Banned chemicals /antibiotic use**



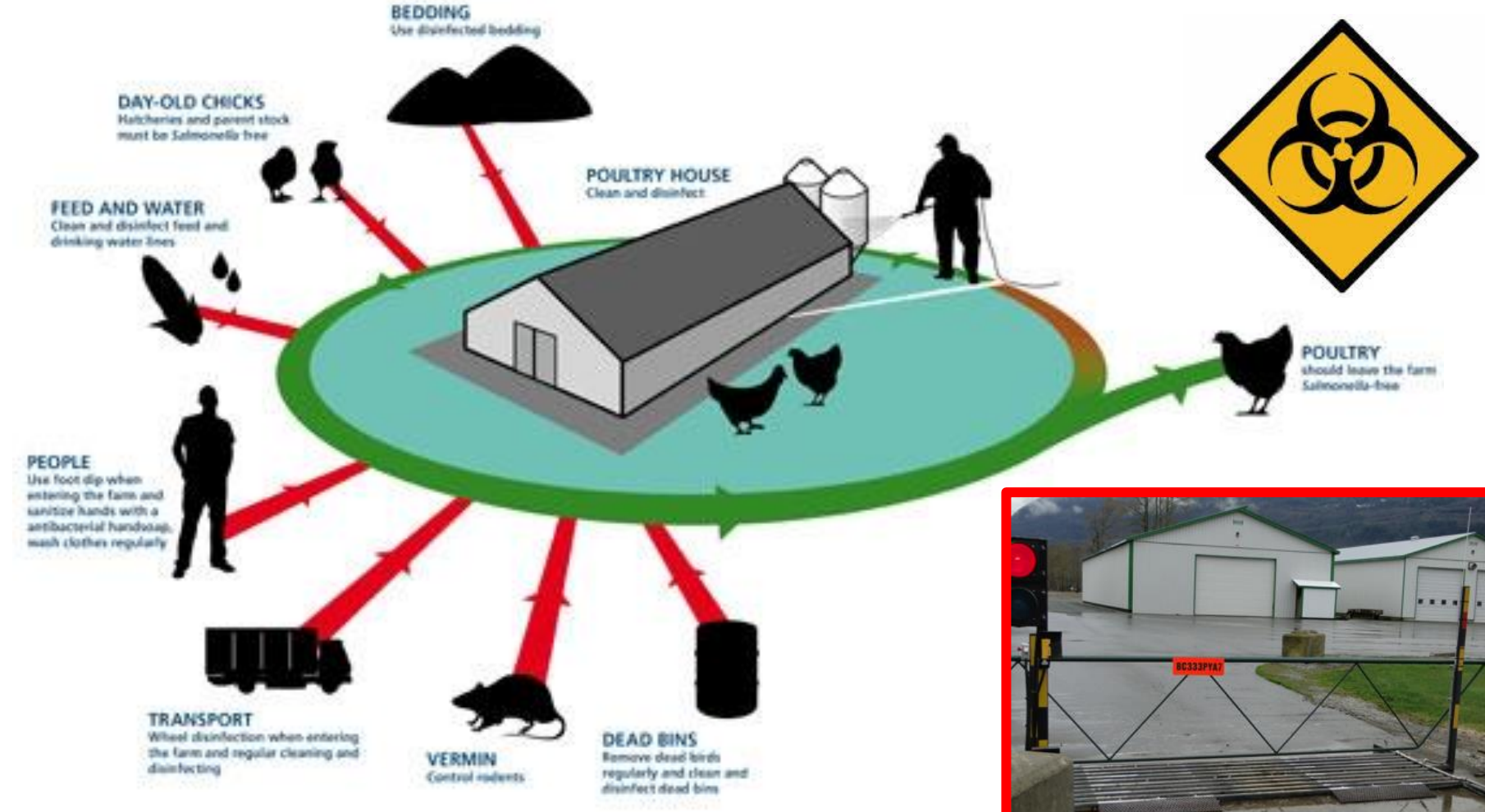
Biosecurity?

According to the FAO, **"Biosecurity is defined as the implementation of measures that reduce the risk of disease agents being introduced and spread. It requires that people adopt a set of attitudes and behaviors to reduce risk in all activities involving domestic, captive/exotic, and wild animals and their products"**

FAO/OIE/World Bank. (2008). Biosecurity for highly pathogenic avian influenza. Issues and options. FAO Animal Production and Health Paper No. 165. FAO, Rome, Italy.

BIOSECURE FEEDS & FEEDING PRACTICES

<u>means</u> that "Feed, whether live, fresh or formulated, and the management of the feed on the farm, should not be an entry point of potential pathogens and/or toxins to the animal or culture system"




Biosecurity nightmare

Biosecurity






Problem: Variety of Farming Systems

Wide range of production systems
earth pond, lined pond, raceway, tank, cage

Wide range of stocking densities employed
<1 to >600/m^3

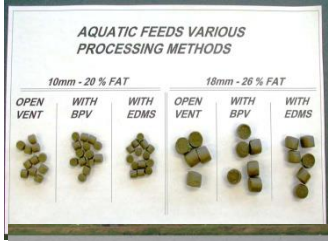
Wide range of water management practices
0 >100%/day, green-water, zero-exchange

Wide range of aeration methods
None, paddle wheel, aerotube, HP/ha

Wide range of feeds employed
low/high protein/energy, pelleted/extruded

Wide range of feeding methods
hand, boat, truck, feeding tray, auto feeder

Salmon - cage, intensive, extruded feeds








Problem: Variety of Shrimp Feeds

Natural wild live foods: Natural diet of shrimp (extensive), including aerial insects

Wild caught live and/or processed natural foods: Artemia, Squid, Mussels, Oysters, Polychaetes, Crabs, Shrimp

Cultured live and/or processed natural foods: Algae, Rotifers, Artemia, Polychaetes, Biofloc

Supplementary & Farm-made feeds: Fermented feedstuffs, Farm-made feed mashes & pelleted feeds

Commercial formulated nutritionally complete feeds: Semi-moist or dry steam pelleted feeds & extruded feeds





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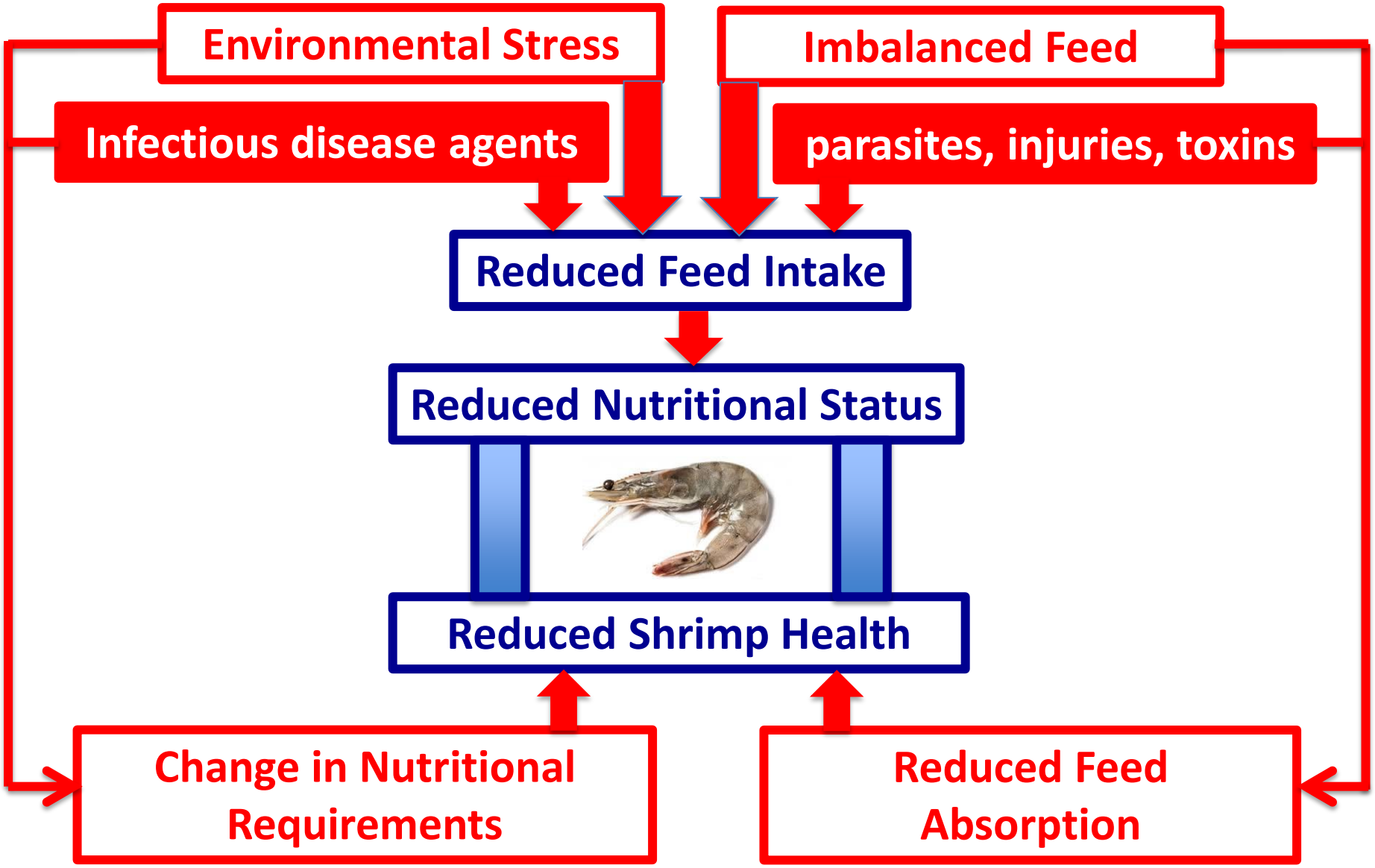
- Roles & responsibilities of feed companies, traders, farmers & government authorities



Environmental interactions between nutrition & health

(modified after Waabo, 1994; Tacon, 1997)






Feed Biosecurity Risks

Viable Pathogens

- **White spot syndrome virus (WSSV):**
- **polychaete *Dendronereis* spp. (Desrina 2016); polychaete *Pereneis nuntia* (Laoaroon et al. 2005), polychaete worms (Vijayan et al. 2005); *Artemia* biomass (Chang et al. 2002; Sahul Hameed et al. 2002; Li et al. 2003; Parenrengi 2004; Alday-Sanz 2016); phytoplankton, rotifer, *Artemia*, shrimp (Jiang 2012); copepods, amphipods, nonpenaeid shrimp, crabs (Song et al. 2001); shrimp – cannibalism (Satoh 2012); hermit crabs (Chang et al. 2012); live molluscs (Tendencia et al. 2011)**






Feed Biosecurity Risks

Viable Pathogens

- **Hypodermal hematopoietic necrosis baculovirus (HHNB): shrimp, phytoplankton, small crustaceans, fish (Huang et al. 1995)**
- **Infectious hypodermal and hematopoietic necrosis virus (IHHNV): wild shrimp and crabs (Lavilla-Pitogo et al. 2009), *Artemia* biomass (polymerase chain reaction [PCR] positive; Alday-Sanz 2016)**






Feed Biosecurity Risks

Viable Pathogens

- **Bacteria – general: *Artemia* (Igarashi et al. 1989; Hoj et al. 2009); Luminous bacteria: *Artemia* (Abraham & Palaniappan 2004); *Enterococcus* spp: Artemia (Babu et al. 2014); *Vibrio parahaemolyticus*: broodstock, fresh feed (Yingkajorn et al. 2014), pond zooplankton (Karunasagar 2016); *Vibrio*: *Artemia* (Vaseeharan & Ramasamy 2003; Lavilla-Pitogo 2016); *Vibriosis* contamination: mantis shrimp *Squilla* spp. (Lee & Najiah 2009), live polychaetes & bivalves for maturation (Songsangjinda et al. 2016)**






Feed Biosecurity Risks

Viable Pathogens

- **Bacteria - Acute hepatopancreatic necrosis disease (AHPND): live polychaetes & bivalves (NACA 2014, 2015); filter feeders & zooplankton (Brock 2016); polychaetes, squid, *Artemia*, clams (positive for AHPND AP2 detection; Flegel 2016a); *Artemia* contamination during the nursery phase (Chanratchakool 2016); polychaetes (PCR positive; Desrina 2016)**

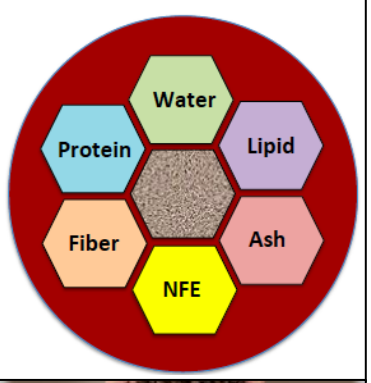


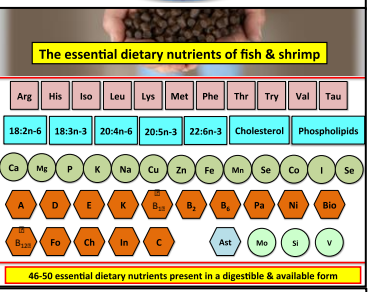


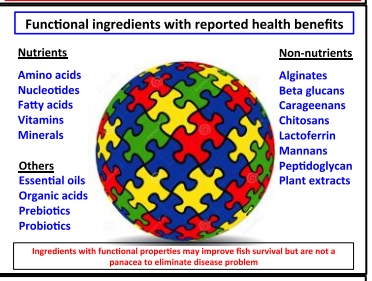

Feed Biosecurity Risks

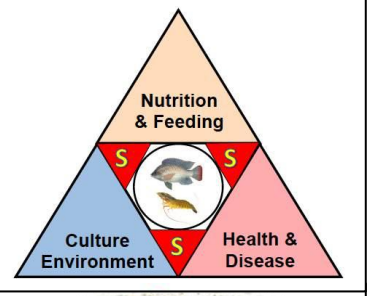
Viable Pathogens

- **Microsporidean parasites: sergestid shrimp *Acetes* spp. (Turnbull et al. 1994); polychaetes, mussels, and other filter feeders; crustaceans (Alday-Sanz 2016)**
- ***Enterocytozoon hepatopenaei*: live polychaetes (NACA 2014, 2015); live diseased shrimp, frozen *Aremtia* biomass (Han et al. 2016); polychaetes, clams, snails (PCR positive; Flegel 2016b); polychaetes**
- **(PCR positive: Desrina 2016); live feeds, including bloodworms, bivalves & gastropods (Tran 2016)**







