Shrimp nutrition & health: a holistic approach

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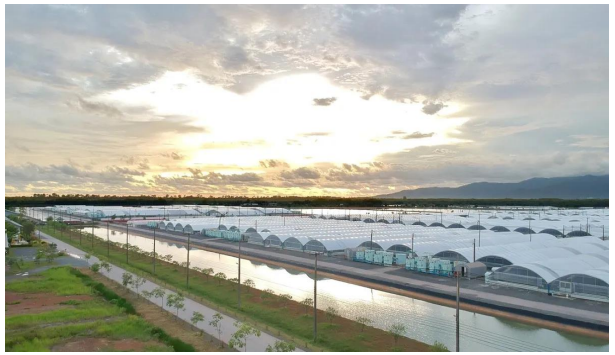
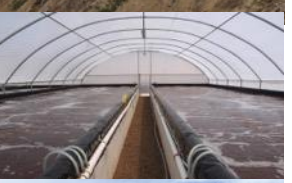


AQUAHANA

A'ohe hana nuí ke alu'ía → No task is too big when done together






The problem

The World & Brasil

Different culture systems, genetics & feeds used

Different farming systems

Stocking densities
Farming systems
Water & aeration methods
Feeding methods
Biosecurity

Different feeds & feeding

Natural foods
Supplementary feeds
Pelleted feeds
Extruded feeds
Autofeeders

Bottom line for farmer: US $ /kg production & intended market






Another problem: Need to reduce Stress & Disease during the culture cycle

Diet and feeding stressors

Sub-optimal feed & nutrition
Poor ingredient quality
Antinutrients & toxins
Poor feed management
Over/under feeding
Feed pathogens

Environmental stressors

Open unstable environment
Sub-optimal water quality
Anoxic sediment buildup
Algal blooms/crashes
Competing bacterial flora & biota
^{o}C & 0_2

Need for strict environmental control & biosecurity to minimise Stress

Stress

Environmental culture stress

Infectious disease agents

Open unstable environment
Sub-optimal water quality
Poor water management
Toxic sediment buildup
Algal blooms & crashes
Competing bacterial
flora & biota

Imbalanced sub-optimal feed

parasites, injuries, toxins

Stress

Sub-optimal feed
Poor ingredient quality
Antinutrients & toxins
Poor feed management
Over & under feeding
Viable pathogens
through feeds

Reduced Feed Intake

Reduced Nutritional Status

Reduced Shrimp Health

Change in dietary nutrient requirements

Reduced gut health & nutrient absorption

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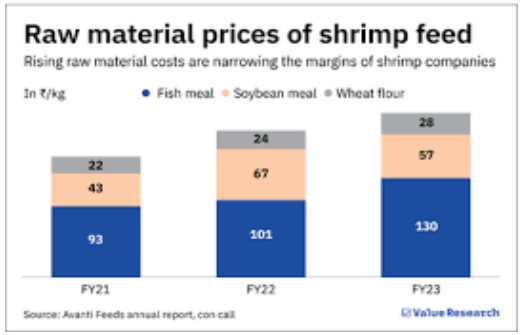
Gut: first line of defense

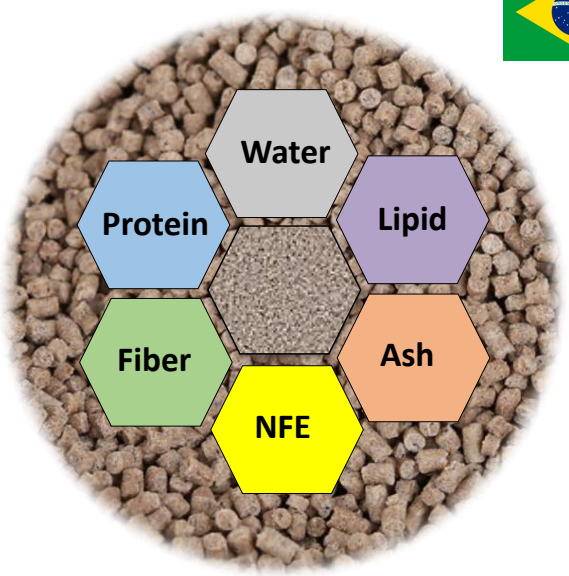
Nutrition & Health Interactions

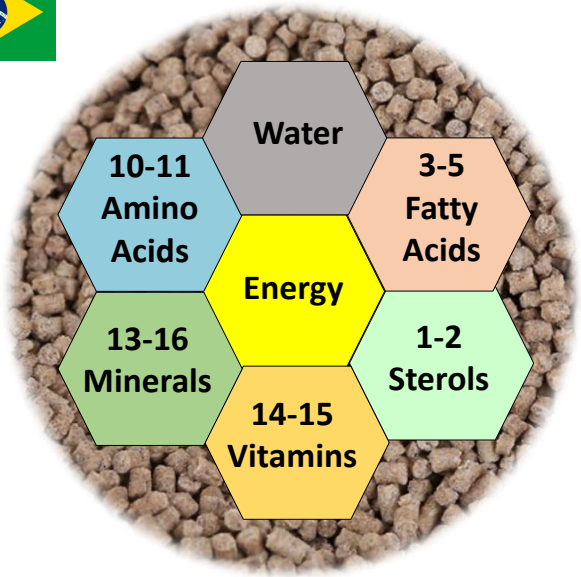
(modified after Tacon & Tran, 2022)

Part of the solution: Shrimp Feed

Farmers largest operating cost item







Shrimp do not have a dietary requirement for Protein, Lipid, Fiber or Ash

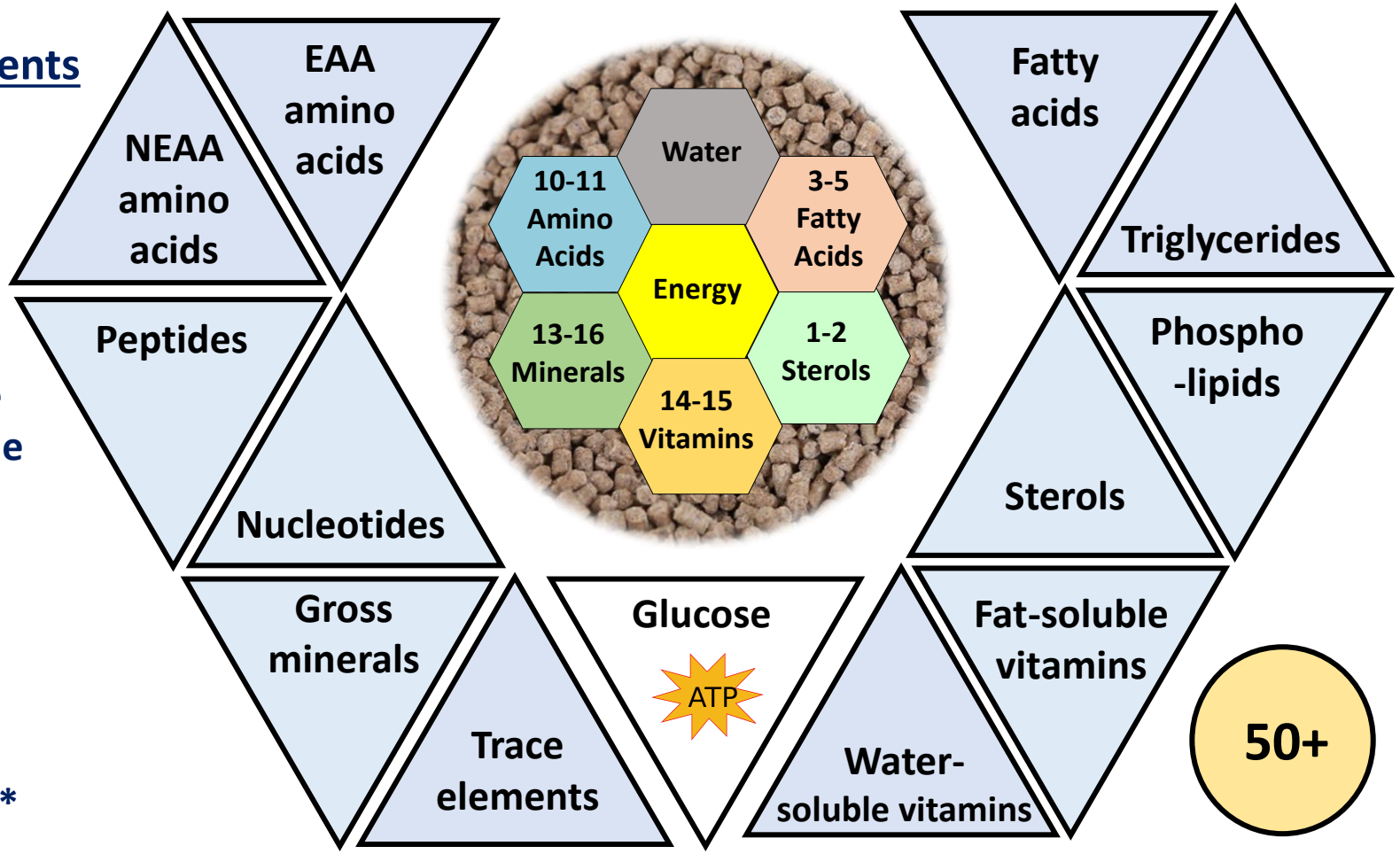
but have a requirement for the 50 + biologically available essential nutrients contained in the feed

Shrimp Feed Formulation: 50+ Essential Nutrients in biologically available form

Essential nutrients

Arginine
Histidine
Isoleucine
Leucine
Lysine
Methionine
Phenylalanine
Threonine
Tyrosine
Valine
Taurine *

Peptides *
Nucleotides *



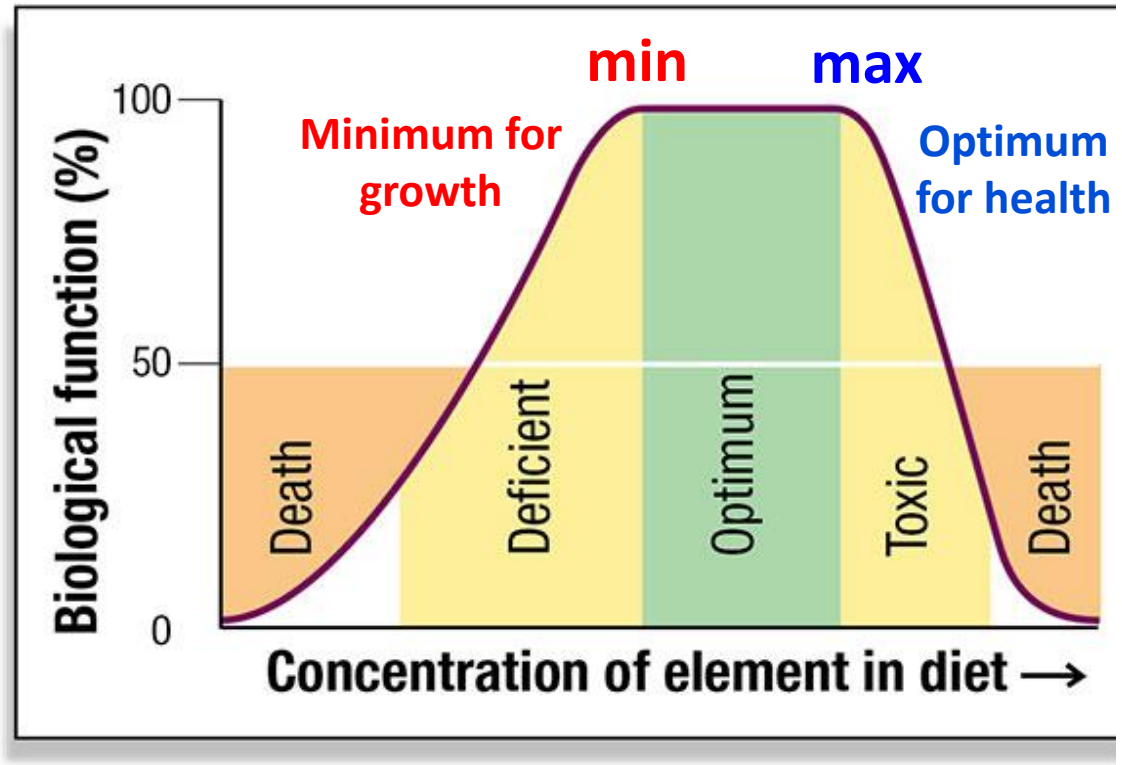
Essential nutrients

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

Vitamin A, C, D, E, K
Vitamin B_1 B_2 B_5 B_6 B_7 B_{12}
Choline, Inositol, Folic acid,
Carotenoids/astaxanthin *