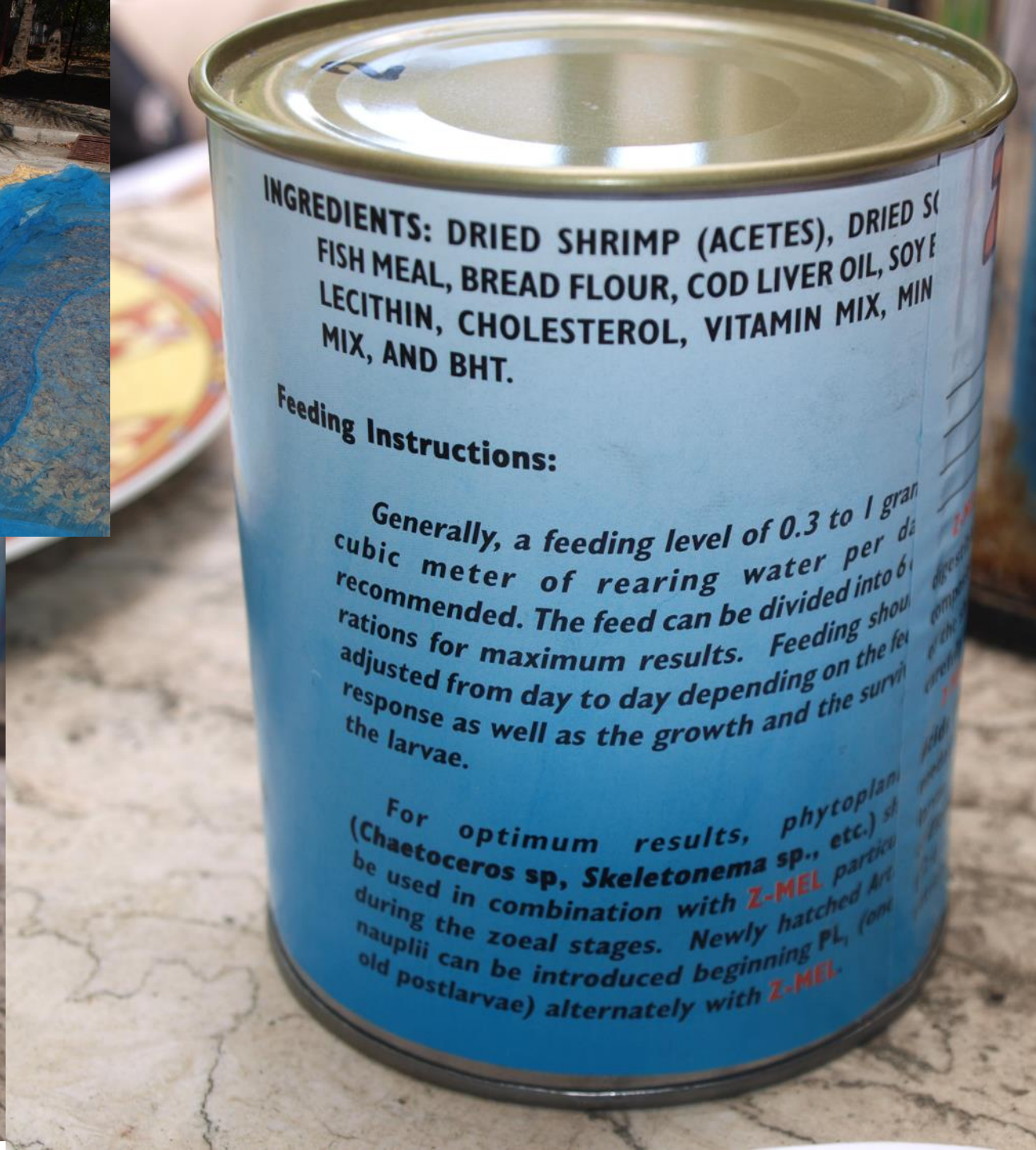


Feed Biosecurity Risks

Feed Formulation

- Use of pathogen contaminated feed ingredients within larval, juvenile, grow-out, broodstock & maturation feeds, including imported dry feeds:
- Crustacean meals: Shrimp head meal, Acetes indicus, Artemia biomass/cysts, Crab meal,
- Other marine meals: Fishmeals (local), Squid meal, Squid liver powder, Polychaete meals, Snail meals, Bivalve meals:
- Prohibition of feeding shrimp to shrimp or intra-species feeding: GlobalGap, GAA, FAO


Z-MEL
MICROBOUND FEED
ZOEA
MYSIS
EARLY PL
LATE PL


INGREDIENTS: DRIED SHRIMP (ACETES), DRIED SC
FISH MEAL, BREAD FLOUR, COD LIVER OIL, SOY E
LECITHIN, CHOLESTEROL, VITAMIN MIX, MIN
MIX, AND BHT.
Feeding Instructions:
Generally, a feeding level of 0.3 to 1 gran
cubic meter of rearing water per da
recommended. The feed can be divided into 6
rations for maximum results. Feeding shou
adjusted from day to day depending on the fe
response as well as the growth and the survi
the larvae.
For optimum results, phytoplan
(Chaetoceros sp, Skeletonema sp., etc.) sh
be used in combination with Z-MEL partic
during the zoeal stages. Newly hatched Art
nauplii can be introduced beginning PL, (one
old postlarvae) alternately with Z-MEL.

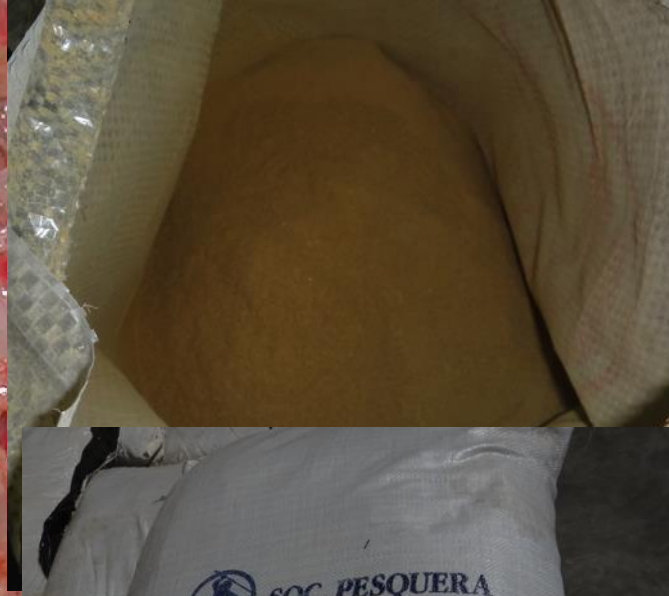
ADULTERANTS

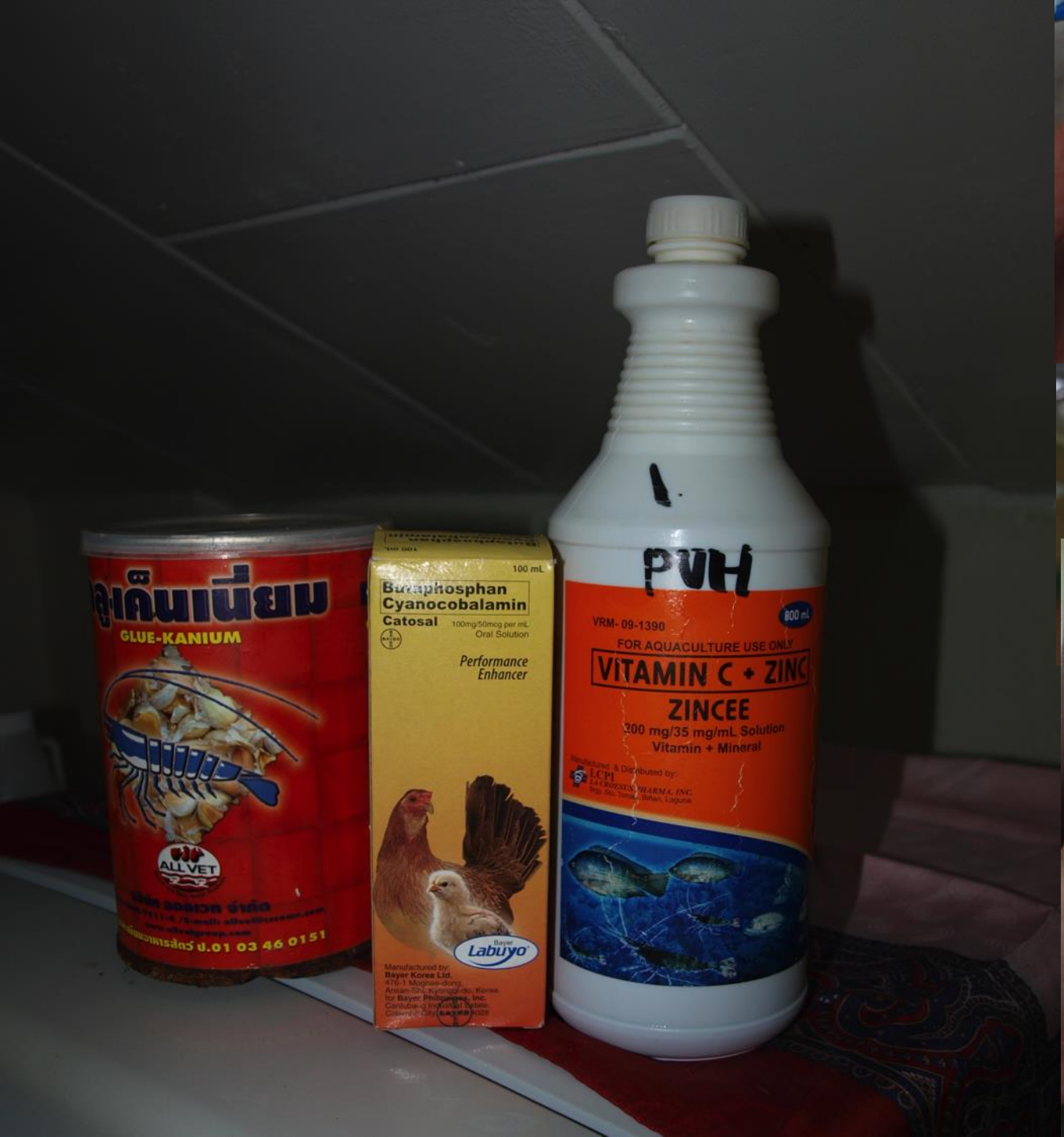
Traders - Asia

Krill meal

or

Shrimp head meal

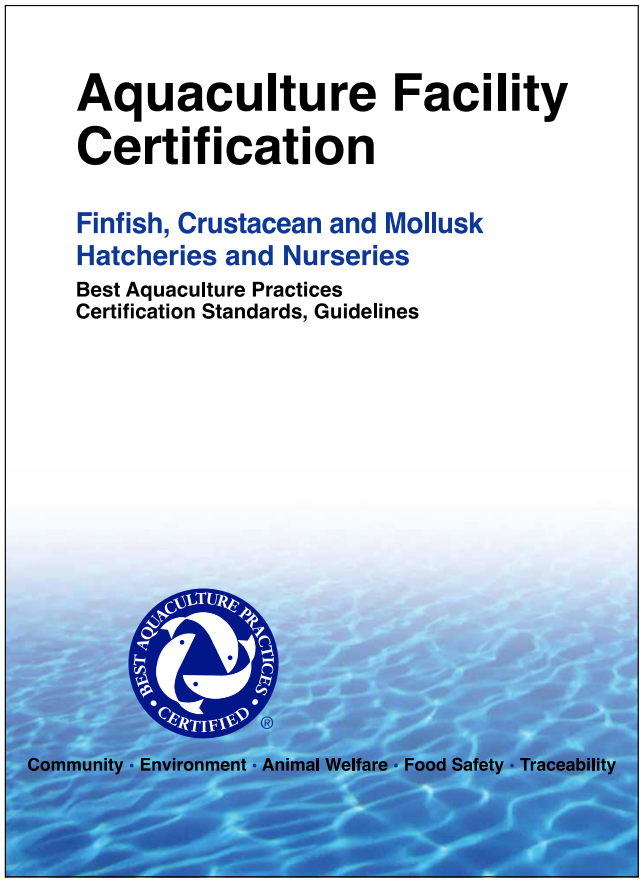



กลูเค็นเนี่ยม
GLUE-KANIUM
ALL VET
Catosal
100mg/50mcg per mL
Oral Solution
Performance Enhancer
Labuyo
PVH
VRM- 09-1390
FOR AQUACULTURE USE ONLY
VITAMIN C + ZINC
ZINCEE
200 mg/35 mg/mL Solution
Vitamin + Mineral


TRIVIT-B
Each 3 ml ampoule contains:-
50 x 3 ml Ampoules
FOR INTRAMUSCULAR USE


VITAMIN
STAR-VIT


BESTA FEED



7. Environment (All Production Systems)
Feed Biosecurity
Fishmeal and Fish Oil Conservation

7.6: No feeds that contain material derived from the flesh or carcasses of the same species that is reared in the facility shall be used, even if such materials have supposedly been disinfected by cooking or other treatment.

BEST AQUACULTURE PRACTICES CERTIFICATION

The following Best Aquaculture Practices standards and guidelines apply to facilities that process and manufacture finished feeds for the culture of fish, crustaceans and other aquatic animals.

The BAP standards are achievable, science-based and continuously improved global performance standards for the aquaculture supply chain that assure healthful foods produced through environmentally and socially responsible means. They are designed to assist program applicants in performing self-assessments of the environmental and social impacts, and food safety controls of their facilities, and to lead to third-party certification of compliance. For further information, please refer to the additional resources listed.

BAP standards demand compliance with local regulations as the first step toward certification. However, not all regulations are equally rigorous. For this reason, BAP standards set out requirements for documentation and procedures that must be in farm management plans, whether they are prescribed by local regulations or not. By so doing, they seek, where possible, to impose consistency in performance among facilities in different producing regions and to engage the industry as a whole in a process of continuous improvement.

In common with ISO usage, these standards use the words “shall” to mean compliance is required and “should” to mean compliance is recommended. Auditable points are “shall” statements listed at the end of each standard.

To obtain BAP certification, applicants shall be audited by an independent, BAP-approved certification body. To apply for certification, contact:

Best Aquaculture Practices Management
P. O. Box 2530 – Crystal River, Florida 34423 USA
Telephone: +1-352-563-0565 – Fax: +1-425-650-3001
Web: www.bestaquaculturepractices.org – E-mail: info@aquaculturecertification.org, aquacert@tampabay.rr.com

The audit consists of an opening meeting, a site assessment, the collection of necessary samples, a review of management records and procedures, and a closing meeting. All points in the standards shall be addressed. Any non-conformity raised during the evaluation is recorded by the auditor in the formal report as:

Critical – When there is a failure to comply with a critical food safety or legal issue, or a risk to the integrity of the program, the auditor immediately informs the certification body, which then informs BAP Management. Pending clarifications, failure to certify or immediate temporary suspension can ensue.

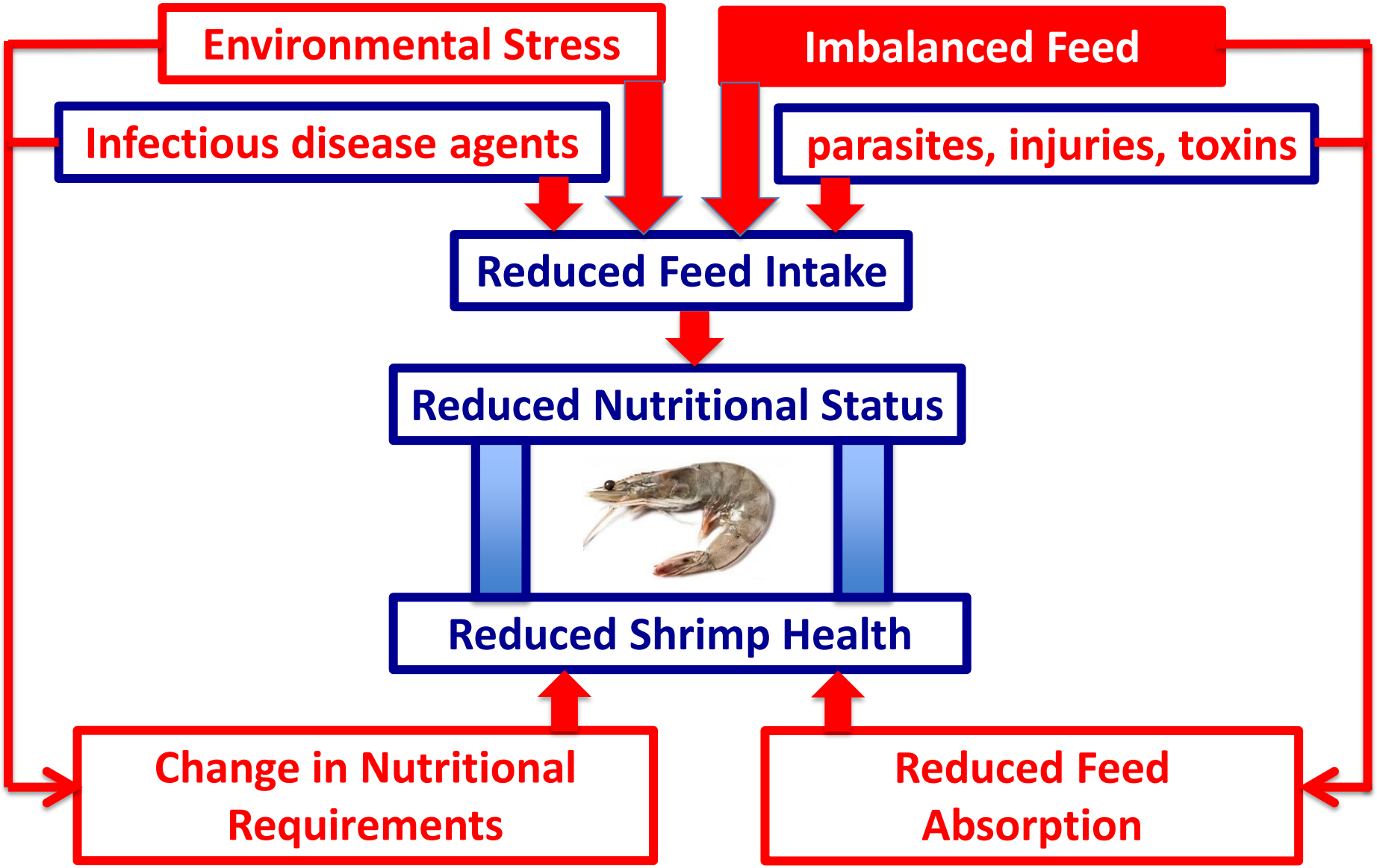
Major – When there is a substantial failure to meet the requirements of a standard but no food safety risk or immediate risk to the integrity of the program, the auditor notifies the certification body and records this in the report. Verification of the implementation of corrective actions shall be submitted to the certification body within 28 days of the evaluation. (Major non-conformities typically reflect issues with general policies.)