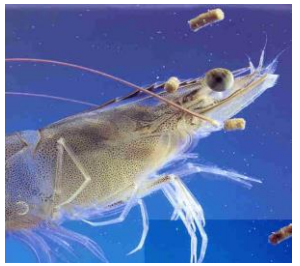
Calcium, Phosphorus,
Potassium, Sodium, Iron,
Magnesium, Manganese,
Zinc, Copper, Cobalt, Iodine,
Selenium, Chromium,
Molybdenum, Silicon *

Dietary nutrient requirements



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

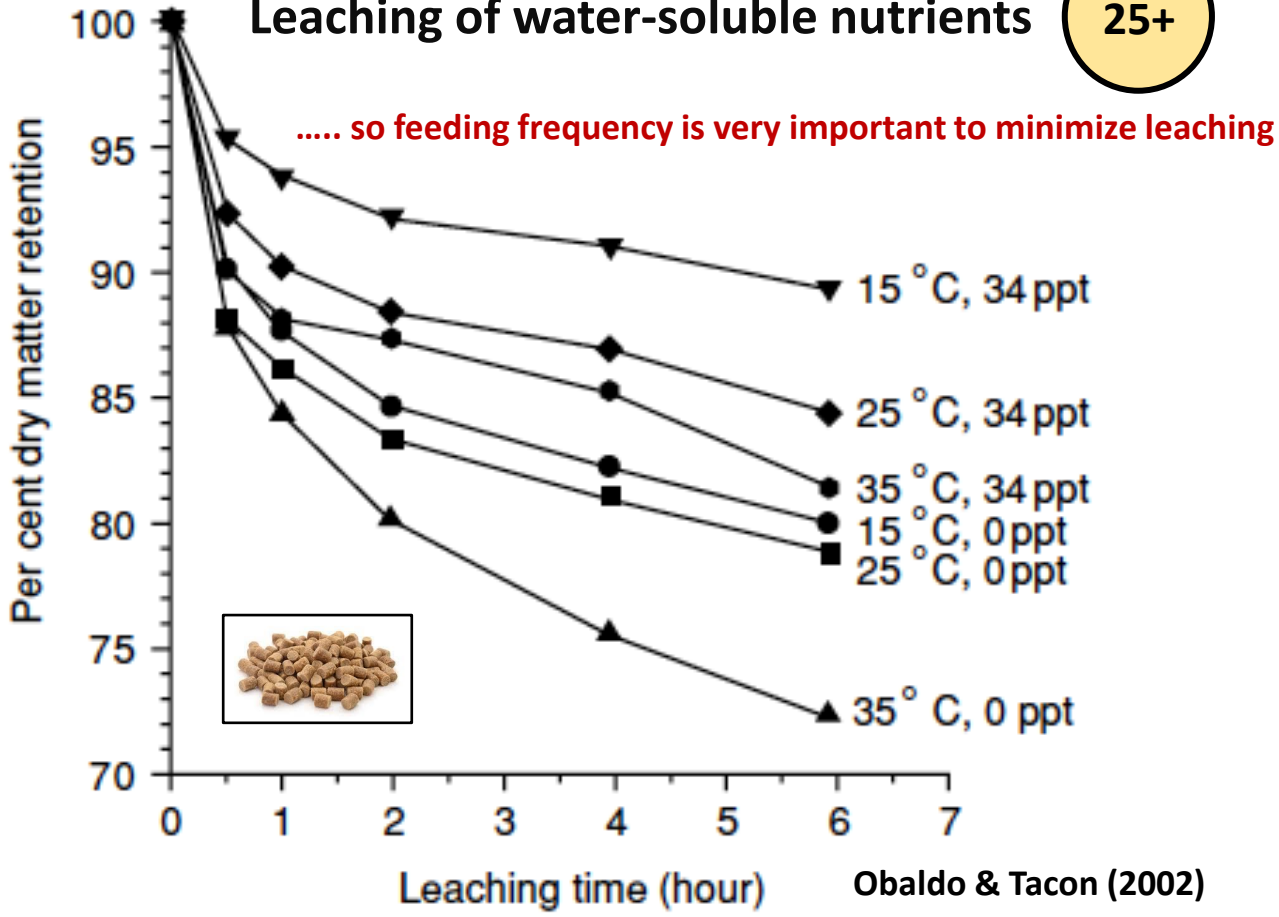
Specific shrimp issues



Leaching of water-soluble nutrients

25+

….. so feeding frequency is very important to minimize leaching



Obaldo & Tacon (2002)

Increasing use of plant proteins, meals & oils in shrimp feeds

Including:

Oilseeds & legumes: Soybean meal, soybean protein concentrate, soybean protein isolate, fermented soybean meal, rapeseed meal, canola protein concentrate, canola meal, mustard seed meal, sunflower seed meal, cottonseed meal, peanut meal, Pea protein meals, Lupin kernel meal;

Cereals: Vital wheat gluten, Wheat gluten meal, Corn gluten meal, Corn protein concentrates, Fermented corn protein meals, Distillers dried grains with solubles (DDGS), Barley protein meals, Rice protein concentrate;

Tubers/fruit: Potato protein meals, Palm kernel meal, Copra meal, Fermented copra meal

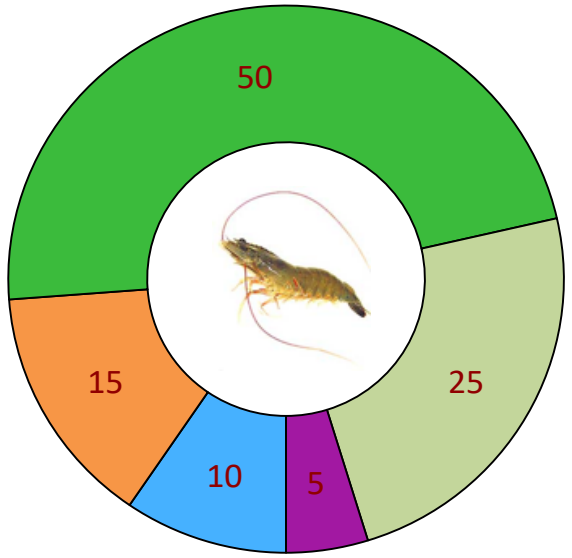
Aquatic meals & oils	5-10%
Fishmeal & fish oil	5-10
Squid meal, crustacean meal	3-10
Seaweed meals & products	1-5
Cultured microbial biomass	1-5

Terrestrial animal proteins & oils	5-15%
Poultry by-product meals	5-10
Porcine by-products	2-5
Ruminant by-products	2-5
Terrestrial invertebrates	1-5

Terrestrial plant proteins & oils	25-50%
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	15-25%
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, chelated minerals	
Amino acids, nucleotides, feeding attractants	
Enzymes, gut modifiers, prebiotics, probiotics, acidifiers	
Immune enhancers, anti-fungal, anti-viral, anti-parasitical	
Cholesterol, binders, pigments, growth promoters	

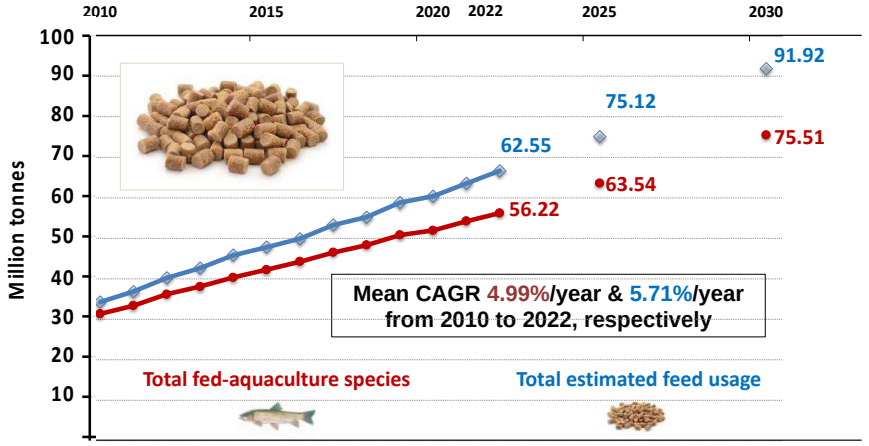
May 2024

Oilseeds: World Markets and Trade

Major protein meals	2023/24 (Mt)
Meal, Copra	1.98
Meal, Cottonseed	15.13
Meal, Fish	4.91
Meal, Palm kernel	10.74
Meal, Peanut	7.43
Meal, Rapeseed	48.68
Meal, Soybean	258.93
Meal, Sunflowerseed	23.05
Total	370.84 Mt

Figure 13. Total global fed-aquaculture species production and estimated aquaculture feed usage from 2010 to 2022, and estimates for 2025 & 2030

(Fed-species production calculated from FishStatJ release 4.03.06: FAO, 2024)



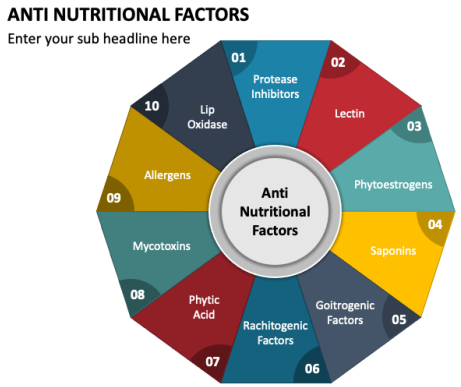
Agri-Food Outlook | 2024

Alltech

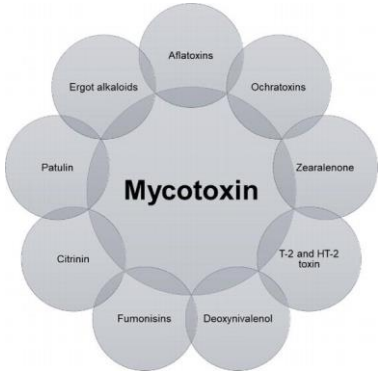
Feed Tonnage by Sector

Volume growth in feed tonnage came predominantly

Sector	2022 feed tonnage (MMT*)
Broiler	385.04
Pig	320.80
Layer	170.88
Dairy	126.23
Beef	117.49
Aqua	52.09
Pet	34.96
Equine	7.98
Totals*	**1,286.58**



The Problem & Risk



All Plant ingredients may contain Anti-Nutritional Factors (ANF) & Mycotoxins, which unless removed or inactivated can have a negative effect on growth, gut health, nutrient digestion, disease susceptibility & health

ANFs are secondary metabolites found in plants, which generally serve protective functions against predation & for maximize plant survival

Algae - 1.2 billion years; Flowering plants/insects 400 million; Humans 1-2 million

- **Proteins**: protease inhibitors, phytohemagglutinins, toxic amino acids, food allergens
- **Glycosides**: goitrogens, cyanogens, saponins, estrogens
- **Phenols**: gossypol, tannins
- **Miscellaneous**: phytic acid, anti-vitamins, anti-enzymes, toxic fatty acids & NSP

Endogenous anti-nutritional factors within plant feed ingredients

(Source: Tacon, Metian & Hasan, 2009)

Cereals	
Rice	1, 2, 5, 8, 13 (5)
Wheat	1, 2, 5, 8, 11, 18, 22 (7)
Corn/maize	1, 5, 8, 19 (4)
Oilseeds	
Rapeseed	1 (T), 3, 5, 7, 28, 29 (6)
Indian mustard	1 (T), 3, 5, 7, 13, 28, 29 (7)
Soybean	1 (T, E, C, Pa, In), 2, 3, 5, 6, 8, 11, 12, 14, 16, 17, 27, 28 (13)

1: Protease inhibitors (T-trypsin, C-chymotrypsin, In-insect proteases, Pa-papain, E-elastin), 2: Phyto-haemagglutinins, 3: Glucosinolates, 4: Cyanogens, 5: Phytic acid, 6: Saponins, 7: Tannins, 8: Estrogenic factors, 9: Lathyrogens, 10: Gossypol, 11: Flatulence factor, 12: Anti-vitamin E factor, 13: Anti-thiamine factor, 14: Anti-vitamin A factor, 15: Anti-pyridoxine factor, 16: Anti-vitamin D factor, 17: Anti-vitamin B_{12} factor 18: Amylase inhibitor, 19: Invertase inhibitor, 20: Arginase inhibitor, 21: Cholinesterase inhibitor, 22: Dihydroxyphenylalanine, 23: Mimosine, 24: Cyclopropenoic acid, 25: Alkaloids, 26: Canavanine, 27: Allergens, 28: Non-starch polysaccharides (oligosaccharides), 29: Erucic acid