Minor – When full compliance with the intent of the standards has not been demonstrated, the auditor notifies the certification body and records this in the report. Verification of the implementation of corrective actions shall be submitted to the certification body within 28 days of the evaluation. (Minor non-conformities typically reflect general housekeeping issues.)

BAP standards are developed by committees of technical experts following a process aligned to the FAO Technical Guidelines on Aquaculture Certification. See www.gaalliance.org/bap/standardsdevelopment.php.

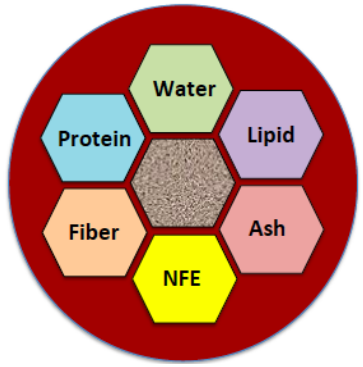
6. Food Safety
HACCP Process Controls, Good Manufacturing Practices

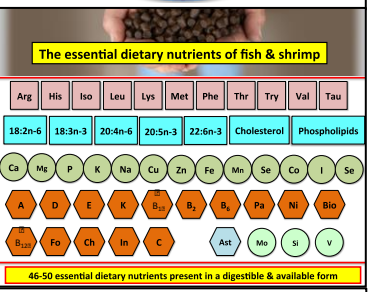
The refeeding of a given species back to the same or closely related species in the form of processed and/or non-processed aquaculture feeds shall be avoided to block this possible route for the spread of disease

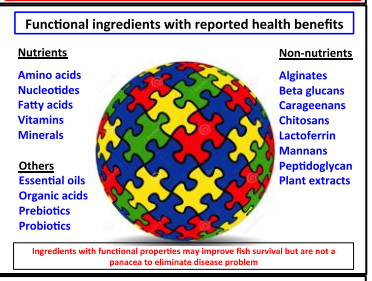


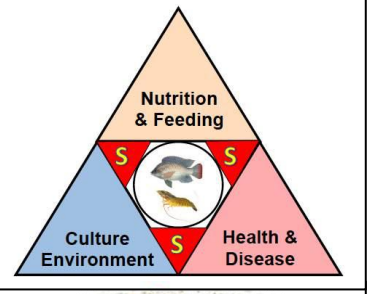
Environmental interactions between nutrition & health

(modified after Waabo. 1994; Tacon, 1997)







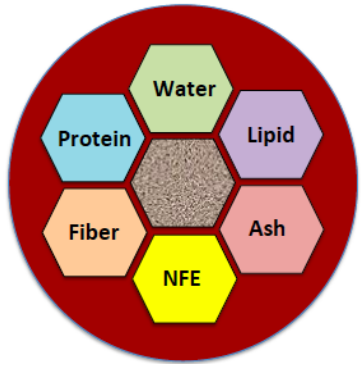


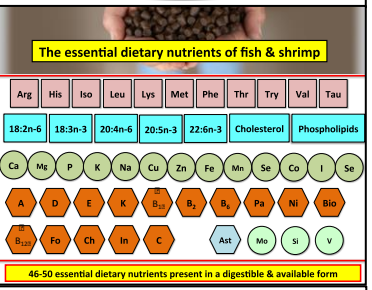
Feed Biosecurity Risks

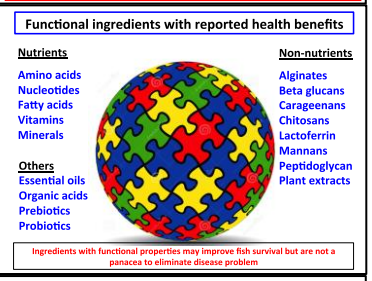
Feed Formulation

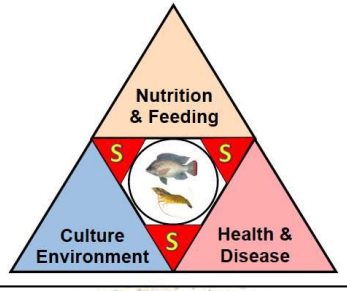
- Use of feed ingredients containing high levels of endogenous anti-nutritional factors (ANFs) and/or contaminated with mycotoxins, and their possible negative effect on gut integrity & shrimp health;

- For example, microbial toxins (produced from bacteria & fungi) promote infection & disease by directly damaging host tissues & disabling the immune system (Bordoloi & Ganguly, 2014);



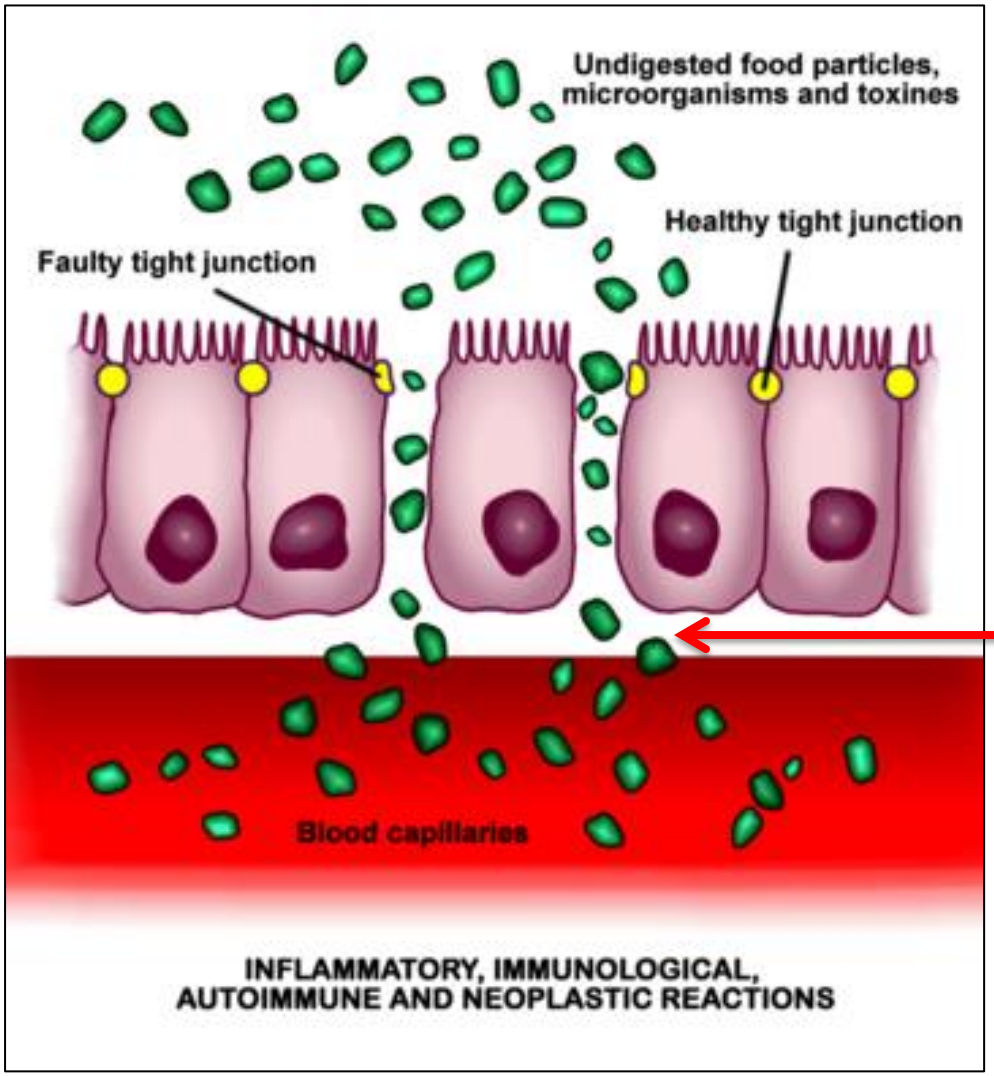




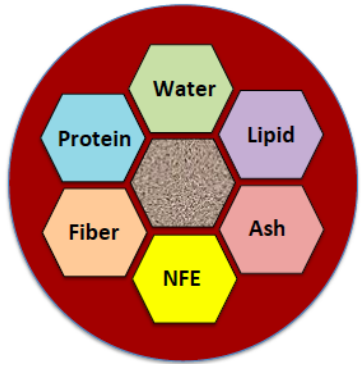


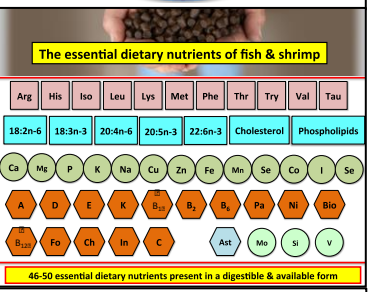
Feed Biosecurity Risks

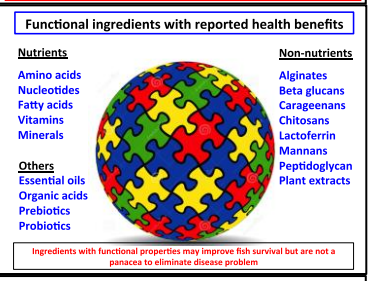
Feed Formulation

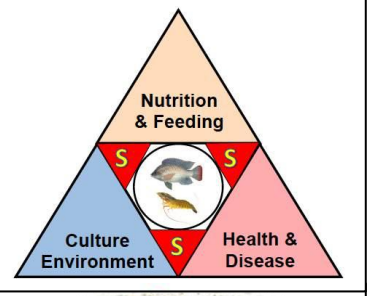


Ingredients that may promote leaky guts







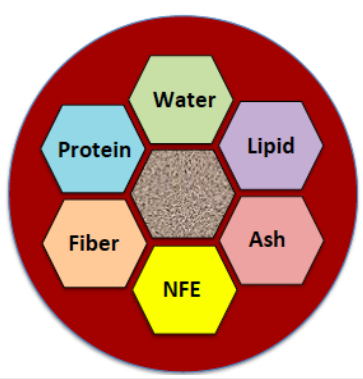


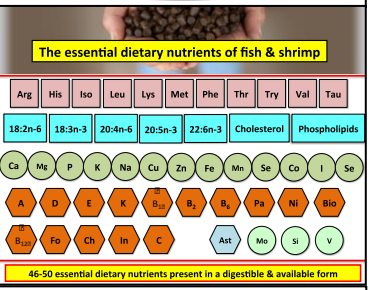
Feed Biosecurity Risks

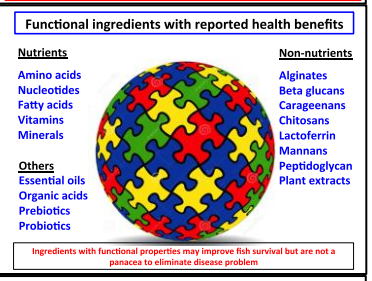
Feed Formulation

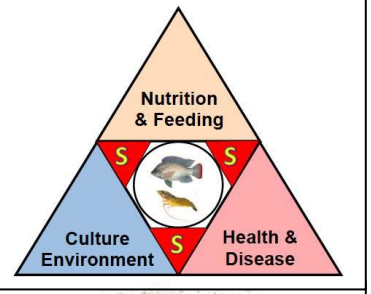
Reported ANF & mycotoxins negatively affecting gut permeability

- Saponins (Salmonids - Knudsen et al. 2008, Yamamoto et al., 2012);
- Oxidized fish oil (Grass carp – Chen, Ye & Cai, 2016; Huang, 2015);
- Deoxynivalenol (DON) targets epithelial cells of the GI tract leading to immuno-suppression & facilitation of persistence of intestinal pathogens in the gut, rendering host more vulnerable to luminal toxic compounds (Ghareeb et al. 2015)









Feed Biosecurity Risks

Feed Formulation

- **Mycotoxins (> 400) are capable of reducing feed intake and causing abnormalities in gut morphology & nutrient absorption (D'Mello, 2006);**

- **Aflatoxin is a serious immune suppressant in aquaculture, with evidence demonstrating that the consumption of diets contaminated with mycotoxins suppress the immune system and decreases disease resistance (Hasan & Goncalves, 2017);**

Mycotoxins

and their economic impact on aquaculture

Rui Gonçalves, Technical Manager
Paula Kovalsky, Product Manager

Table 1. Survey results for various ingredients and by-products.

Finished aquafeed	Afla	ZEN	DON	FUM	OTA
Number of tests	43	43	43	43	43
% positive	47%	63%	40%	19%	51%
Average of positive (µg/kg)	37	23	142	359	2
Maximum (µg/kg)	180	51	262	615	9
Corn	**Afla**	**ZEN**	**DON**	**FUM**	**OTA**
Number of tests	732	775	810	695	642
% positive	30%	36%	63%	73%	12%
Average of positive (µg/kg)	61	177	669	1,995	4
Maximum (µg/kg)	1,563	5,324	9,910	23,180	44
Corn DDGS	**Afla**	**ZEN**	**DON**	**FUM**	**OTA**
Number of tests	58	58	59	56	52
% positive	60%	52%	73%	79%	27%
Average of positive (µg/kg)	9	94	1,241	2,852	13
Maximum (µg/kg)	23	434	7,030	26,828	43
Soybean meal	**Afla**	**ZEN**	**DON**	**FUM**	**OTA**
Number of tests	50	55	55	52	51
% positive	16%	22%	11%	15%	12%
Average of positive (µg/kg)	2	27	428	226	2
Maximum (µg/kg)	6	99	1,680	549	4

Aquaculture 451 (2016) 1–10

Contents lists available at ScienceDirect

Aquaculture

journal homepage: www.elsevier.com/locate/aqua-online

Review

Mycotoxins and their consequences in aquaculture: A review

Amanda Anater [a], Lara Manyes [b], Giuseppe Meca [b], Emilia Ferrer [b], Fernando Bittencourt Luciano [a], Cláudia Turra Pimpão [a,*], Guillermina Font [b]

Aquatic animal health

Volume XVIII No. 1, January-March 2013

Importance of mycotoxins in aquaculture feeds

Vikash Kumar[1]*, Suvra Roy[1], Debtanu Barman[2], Aditya Kumar[1], Lokesh Paul[2] and Wakambam Anand Meetei[1]

1. Central Institute of Fisheries Education, Mumbai, India, 400061; 2. College of Fisheries, Central Agricultural University, Lembucherra, Tripura-799210, India. Correspondence: kumar.vika.vikash2@gmail.com

Rul A. Goncalves, Karin Naehrer & Goncalo A. Santos. (2016). **Occurrence of mycotoxins in commercial aquafeeds in Asia and Europe: a real risk to aquaculture?** Reviews in Aquaculture (In Press), 1-16p.