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That's why we cook our foods

GOOD NEWS

ANFs - commercial methods used for their removal and/or reduction

ANFs	Feed source	Treatment methods used
Amylase inhibitors	Cereal grains, peas	Heat
Fibre	All plants	Dehulling
Goitrogens	Rapeseed	Heat, Iodine supplementation
Gossypol	Cottonseed	Non-polar extraction, iron supplementation
Protease inhibitors	Cereal grains, legumes	Heat, methionine supplementation
Lectins	All plant seeds	Heat
Lipase inhibitors	Cereal grains, beans	Heat
Oligosaccharides	Legumes	Alcohol/aqueous extraction
Phytic acid	All plants	Mineral supplementation
Phytoestrogens	Beans	Alcohol/non-polar extraction
Phytosterols	Legumes	Alcohol/non-polar extraction
Quinolozidine alkaloids	Lupins	Aqueous extraction
Saponins	Legumes	Alcohol extraction
Tannins	Rapeseed, beans, sorghum	Dehulling, autoclaving

For all ANFs listed, levels may be reduced further by fermentation or use of dietary exogenous enzymes that specifically inactivate the compound, or through the use of selective breeding techniques/genetic modification

MYCOTOXINS – THE HIDDEN THREAT

The greatest risk to fish/crustacean health is from the use of ingredients/aquafeeds contaminated with mycotoxins; the risk being highest under warm/humid conditions which favor the growth of the mycotoxin producing filamentous fungi

Nutritional disorders

Related to

- Proteins & amino acids
- Lipids & fatty acids
- Minerals & trace elements
- Vitamin imbalances
- Anti-nutritional factors
- Feed contaminants

Usually results in

- Reduced growth & FCR
- Reduced disease resistance, health & survival

Pathology signs

EXTERNAL

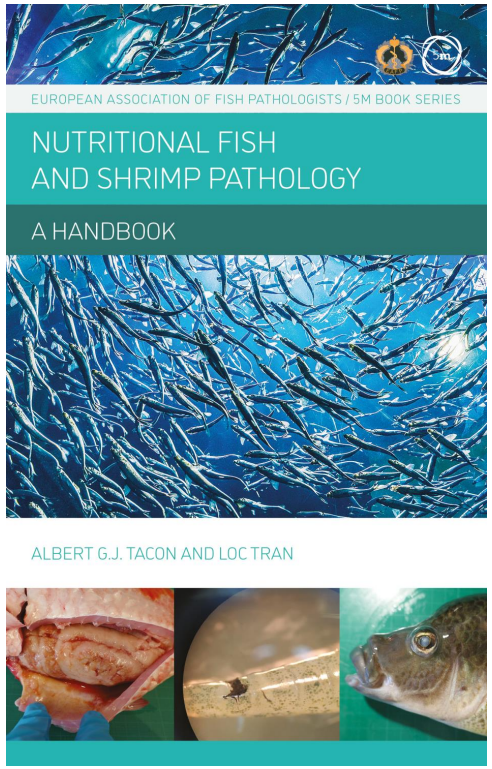
- Animal behavior
- Body shape & size
- Eyes, fins & gills
- Lesions & hemorrhage
- Skin color & pigmentation
- Feed intake & FCR

INTERNAL

- Blood & hematology
- Gut structure & function
- Heart
- Immunity & disease resistance
- Liver/hepatopancreas
- Muscle S & F
- Skeletal & bone abnormality
- Kidney/spleen S & F

Example of major pathology signs related to nutrition

Major pathology sign	Nutrient
Reduced disease resistance & immune function	➢ Essential amino acid deficiency: Arginine, Isoleucine, Methionine, Phenylalanine, Taurine, Threonine, Tryptophan & Valine ➢ Essential fatty acid deficiency ➢ Mineral deficiency: Copper, Chromium ➢ Vitamin deficiency: Vitamin A, Vitamin E, Vitamin C, Thiamine, Riboflavin, Pantothenic acid, Nicotinic acid, Folic acid, Choline ➢ Oxidized lipids ➢ Mycotoxin contamination



ADVENTITIOUS FACTORS
MYCOTOXINS – THE HIDDEN THREAT

The greatest risk to fish/shrimp health is from the use of ingredients/aquafeeds contaminated with mycotoxins; the risk being highest under warm/humid conditions which favour the growth of the mycotoxin producing filamentous fungi

Major mycotoxins of concern to human health, food & feed sector, include:

Aflatoxin (AFL): major metabolites - AFB_1, AFB_2, AFG_1, AFG_2;
Fumonisin (FUM): major metabolites - Fumonisin B1, B2, B3;
Ochratoxin A (OTA): major metabolite - Ochratoxin A
Trichothecenes (TCT): major metabolite - T-2 toxin, Deoxynivalenol (DON), Nivalenol;
Zearalenone (ZEN): major metabolite - Zearalenone.

Mycotoxins are toxic secondary metabolites produced by saprophytic filamentous fungi or molds; to date over 500 different mycotoxins have been categorized as toxic; their reported adverse effects in humans may include necrosis, hepatitis, hemorrhage, gynecomastia with testicular atrophy, neurological disorders, cancer and death