Reported endogenous anti-nutritional factors (ANFs) and possible contaminants present in soybeans

Reported endogenous ANFs

- Protease inhibitors
- Phyto-haemagglutinins
- Glucosinolates
- Phytic acid
- Saponins
- Estrogenic factors
- Flatulence factor
- Anti-vitamin E factor
- Anti-vitamin A factor
- Anti-vitamin D factor
- Anti-vitamin B12 factor
- Allergens
- Non-starch polysaccharides

Reported contaminants*

- Mycotoxins
- Glyphosate & AMPA

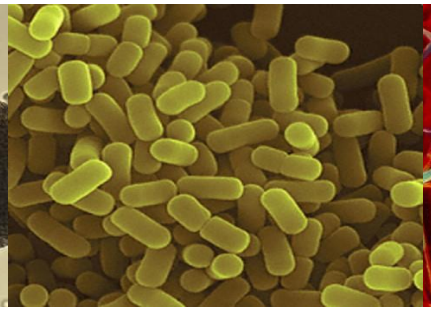
Use of **Solid State Fermentation** to better utilize locally available agricultural feed & food wastes & for the **reduction of the anti-nutritional factors** present in plant proteins such as soybean, rapeseed, lupin & pea

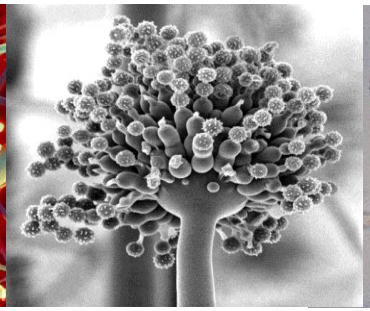
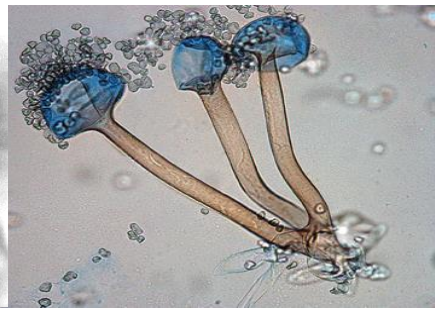










Analysis of raw copra meal compared to fermented bio-treated copra meal

COMPONENT (%)	Raw Copra Meal (% DM)	Bio-treated copra meal (% DM)
Crude protein	21.60	43.30
Crude fiber	11.27	7.58
Crude fat	7.10	8.42
Ash	7.30	8.01
Carbohydrate	64.00	39.17
Aflatoxin , ppb	126	Not detected

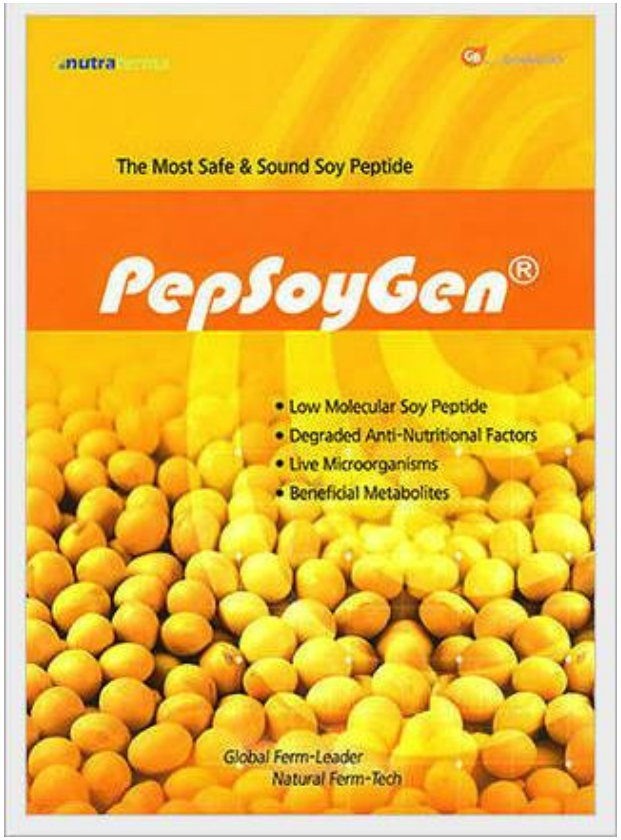
REPUBLIC OF THE PHILIPPINES
DOST - PCAARRD
Providing science solutions for a vibrant agriculture, aquatic and natural resources

Reported successful feeding trails with tilapia, shrimp & milkfish

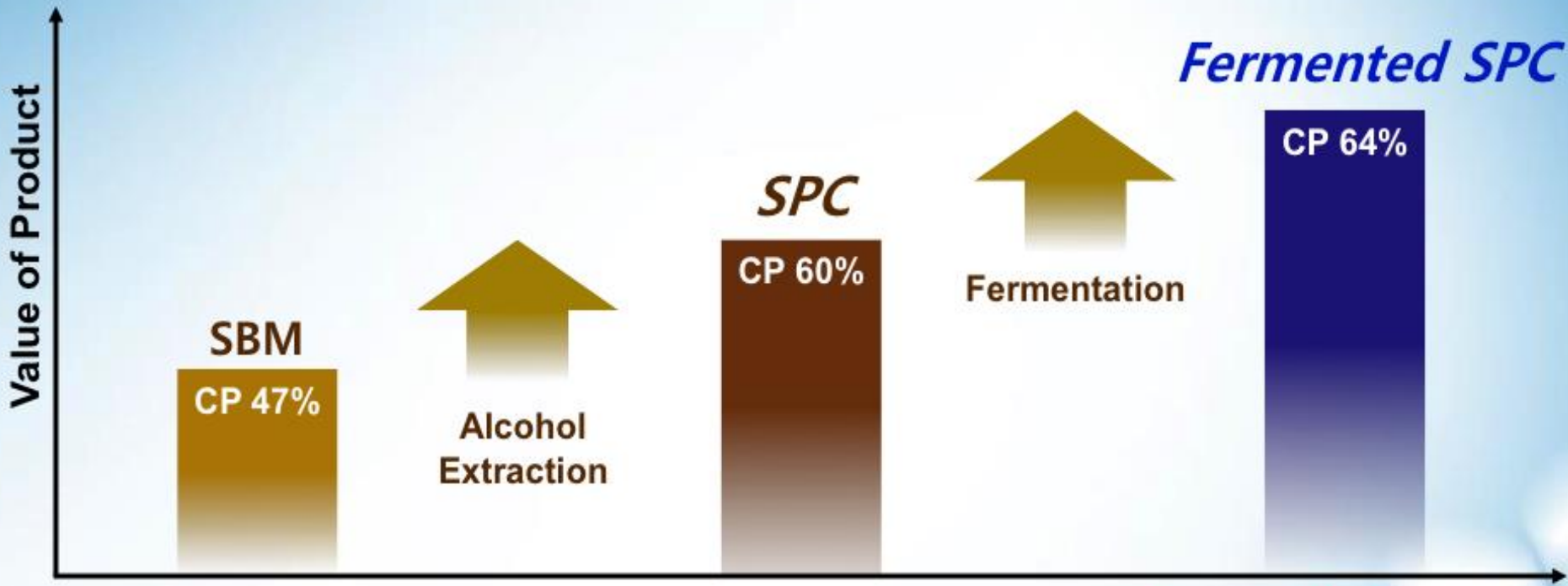
www.fao.org/uploads/tx_chcforum/Fish%20Feed%20Project.doc

Comparison of physicochemical properties between soybean meal and fermented soybean meal

items	common soybean meal	soybean meal fermented by mixed fermentation of P23 and TP6 strains	soybean meal fermented by single fermentation of TP6 strain
dry matter, DM (%)	88.04	91.01	89.68
CFU/g DM	N.D.	6.6×10^9	2.0×10^9
lactic acid(g/kg DM)	N.D.	74.3	N.D.
pH	6.7	4.75	8.19
crude protein(%)	48.5	56.2	56.4
trypsin inhibitor(TI)	9.01	0.64	0.47
KOH solubility	84.97	61.3	59.21
total carbohydrate(%)	32.5	23.99	25.29
Raffinose(%)	1	0.05	0.82
Stachyose(%)	3	0.1	2.19
poly-γ-glutamic acid(%)	N.D.	0.5	0.6



1. Background of Development - Concept

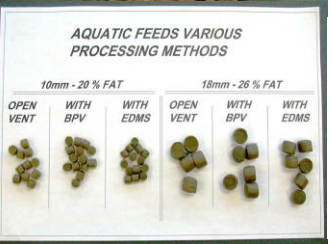


- Cost efficient
- Low protein content
- High ANFs

- High Protein (60%)
- Decreased ANFs
  : CHOs Alcohol washout
- Cost efficient

- **Low protein allergen**
  - Conglycinin etc.
  - Low trypsin inhibitor
- **Low CHOs (by fermentation)**
- **High protein Content (64%)**
- **high digestible protein**
- **Cost efficient**

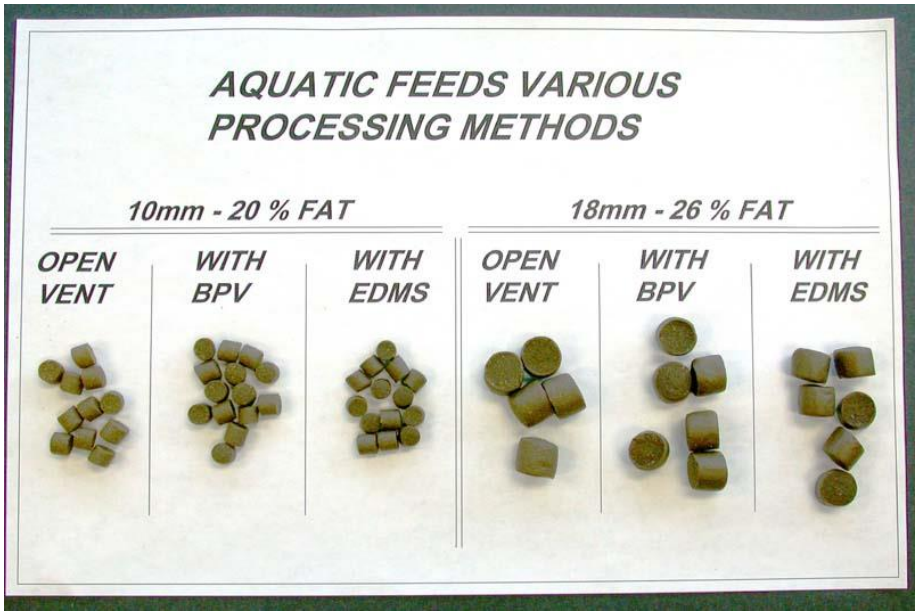
CJ Selecta



Feed Biosecurity Risks

Feed Processing

- **Although reported that viable pathogens such as WSSV which may be present within contaminated feed ingredients are readily destroyed during the conventional steam pelleting process (Pongmaneerat et al. 2001);**
- **There is risk that more heat-resistant pathogens & parasites may survive the pelleting process: as compared with extrusion processing in which higher cooking temperatures are involved & the feed is usually completely pasteurized (Muñoz 2011);**



Benefits of extruded feeds

- Reduced feed ingredient costs
- Improved feed water stability
- Reduced nutrient leaching
- Improved nutrient digestibility
- Increased oil & energy addition
- Higher starch gelatinization
- Improved feed efficiency
- Less fines & feed wastage
- Facilitate use of wet waste streams
- **Improved feed biosecurity**

Extrusion

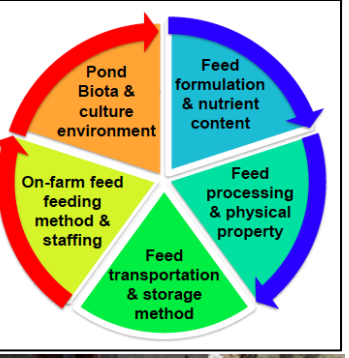
Report of experience of Guabi with extruded shrimp feeds

Manufacturing extruded shrimp feeds in Brazil for the past 13 years

Extrusão

Temperatura: 110 a 180° C

Gelatinização do amido: alta (80% a 95%)

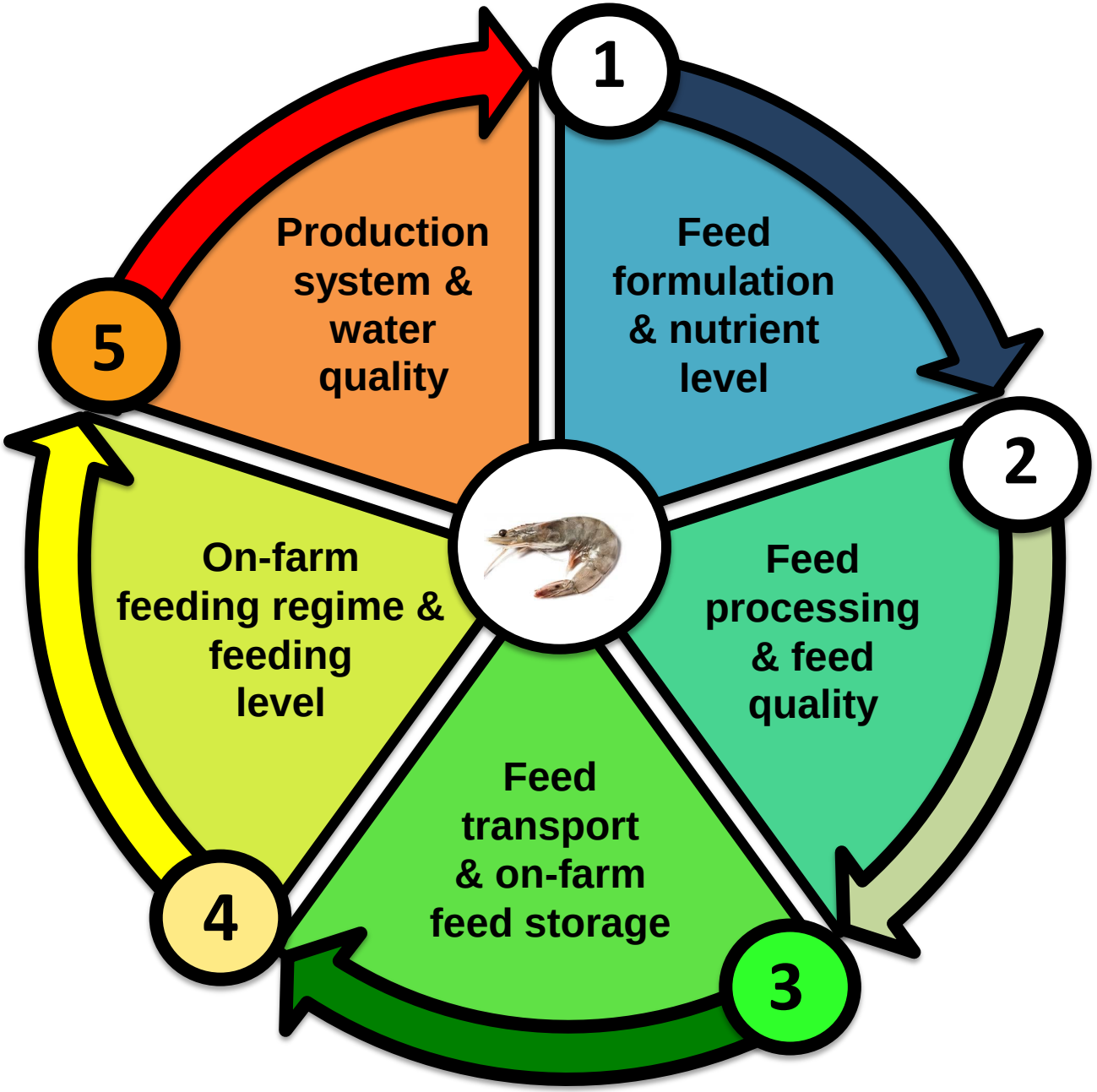


Feed Biosecurity Risks

Feed Management

- **Risk of negatively effecting shrimp growth & health through the use of poor on-farm feed management practices, including feed storage, and the consequent loss of nutrients through oxidation, spoilage or contamination;**

Main factors affecting on-farm shrimp feed performance



Main factors affecting on-farm fish & shrimp feed performance

- **Minimum dietary nutrient profile for each shrimp size group**

➢ **Hatchery feed, Nursery feed, Grow-out feed, Broodstock feed**

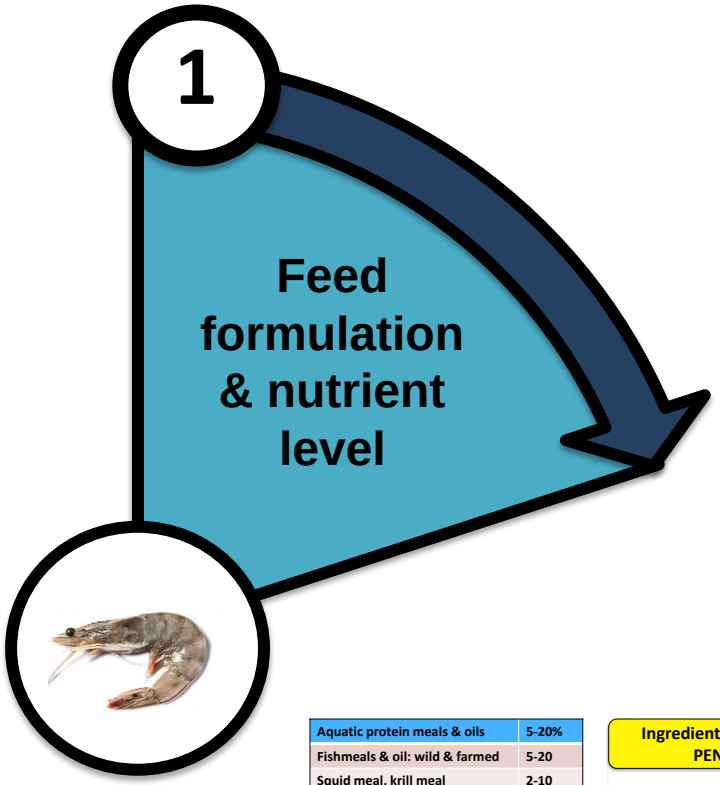
➢ **CP, CL, CF, EAA, EFA, Phospholipids, Cholesterol, Minerals, Vitamins**

- **Feed ingredient selection & use (min & max constraints)**

➢ **Aquatic & terrestrial animal protein & lipid sources**

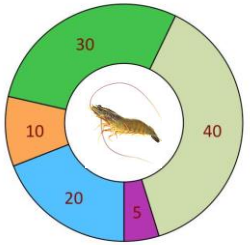
➢ **Plant protein & lipid sources, cereals, binders, feed additives**

- **Feed formulation on a total or digestible nutrient basis**



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

Ingredients commonly used in feeds for PENAEID SHRIMP SPECIES



Feed additives	0-5%
Vitamins, antioxidants, pigments, emulsifiers	
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	

The essential dietary nutrients of fish & shrimp

H_2O	CARBOHYDRATES	PROTEINS	LIPIDS	ASH

40-50 essential dietary nutrients depending upon the culture species

The essential dietary nutrients of fish & shrimp

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

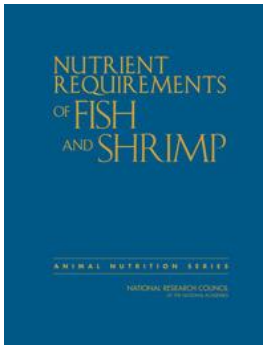
Ca | Mg | P | K | Na | Cu | Zn | Fe | Mn | Se | Co | I | Se

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

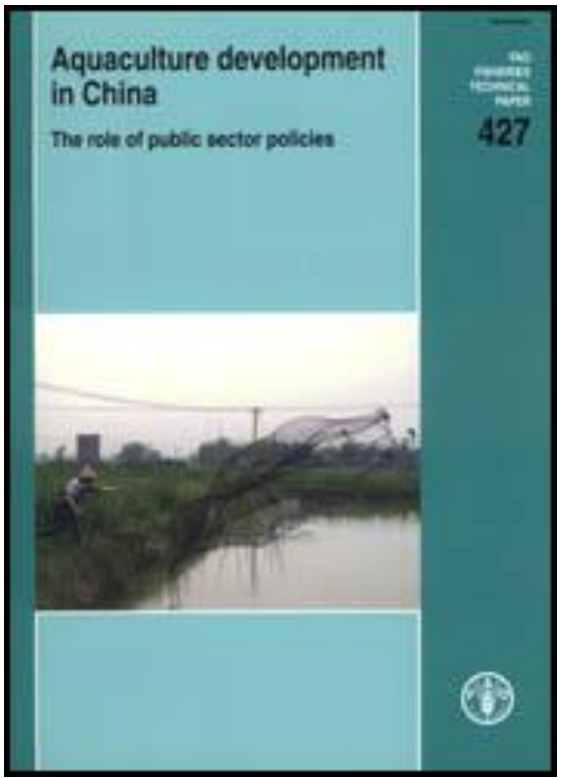
B_{12} | Fo | Ch | In | C | Ast | Mo | Si | V

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

Approaches currently used by feed companies to formulate their fish & shrimp feeds



1. Formulating feeds based on published NRC total nutrient basis (where data is available) or on government guidelines (60-70%);

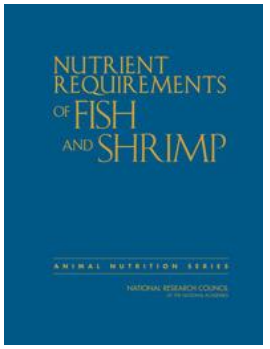


Recently, the Government started paying attention to the quality of feed used in aquaculture. It has set feed standards for some important species such as carps, tilapia, trout and eel. Most of these standards were formulated in 1997. Some of them are: "*Nutritional Standard of Formulated Feed for Common Carp, SC/T 1026-1997*" for common carp, "*Nutritional Standard of Formulated Feed for Grass Carp, SC/T 1024-1997*" for grass carp, "*Nutritional Standard of Formulated Feed for Tilapia, SC/T 1025-1997*" for tilapia, "*Technical Criteria in Rainbow Trout Culture-Formulated Pellet Feed for Rainbow trout, SC/T 1030-1997.7*" for rainbow trout and "*Formulated Feed for Japanese Eel, SC 1004-1992*" for eel.

COMPOUND FEED FOR WHITE LEG SHRIMP
TCVN 10325:2014
Ministry of Agriculture, Hanoi 2014

Feed #	1	2	3	4	5	6
Feed diameter mm	0.6	0.8	1.2	1.8	2.2	2.5
Length/diameter	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2	1.5-2
Crumble/dust % max	1	1	1	1	1	1
Water stability h min	1-2	1-2	1-2	1-2	1-2	1-2
Moisture % max	11	11	11	11	11	11
Crude protein % min	38	36	34	34	33	32
Crude lipid % min	5-7	5-7	5-7	4-6	4-6	4-6
Crude fibre % max	3	4	4	4	4	4
Ash % max	14	14	15	15	16	16
Sand % max	1.0	1.2	1.3	1.5	1.5	1.7
Lysine % min	1.8	1.8	1.7	1.6	1.5	1.5
Methionine % min	0.8	0.8	0.7	0.7	0.6	0.6
Calcium % max	2.3	2.3	2.3	2.3	2.3	2.3
Ca/Phosphorus	1-1.5	1-1.5	1-1.5	1-1.5	1-1.5	1-1.5
Salt % max	2	2	2	2	2	2
Insects	ND	ND	ND	ND	ND	ND
Salmonella	ND	ND	ND	ND	ND	ND
Aspergillus flavus	ND	ND	ND	ND	ND	ND
Aflatoxin B_1 max ug/kg	10	10	10	10	10	10
Melamine max mg/kg	2.5	2.5	2.5	2.5	2.5	2.5
Antibiotic	ND	ND	ND	ND	ND	ND

Approaches currently used by feed companies to formulate their fish & shrimp feeds



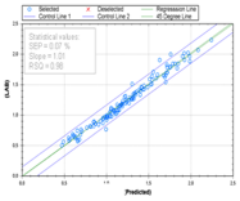
1. Formulating feeds based on published total nutrient basis (where data is available) or on government regulations (60-70%);

2. Formulating feeds on a digestible nutrient basis, based on existing published data from researchers (5-10%);

3. Formulating feeds on a digestible nutrient basis, based on in-house data on the nutrient digestibility of the different feed ingredients used (10-20% total aquafeed production);

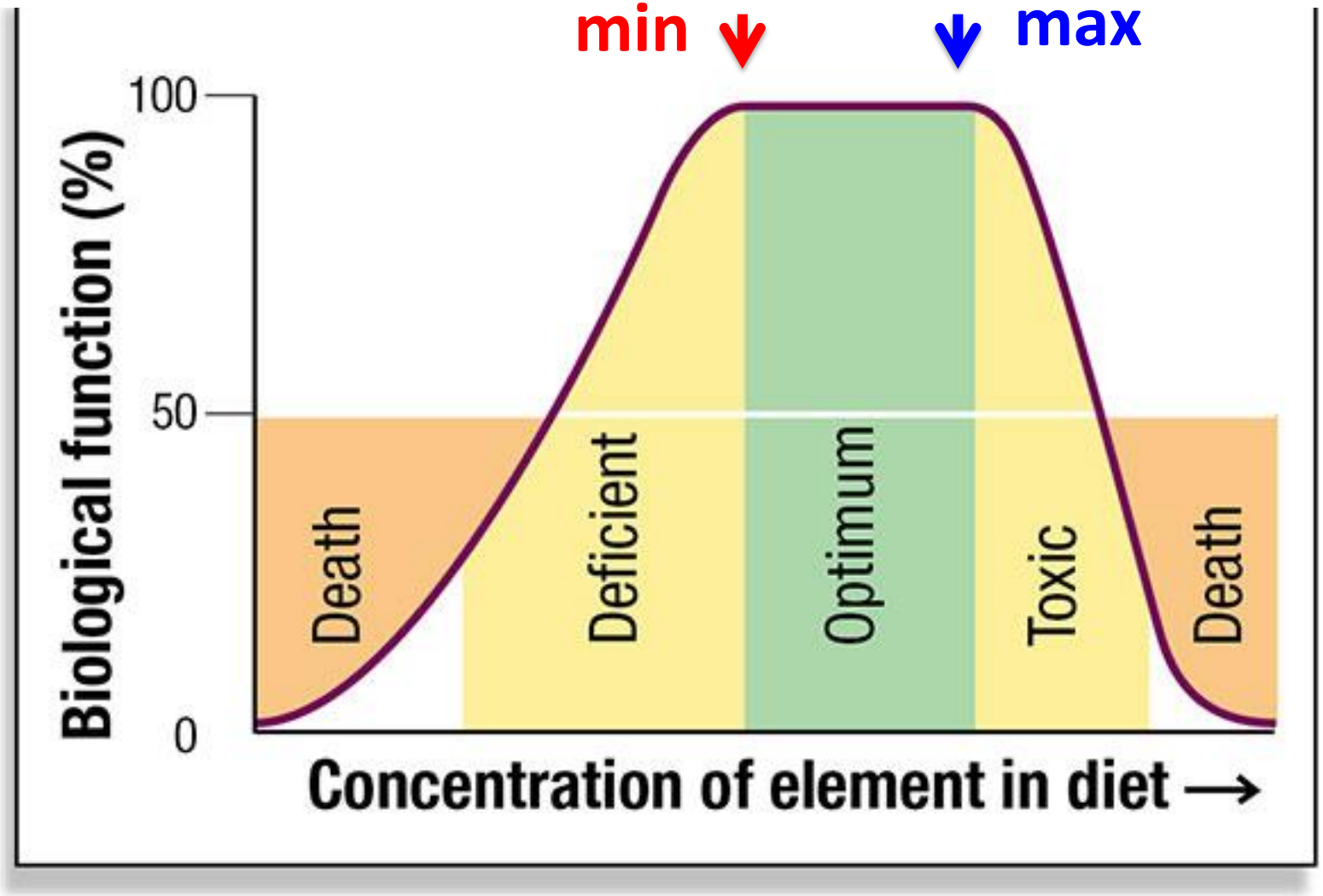
 ?

NIRS



Digestibility systems - Ubatuba – USP/Brazil

Dietary nutrient requirements



More is better when the level of the nutrient in the diet is in the deficient range but the key point is that more is not better when the level is in the optimum range and is indeed harmful thereafter

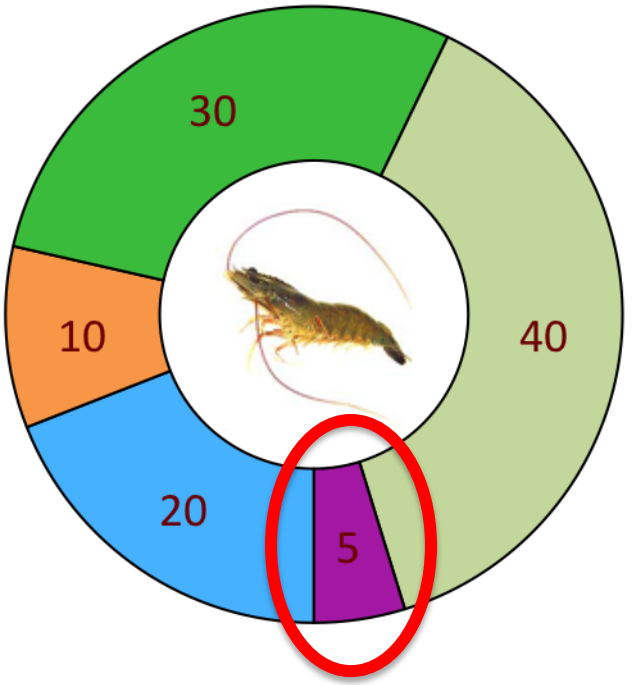
Ingredients commonly used in feeds for PENAEID SHRIMP SPECIES

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, pigments, emulsifiers, MCTs	
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, antibiotics, cholesterol	

Improving the utilization of feed ingredients

Use of renewable nutrient sources

EXOGENOUS MICROBIAL ENZYMES

- **Improved nutrient digestibility**
- **Improving feed efficiency**
- **Release of trapped nutrients**
- **Breakdown of anti-nutritional factors**
- **Improved gut health**
- **Reducing environmental impacts (N, P)**

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

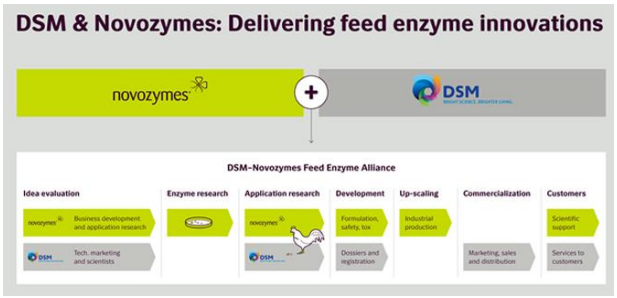
Improving the utilization of feed ingredients