Acetoxyscirpenediol	Acetyldeoxynivalenol	Acetylneosolaniol	Acetyl T-2 toxin	Aflatoxin	Aflatrem	Altenuic acid
Alternariol	Austdiol	Austamide	Austocystin	Avenacein + 1	Beauvericin + 2	Bentenolide
Brevianamide	Butenolide	Calonectrin	Chaetoglobosin	Citrinin	Citreoviridin	Cochliodinol
Crotocin	Cytochalasin E	Cyclopiazonic acid	Deacetylcalonectrin	Deoxynivalenol diacetate	Deoxynivalenol monoacetate	Diacetoxyscirpenol
Destruxin B	Enniatins	Fructigenin + 1	Fumagilin	Fumonisin B1	Fusaric acid	Fusarin
Gliotoxin	HT-2 toxin	Ipomeanine	Islanditoxin	Lateritin + 1	Lycomarasmin + 1	Malformin
Maltoryzine	Monoiliformin	Monoacetoxyscirpenol	Neosolaniol	Nivalenol	NT-1 toxin	NT-2 toxin
Ochratoxin	Oxalic acid	Patulin	Penicillic acid	Penitrem	Roridin E	Rubratoxin
Rubroskyrin	Rubrosulphin	Rugulosin	Sambucynin + 1	Satratoxins F G H	Scirpentriol	Slaframine
Sterigmatocystin	T-1 toxin	T-2 toxin	Triacetoxyscirpendiol	Trichodermin	Trichothecin	Trichoverrins
Trichoverrols	Tryptoquivalene	Verrucarin	Verruculogen	Viopurpurin	Viomellein	Viriditoxin
Xanthocillin	Yavanicin+1	Zearalenone	Source: https://www.mold-help.org/mycotoxin list			

Fusarium sp | Alternaria sp | Monographella sp | Chaetoglobosin sp | Stachybotrys sp

Aspergillus sp | Myrothecium sp | Acremonium sp | Rhizoctonia sp | Trichoderma sp

Penicillium sp | Trichothecium sp | Trichophyton sp | Eurotium sp

Wide diversity of mycotoxins produced by molds: over 500 mycotoxins or metabolites to date

Assessing the risk using Alltech 37+ lab data for 2023: mycotoxins in feed ingredients used in shrimp diets

Koletsi, *Feed and Additives* (August 2023)

Corn			
Mycotoxin group	**Average**	**Maximum**	**Occurrence %**
Emerging Mycotoxins	254.4	4,751	93.9
Fusaric Acid	123.0	2,074	84.6
Fumonisins	1,866.6	26,085	74.9
Type B Trichothecenes	626.6	8,409	69.6
Zearalenone	30.0	1,734	25.5
Type A Trichothecenes	12.2	713	19.4

Cereal byproducts			
Mycotoxin group	**Average**	**Maximum**	**Occurrence %**
Emerging Mycotoxins	70.0	282	100
Type B Trichothecenes	708.5	7,034	82.6
Fusaric Acid	158.4	2,023	60.9
Fumonisins	520.3	3,379	43.5
Type A Trichothecenes	4.4	44	26.1
Ergot Toxins	16.1	203	26.1
Zearalenone	21.2	377	17.4
Other Penicillium Mycotoxins	5.9	56	13.0

"Common" mycotoxins

- Fumonisins
- DON
- Zearalenone

Emerging mycotoxins & fusaric acid

- no detectable with routine methods
- no regulatory limits
- no scientific information

Alltech®

Soybean meal
South America

Mycotoxin concentrations (ppb), occurrence (%) and total risk (REQ) of selected samples

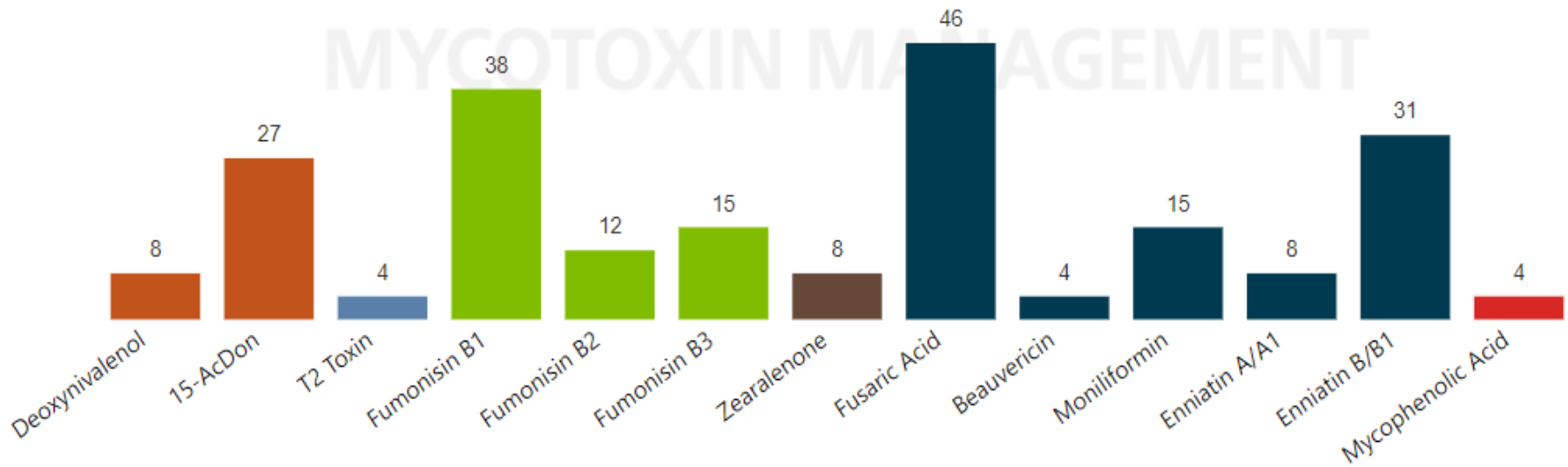
Mycotoxin Group	Median	Average	Maximum	Occurrence, %
Emerging Mycotoxins	0.8	6.8	106	53.8
Fusaric Acid	0.0	28.8	581	46.2
Fumonisins	0.0	63.8	498	38.5
Type B Trichothecenes	0.0	113.9	2,788	26.9
Zearalenone	0.0	60.9	1,518	7.7
Type A Trichothecenes	0.0	0.4	10	3.8
Other Penicillium Mycotoxins	0.0	3.0	77	3.8

26
SAMPLES TESTED

2.2
AVERAGE MYCOTOXINS PER SAMPLE

65%
SAMPLES WITH 2+ MYCOTOXINS

Occurrence (%) of all individual mycotoxins analyzed by Allech 37+



*January- September 2024

Alltech

Wheat

South America

Mycotoxin concentrations (ppb), occurrence (%) and total risk (REQ) of selected samples