Use of renewable nutrient sources

SOME ENZYMES USED WITHIIN AQUAFEEDS

Enzyme	*Common source organism*
• **Amylases:**	***Aspergillus* spp., *Bacillus* spp.,**
• **Phytases:**	***Aspergillus* spp.,**
• **Proteases:**	***Aspergillus* spp., *Bacillus* spp.,**
• **Fiber degrading:**	***Aspergillus* spp; *Trichoderma longibrachiatum***

Allzyme SSF



Jefo
Species-specific additives

Functional ingredients with reported health benefits

Nutrients

EAA - amino acids
Nucleotides
Fatty acids
Vitamins
Minerals

Others

MCTs
Essential oils
Organic acids
Prebiotics
Probiotics

Non-nutrients

Alginates
Beta glucans
Carageenans
Chitosans
Lactoferrin
Mannans
Peptidoglycan
Plant extracts

Ingredients with functional properties may improve shrimp survival but are not a panacea to eliminate a disease problem

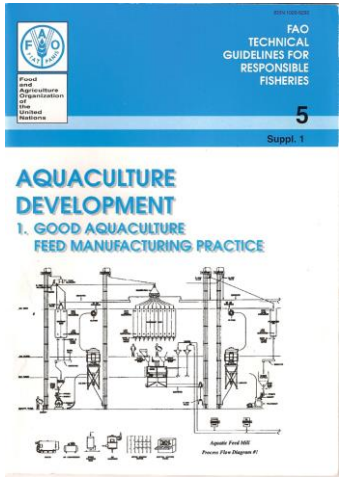
Main factors affecting on-farm fish & shrimp feed performance

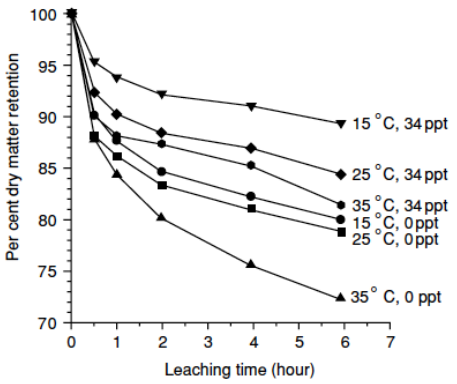
- **Feed processing method**

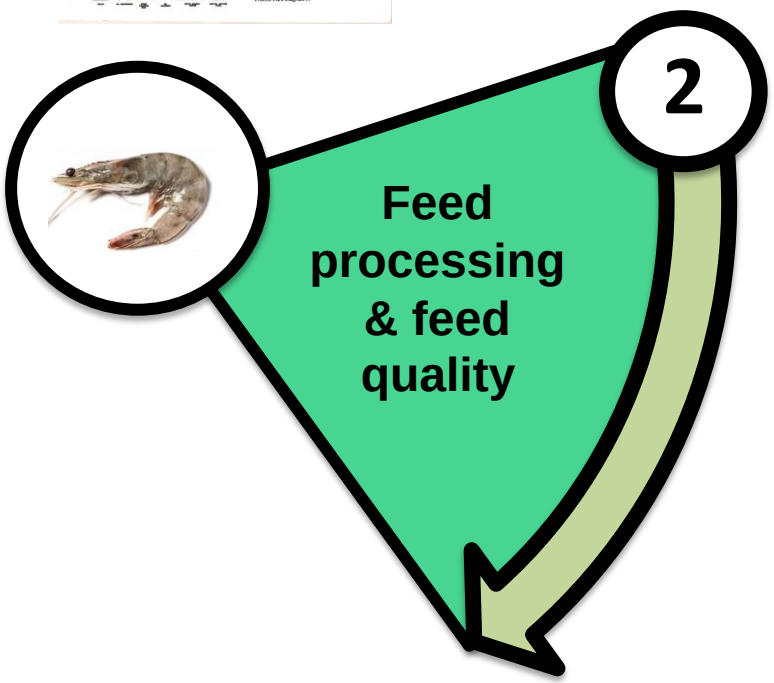
  - Pelleting, extrusion cooking
  - Size reduction (grinding)
  - Pre & post-pellet conditioning
  - Pellet drying, top coating
  - Sifting, crumbler
  - Percent fines & reuse
  - Bagging & labeling
  - Use of specific BMPs or GMPs

- **Feed quality control**

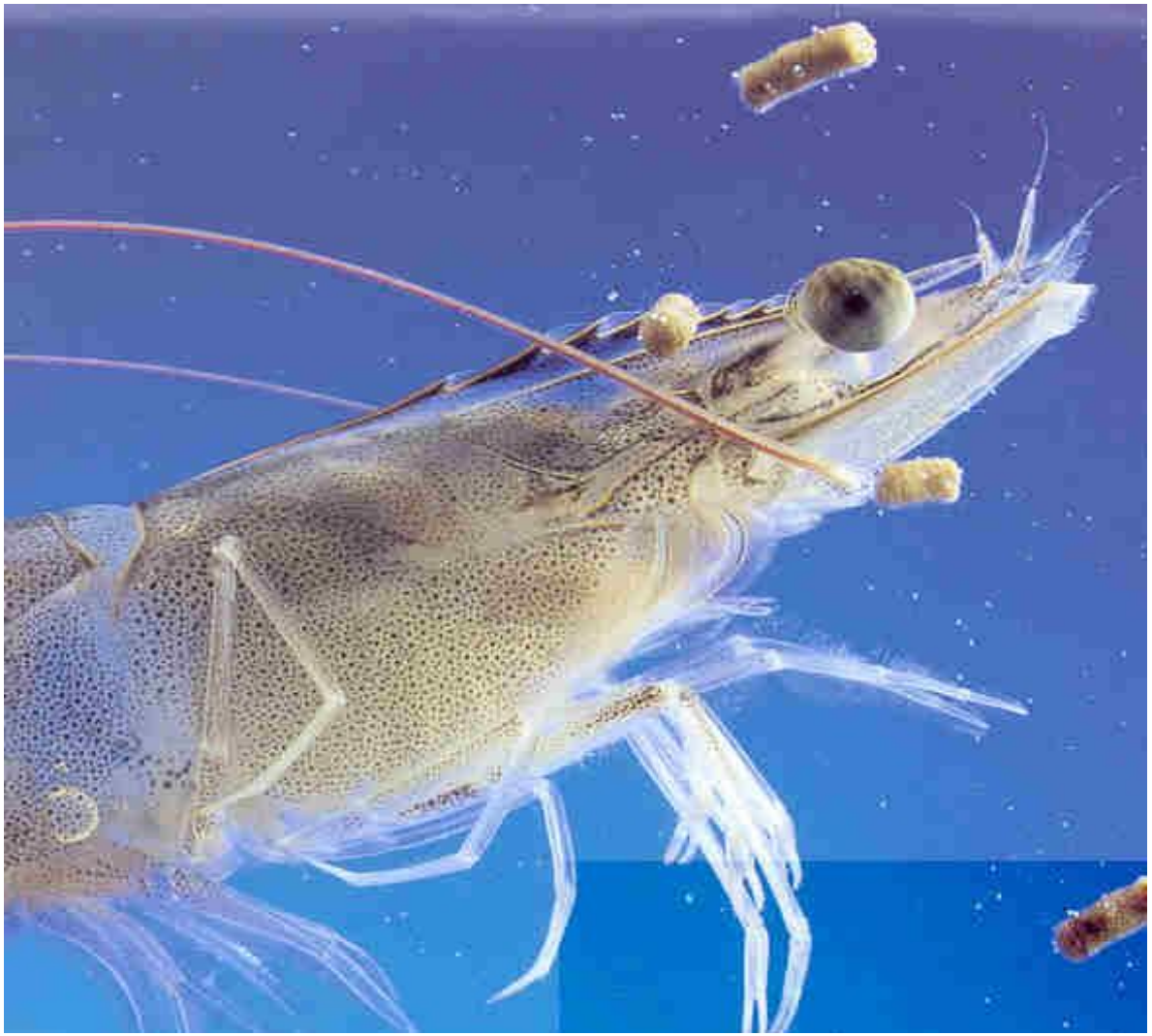
  - Ingredient & feed storage
  - Quality control methods
  - Parameters measured
  - Water stability & nutrient leaching (if known)
  - Feed safety controls
  - Pest control measures

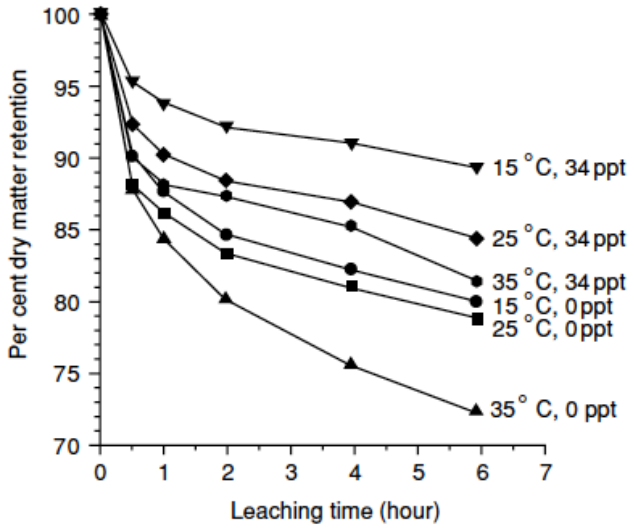


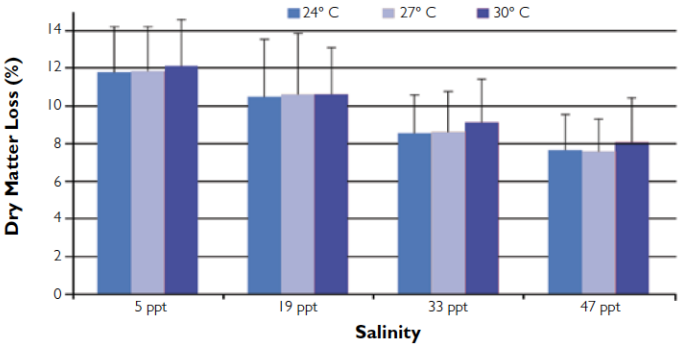


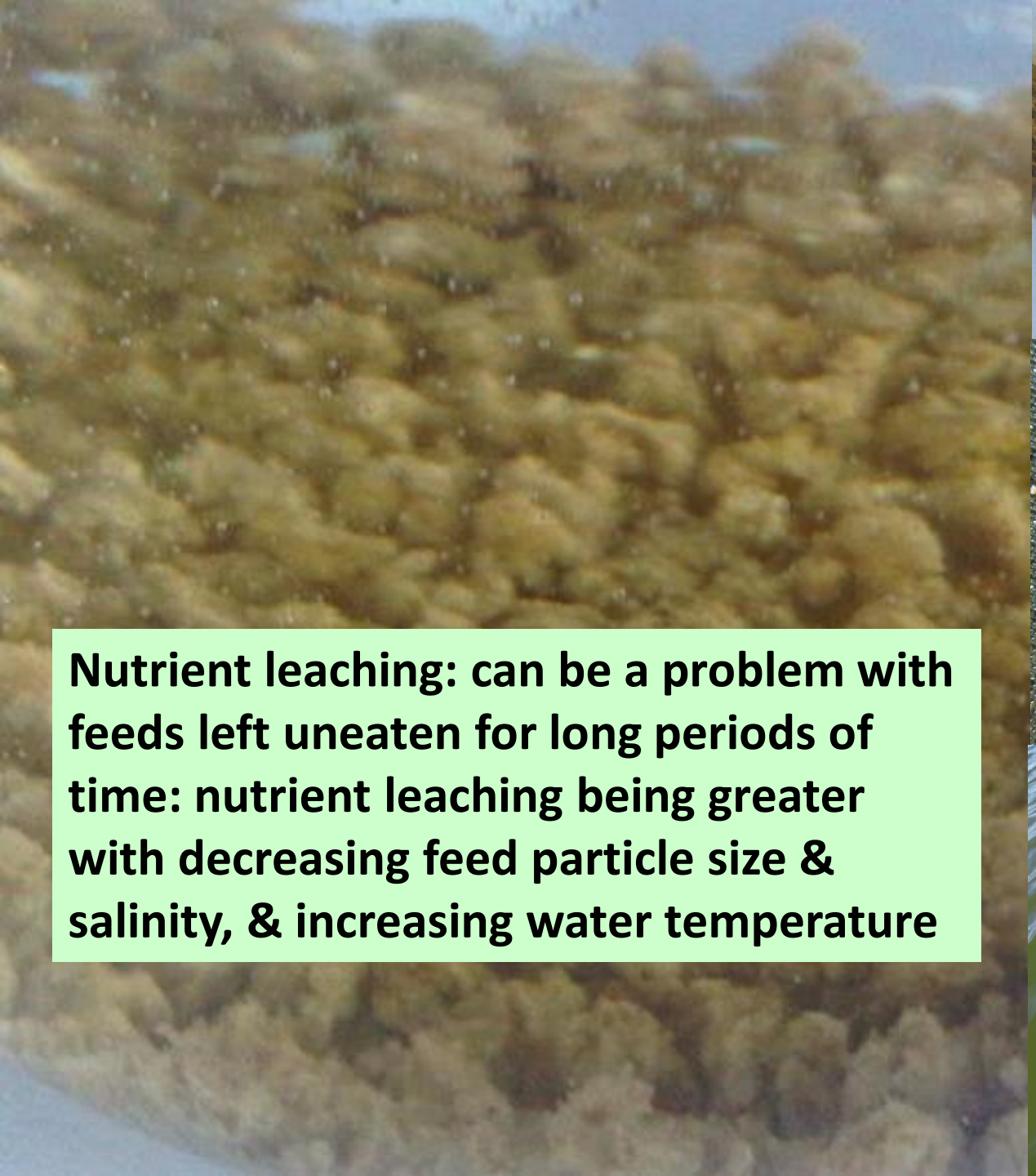


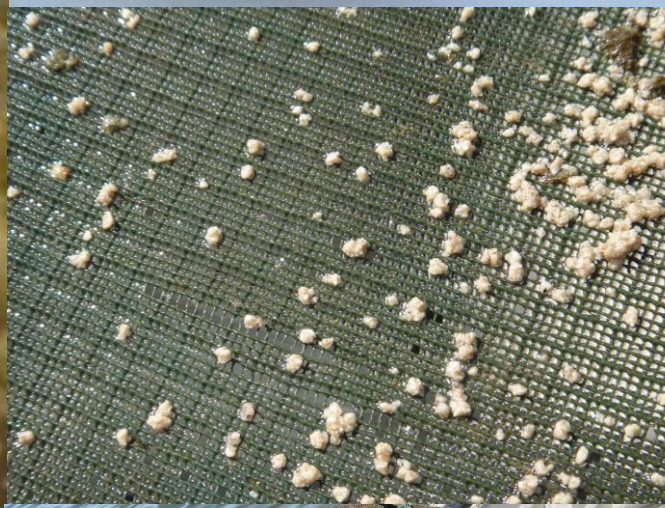
Slow feeding habits of shrimp, and the necessity of shrimp to masticate their feed externally prior to ingestion, and consequent risk of nutrient loss through leaching











Nutrient leaching: can be a problem with feeds left uneaten for long periods of time: nutrient leaching being greater with decreasing feed particle size & salinity, & increasing water temperature

Extru-Tech's SAS™

Low Shear & Low Temperature extrusion of a uniform and pulverized formulation into agglomerated strands. These strands, by cyclonic motion, are then rounded into nutritionally homogenous pellets.