Mycotoxin Group	Median	Average	Maximum	Occurrence, %
Emerging Mycotoxins	2.3	58.5	311	69.2
Type B Trichothecenes	1.0	60.5	359	53.8
Fumonisins	0.7	34.8	146	53.8
Fusaric Acid	0.0	3.3	16	30.8
Ergot Toxins	0.0	114.1	771	23.1
Zearalenone	0.0	31.3	407	7.7

13

SAMPLES TESTED

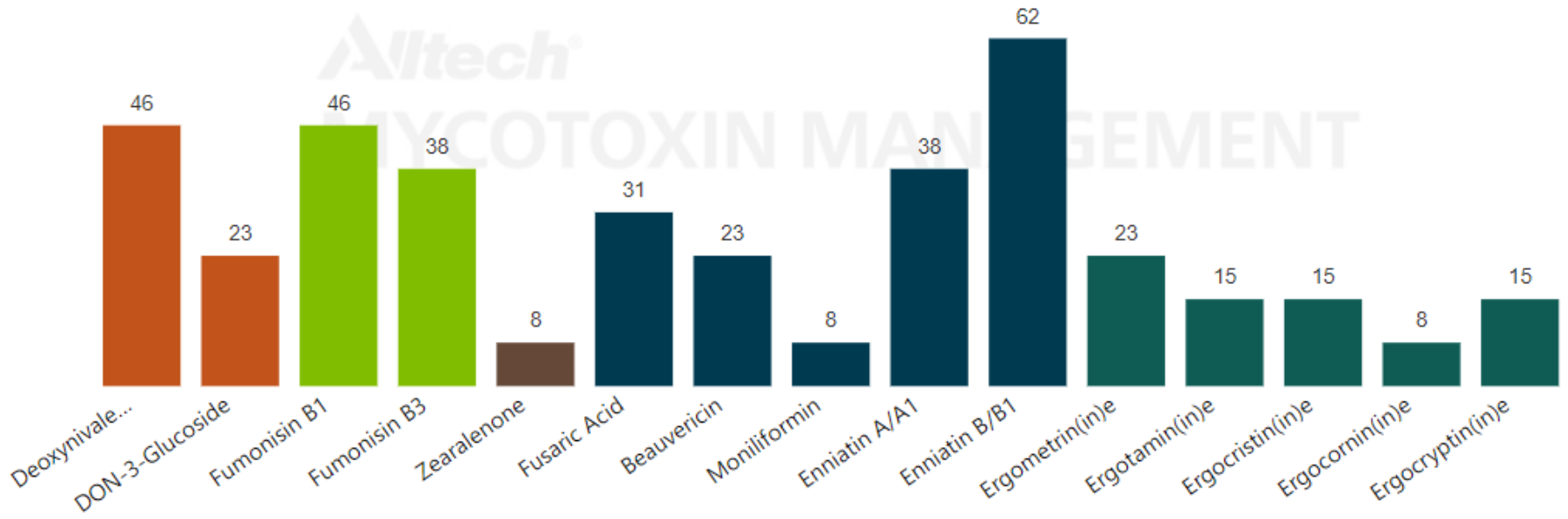
4.0

AVERAGE MYCOTOXINS PER SAMPLE

77%

SAMPLES WITH 2+ MYCOTOXINS

Occurrence (%) of all individual mycotoxins analyzed by Allech 37+



*January- September 2024

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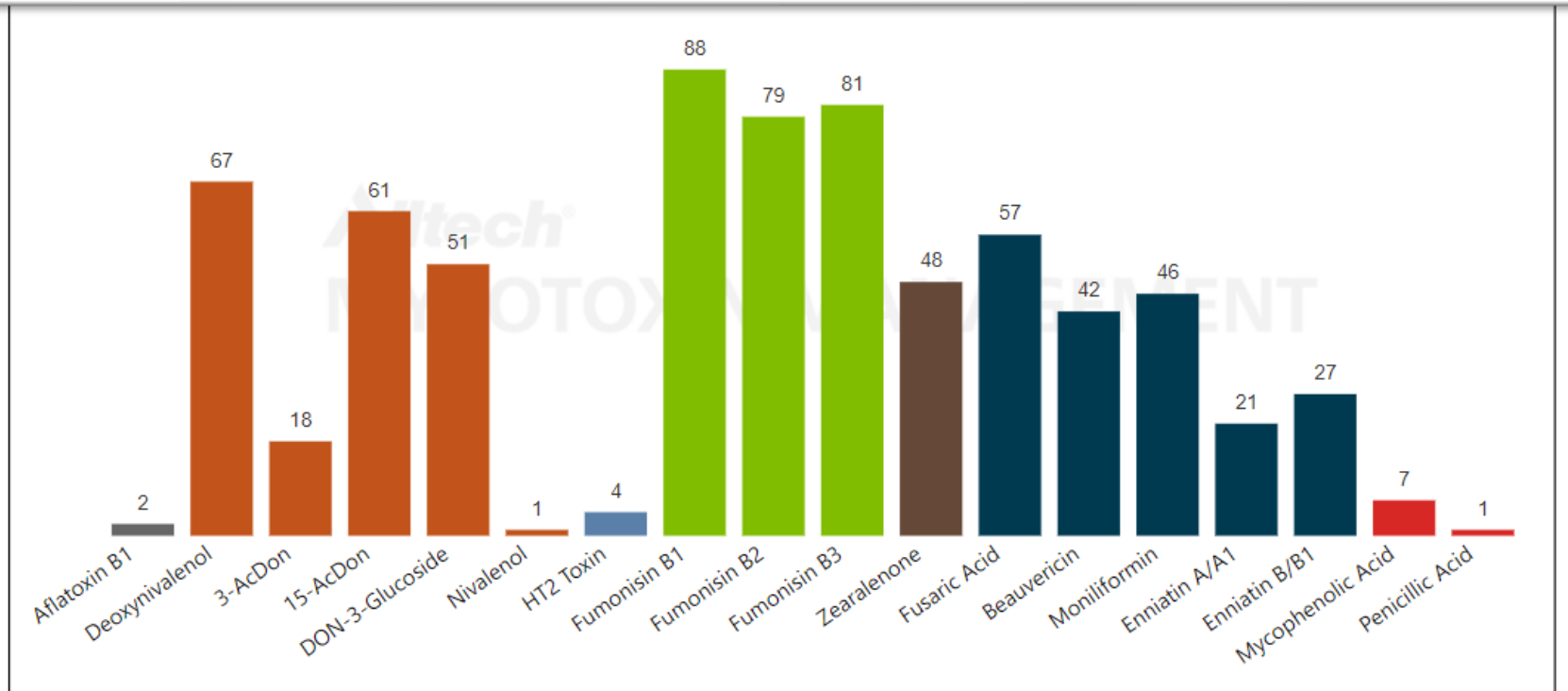
Corn