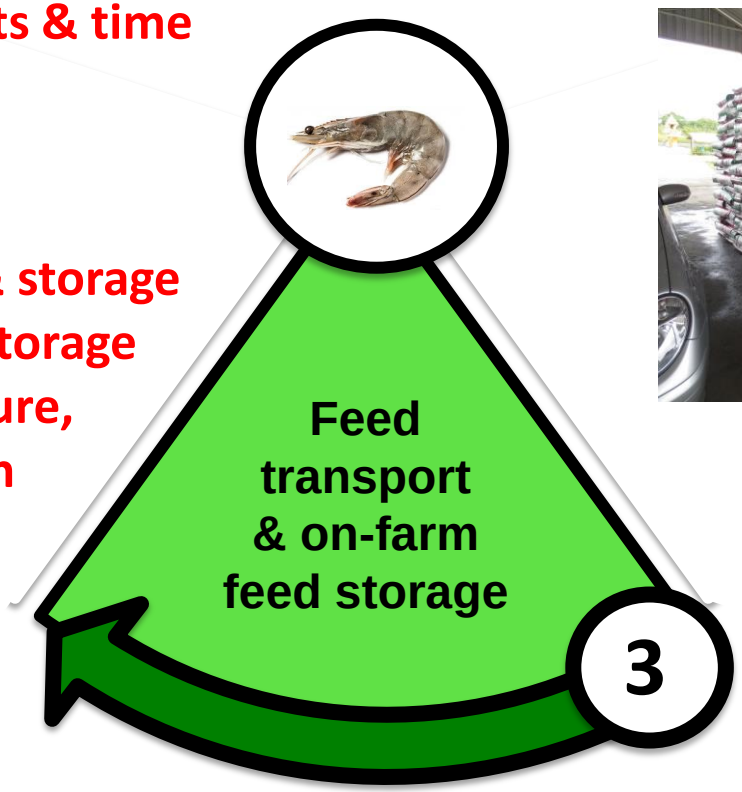
Main factors affecting on-farm shrimp feed performance

- **Feed transportation to farmer**

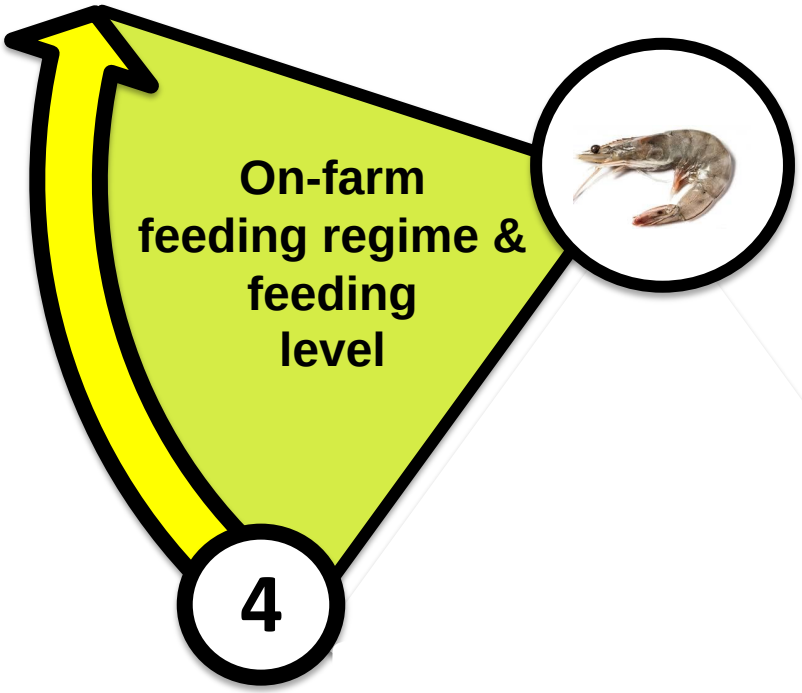
  - Method of transport - truck, boat, rail, plane
  - Packaging - big bags, sacks, containers
  - Protection from elements – sun, water, pests
  - Location of feed depots & time taken to reach depots

- **On-farm feed storage**

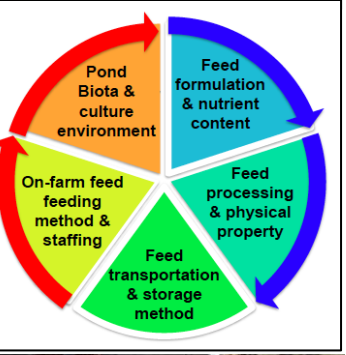
  - Feed record keeping & storage
  - Feed storage area & storage conditions - temperature, ventilation, prevention from water damage, pest control
  - Use of expired feeds



Main factors affecting on-farm fish & shrimp feed performance



- **On-farm feed management practice**
  - **Feeding method - by hand, boat, feeding tray, auto-feeder, truck**
  - **Feed application criteria - feeding table, shrimp appetite, feed trays, past experience, water quality parameters**
  - **Frequency of feed application for each shrimp age class**
- **Application of specific feed additives prior to feeding**
  - **Probiotics, specific vitamins, attractants & method of application**
  - **Record keeping concerning feed use - book, board, laptop**



Feed Biosecurity Risks

Feed Management

- **Risk of disease transmission through the use of raw and/or inadequately processed contaminated marine/shrimp products (including shrimp pastes, fermentation products, shrimp hydrolysates, and/or shrimp silage) applied through the top-dressing of commercial pelleted shrimp feeds by the farmer prior to feeding;**

Study shows automation significantly more efficient than hand feeding Improving the efficiency of aquafeed management in shrimp ponds is critical to improve industry productivity and profitability and minimize any environmental impacts.

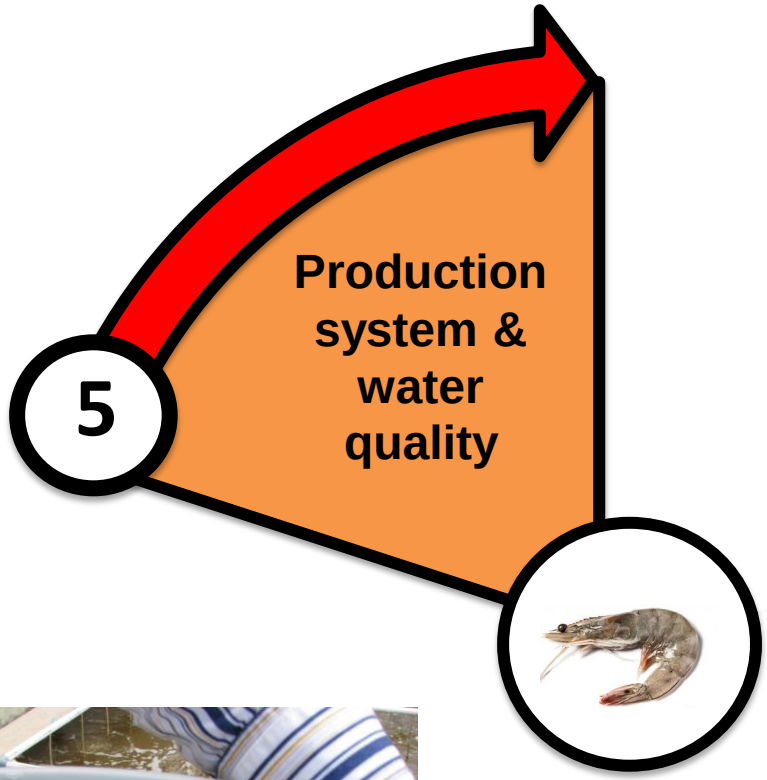
Dr Allen Davis personal communication

AQ1 SYSTEMS

Daniel Gruenberg reported advantages

- Improves feed conversion ratios (FCRs) by 30%
- Improves growth rate up to 30%
- Reduces the amount of feed fed
- Reduces feed costs
- Reduces labor costs by 80%
- Increases the harvest size of shrimp
- Increases the price you get for your shrimp
- Prevents leaching of nutrients
- Prevents degradation of your water quality
- Prevents feed wastes from accumulating on bottom

Main factors affecting on-farm fish & shrimp feed performance



- **Production system**

  - Raceway, earthen pond, lined pond, indoor tank
  - Stocking density
  - Water management - green water, floc or semi-floc, zero-water exchange, flow-through
  - Aeration method used
  - Application/use of probiotics
  - Natural food availability over culture period

- **Water quality variation (24h)**

  - Water temperature - min/max
  - Dissolved oxygen – min/max
  - NH_3 $N0_2$ pH PO_4 alkalinity
  - Bacterial levels
  - Phytoplankton/zooplankton
  - Algal blooms/crashes

<u>OXYGEN</u> is key – more important than feed

Fish & Shrimp cannot digest & make maximum use of the feed fed unless there is sufficient oxygen is available within the culture system

One of the most important pieces of equipment on the farm

Main factors affecting on-farm fish & shrimp feed performance

Technical services Support

1 Feed formulation & nutrient level

2 Feed processing & feed quality

3 Feed transport & on-farm feed storage

4 On-farm feeding regime & feeding level

5 Production system & water quality

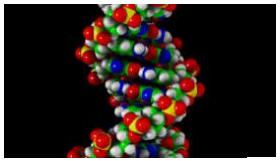
Control by fish or shrimp farmer

Control by feed company

Presentation outline

- Importance of biosecurity & definitions
- Feed biosecurity risks associated with viable pathogens, feed formulation, feed processing & on-farm feed management
- Future role of nutrition, genetics & environmental control in improving shrimp health management & the need for a new generation improved biosecure shrimp feeds & feed management systems
- Future roles & responsibilities of feed companies, traders, farmers & government authorities

Nutrition & Genetics determine the health & well-being of all fish & shrimp

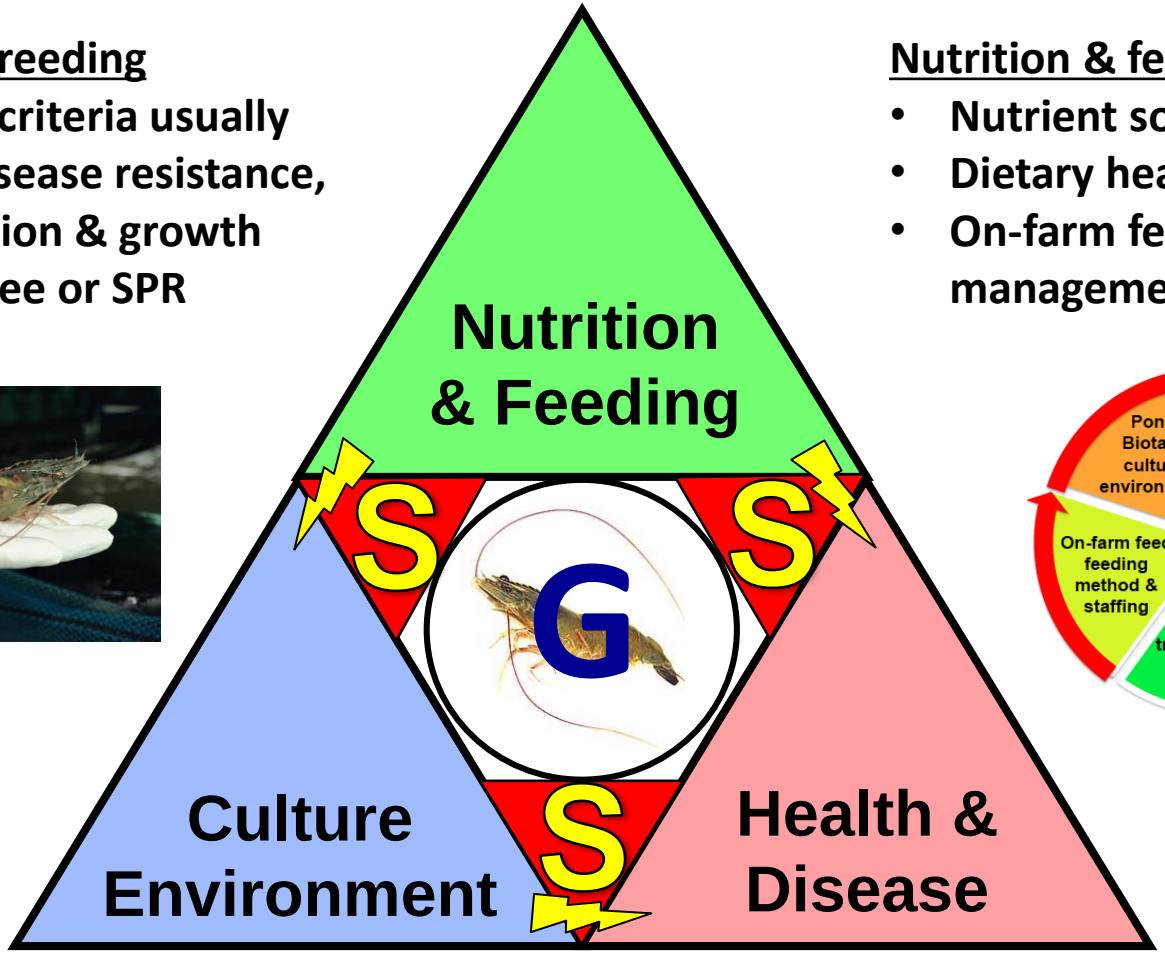


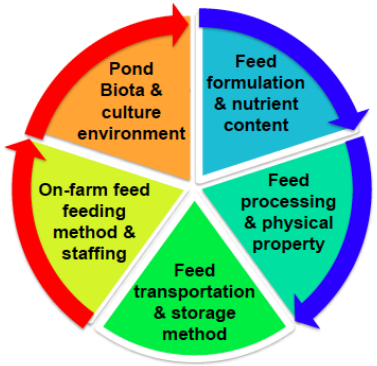
Genetics & breeding

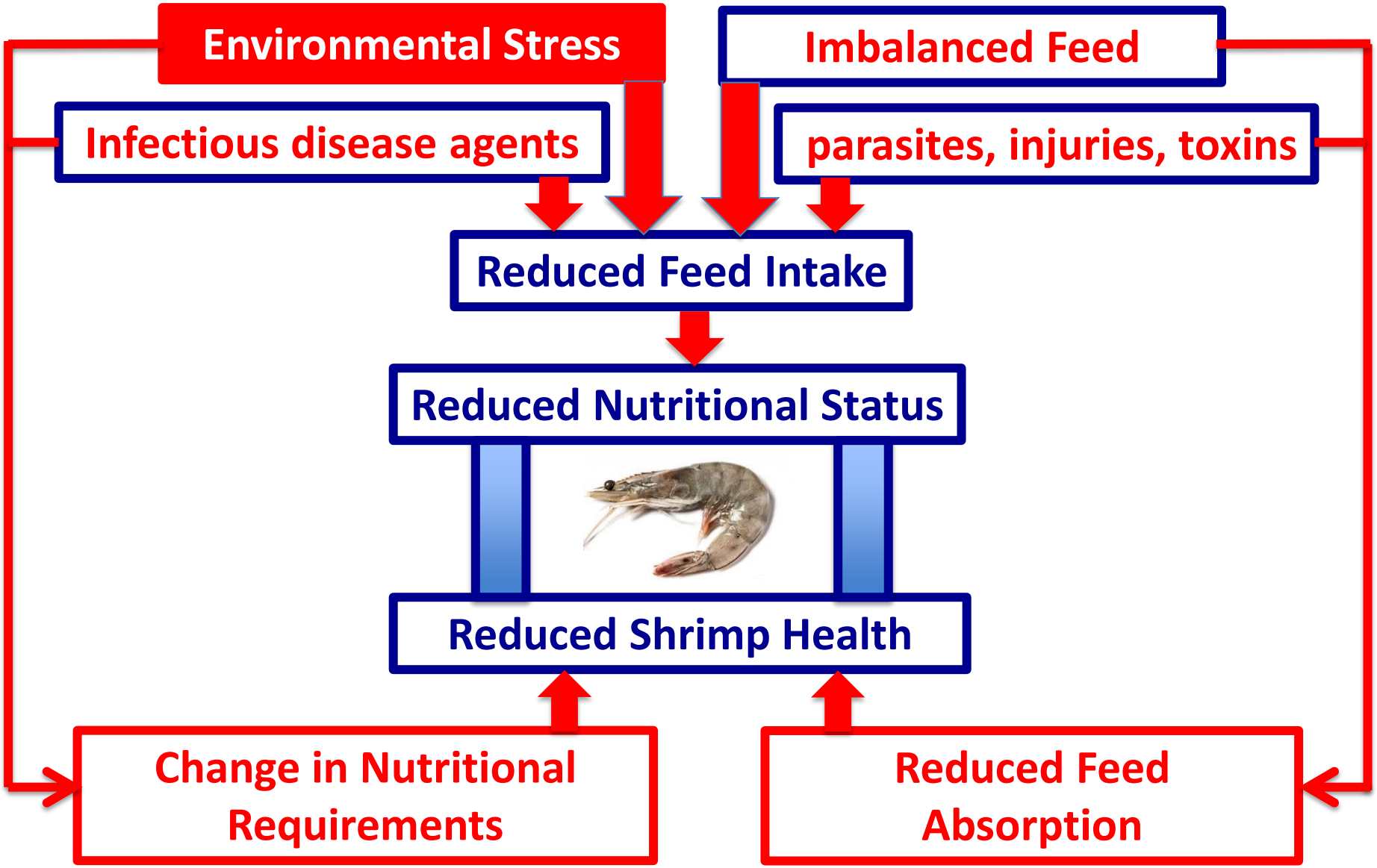
- Selection criteria usually related disease resistance, reproduction & growth
- Disease free or SPR

Nutrition & feeding

- Nutrient source & level
- Dietary health promoters
- On-farm feed & water management







Environmental interactions between nutrition & health

(modified after Waabo. 1994; Tacon, 1997)

Conventional shrimp culture conditions

- shallow ponds with large surface area
- variable water temperature from am to pm
- variable dissolved oxygen levels from am to pm
- build-up of uneaten feed & fecal matter on pond bottom
- irregular feeding & increased leaching & nutrient loss
- deteriorating water quality over culture cycle

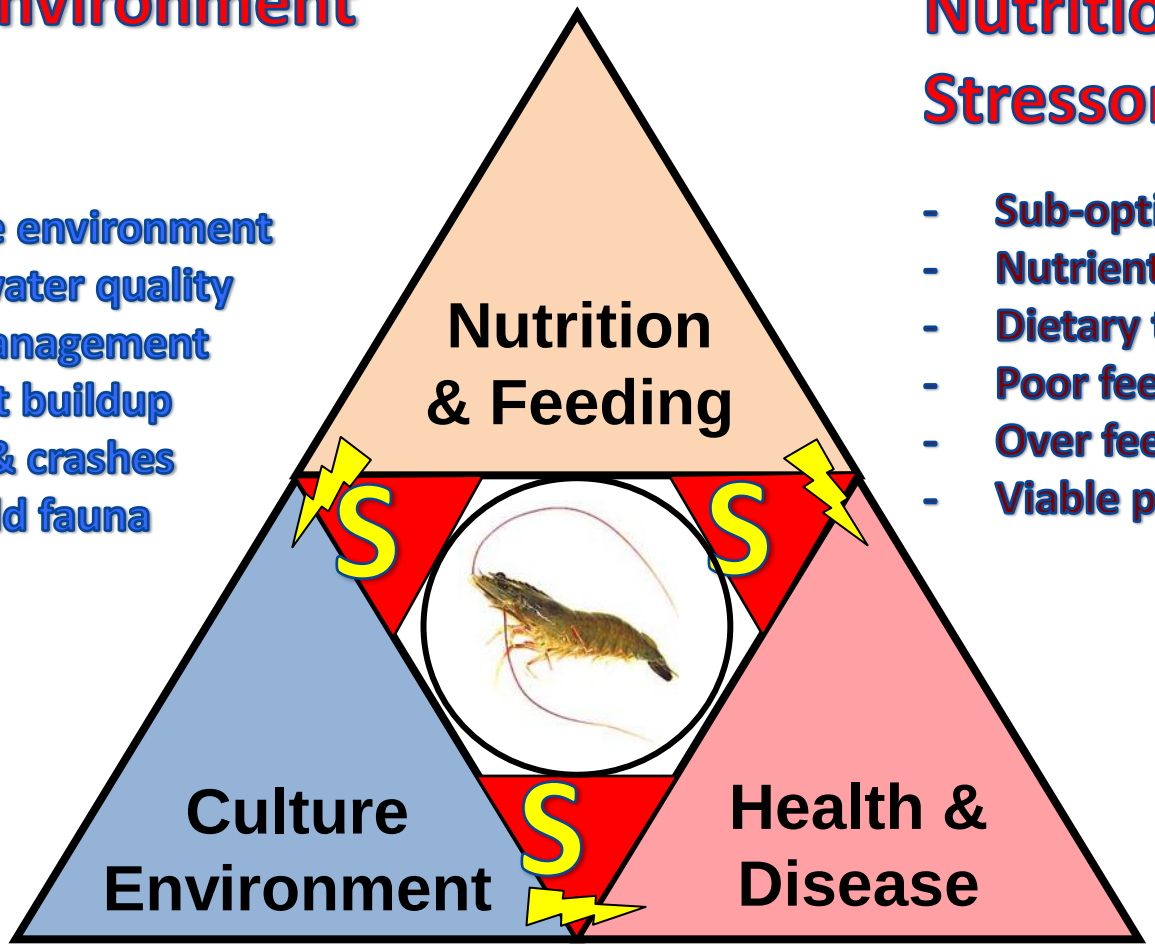
shrimp stress

O_2

Major stressors – through diet, feeding & culture environment

Culture & environment Stressors

- Open unstable environment
- Sub-optimal water quality
- Poor water management
- Toxic sediment buildup
- Algal blooms & crashes
- Competing wild fauna

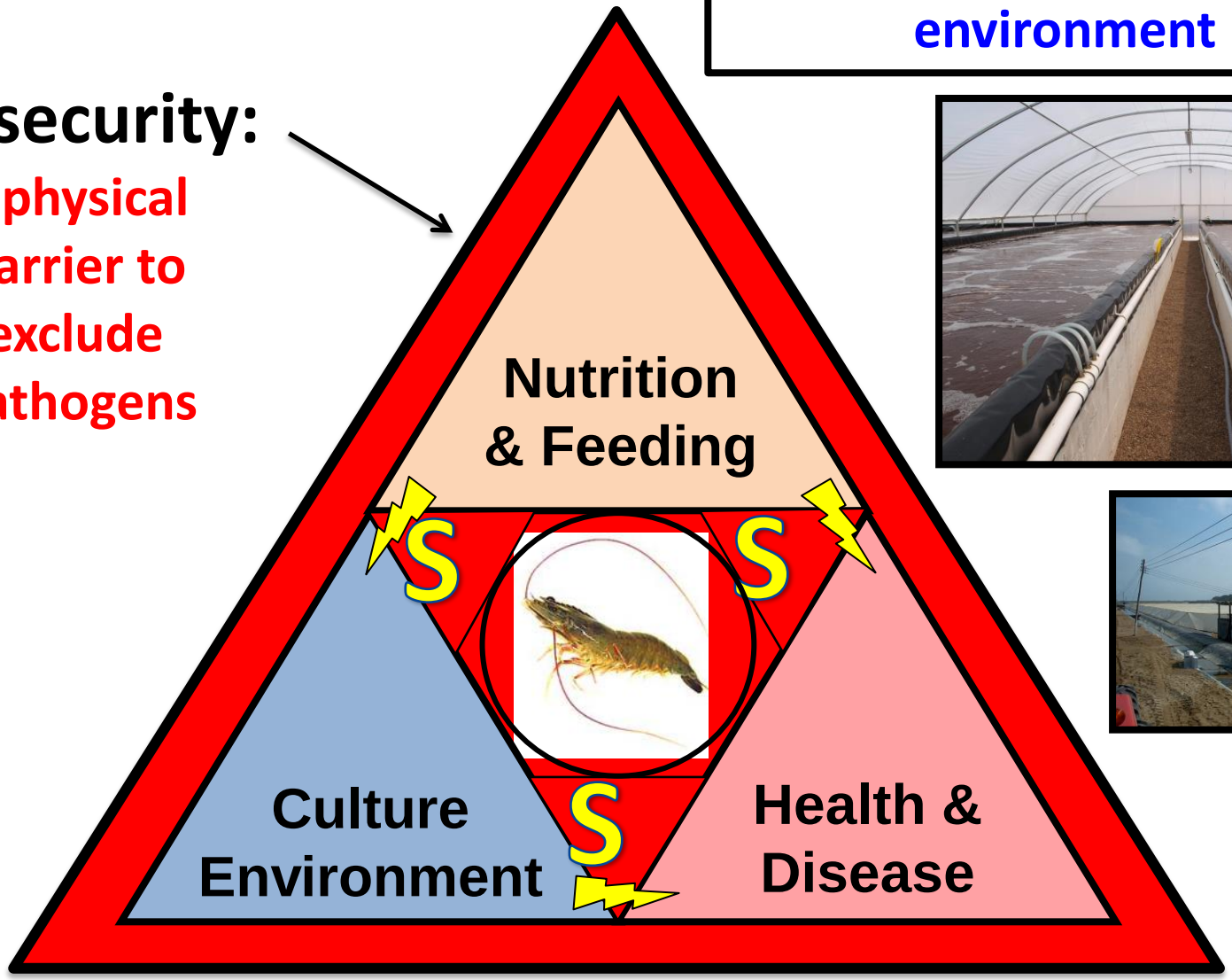


Nutrition & feeds Stressors

- Sub-optimal nutrition
- Nutrient deficiency
- Dietary toxins
- Poor feed management
- Over feeding
- Viable pathogens

Indoor hatchery or nursery:
constant & stable environment

Biosecurity:
a physical barrier to exclude pathogens



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Suggested Recommendations for Biosecure Shrimp Feeds






Feed Manufacturers Responsibilities

- Formulate nutritionally complete feeds on a digestible nutrient basis for optimum health & wellbeing
- Full ingredient & nutrient disclosure, including prohibiting the use of shrimp/locally sourced crustacean meals
- Feeds should be manufactured & sold as being Biosecure & Pathogen-free
- Discourage farmers top-dressing feeds with unregulated feed additives
- Provide training assistance to farmers, and in particular to small-scale farmers, concerning feed BMPs, including disposal of dead shrimp & moults
- Beware of using adulterated ingredients

Need for the Development of Biosecure Pathogen-free Shrimp Hatchery Feeds

For full shrimp hatchery biosecurity the shrimp industry must move away from the use of live food organisms to the use of fully biosecure water-stable dry or liquid shrimp nutritionally-complete hatchery feeds

There is no nutrient or substance present within live feeds, including algae and Artemia nauplii, that we cannot put into a fully biosecure commercially formulated dry or encapsulated larval shrimp feed!

Need for the Development of Biosecure Pathogen-free Shrimp Nursery & Grow-out Feeds

For full farm biosecurity the shrimp industry must move away from the use of live or processed natural food organisms to the use of fully biosecure nutritionally-complete water-stable dry shrimp feeds

As mentioned previously, there is no nutrient or substance present within Artemia that we cannot put into a fully biosecure commercially formulated feed!

Need for the Development of Biosecure Pathogen-free Shrimp Broodstock Feeds & Maturation Feeds

For full shrimp and farm biosecurity the shrimp industry must move away from the use of live and/or frozen feeds to the use of fully biosecure water-stable semi-moist and/or dry nutritionally-complete shrimp broodstock & maturation feeds

There is no nutrient or substance present within these live and fresh food organisms that we cannot put into a fully biosecure commercially formulated dry shrimp feed!






Suggested Recommendations for Biosecure Shrimp Feeds

Shrimp Farmer Responsibilities

- Importance of **record keeping** for monitoring feed intake & feed efficiency on a pond by pond and farm basis
- Only top dress feeds immediately prior to feeding, using only **legally approved** feed additives of known composition
- **Prohibit** use of antibiotics (unless under veterinary control) and **fresh feed** items
- **Disposal** of dead shrimp and exoskeleton using biosecure protocols
- Adheranace to feed management **BMPs**
- Feed shrimp at optimum DO levels & temperature on a continuous little & often basis over a 24-h day, preventing **over-feeding** and feed/sludge settlement











Suggested Recommendations for Biosecure Shrimp Feeds






Government Responsibilities

- **Legislate** for feed companies to formulate shrimp feeds for optimum health & well-being , with full ingredient use & nutrient level disclosure
- **Prohibit** intra-species recycling and the use of non-biosecure crustacean meals
- **Legislate** for feeds to be certified & sold as being fully Biosecure & Pathogen-free
- **Prohibit** farmers from top-dressing their feeds with unregulated feed additives
- **Provide** training assistance to farmers, and in particular to small-scale farmers, concerning feed BMPs, including disposal of dead shrimp & moults etc
- **Clamp** down on illegal unliscenced traders

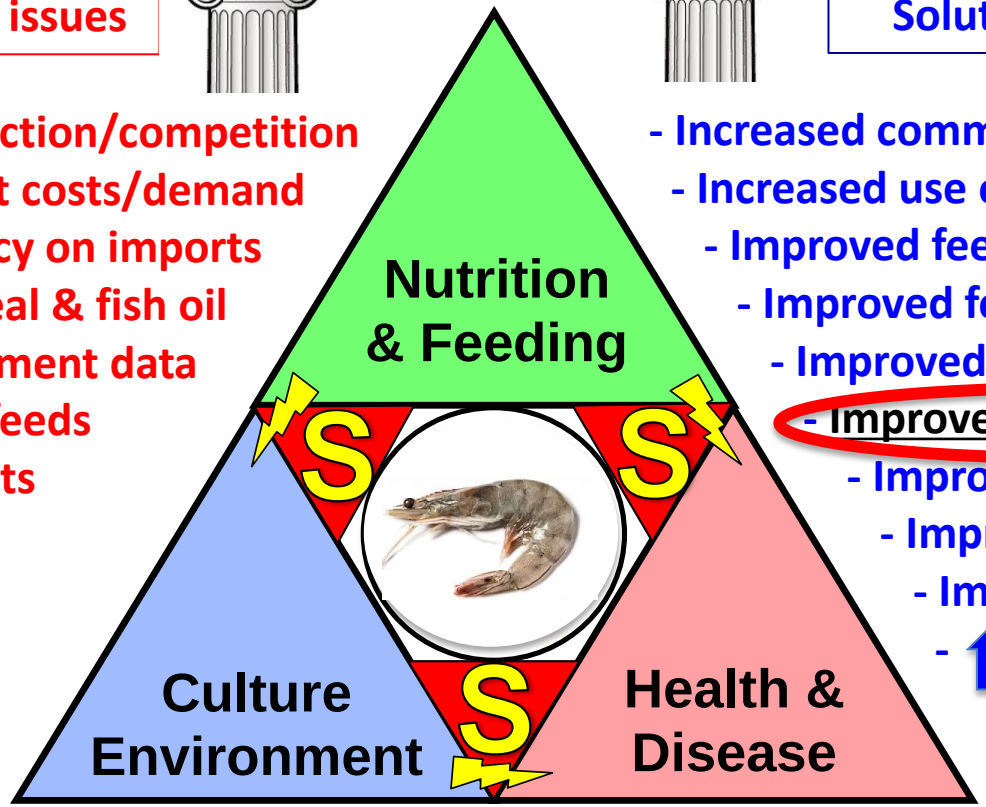
AQUAHANA

A'ohe hana nui ke alu 'ia — *No task is too big when done together*

Towards the development of a more sustainable aquafeed sector

Major issues

- Increased feed production/competition
- Rising feed ingredient costs/demand
- Increasing dependency on imports
- Reliance upon fishmeal & fish oil
- Lack nutrient requirement data
- Over formulation of feeds
- Environmental impacts
- Disease outbreaks
- Feed biosecurity
- Food safety



Solutions

- Increased commitment to R & D
- Increased use of local resources
- Improved feed formulations
- Improved feed processing
- Improved on-farm feed use
- Improved feed biosecurity
- Improved traceability
- Improved food safety
- Improved nutrition
- ↑ Sustainability