South America

Mycotoxin concentrations (ppb), occurrence (%) and total risk (REQ) of selected samples

Mycotoxin Group	Median	Average	Maximum	Occurrence, %
Fumonisins	1,258.4	1,831.2	9,138	91.1
Type B Trichothecenes	2.0	754.2	9,116	80.0
Emerging Mycotoxins	36.3	538.1	13,001	77.8
Fusaric Acid	25.5	85.6	811	56.7
Zearalenone	0.0	28.0	317	47.8
Other Penicillium Mycotoxins	0.0	5.6	450	6.7
Type A Trichothecenes	0.0	1.0	51	4.4
Aflatoxin B1	0.0	0.2	12	2.2
Aflatoxins, Total	0.0	0.2	12	2.2



90

SAMPLES TESTED

7.0

AVERAGE MYCOTOXINS PER SAMPLE

94%

SAMPLES WITH 2+ MYCOTOXINS

*January- September 2024

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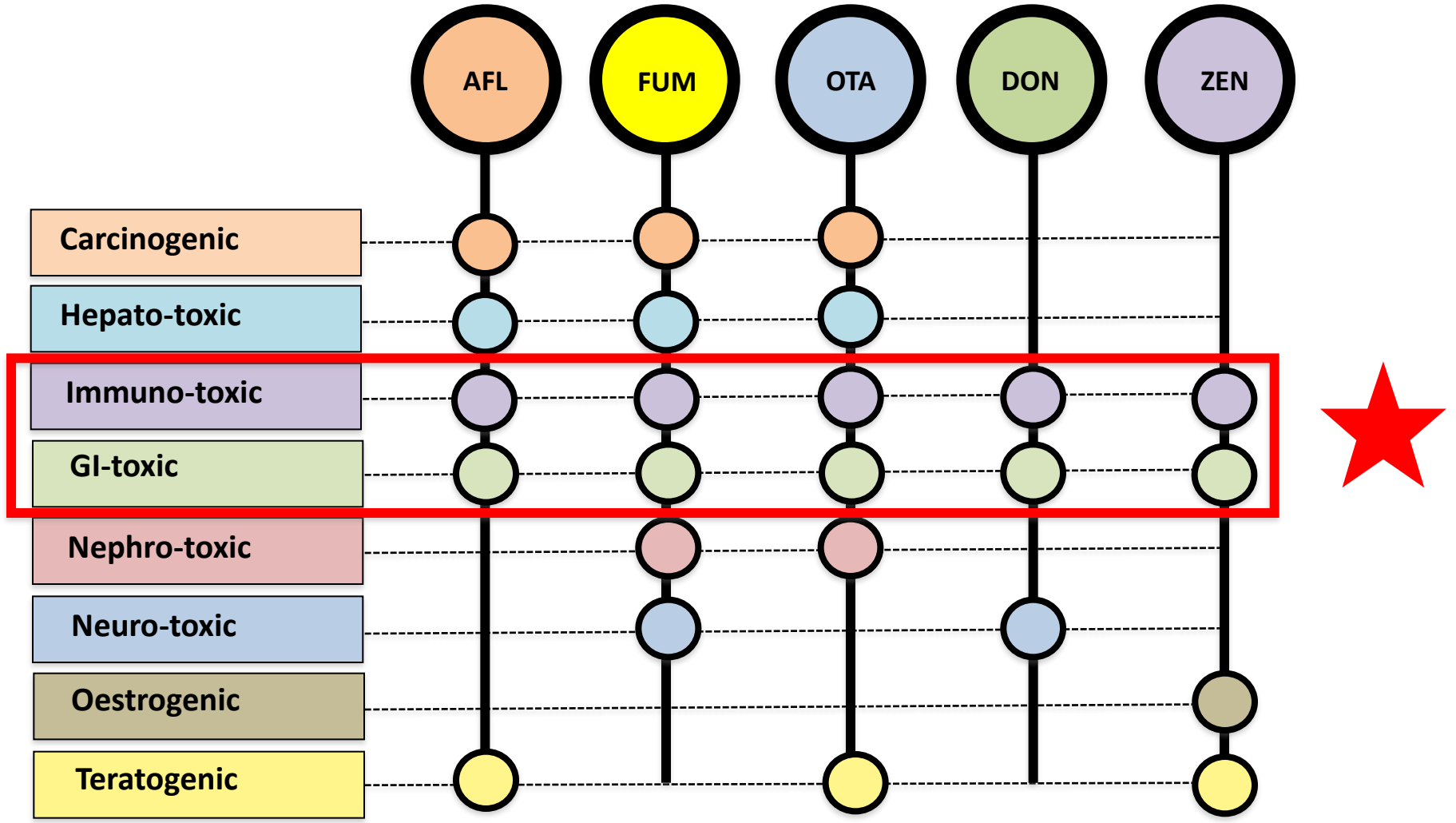
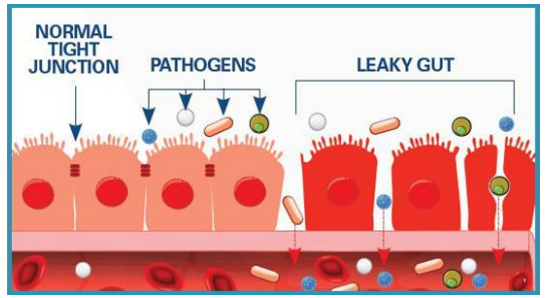
Major reported health effects of aflatoxin (AFL), fumonisin (FUM), ochratoxin A (OTA), deoxynivalenol (DON), and zaralenone (ZEN) in humans and animals (modified after Cinar & Onbasi, 2019)



Tacon & Tran (2022)

IMPORTANCE OF GUT HEALTH – FIRST LINE OF DEFENSE
Leaky Guts – Nutrient Digestibility - Microbiome – Immune Capability



Lectins or phytohemagglutinins: soybean lectins have been shown to bind to the distal intestine, and are believed to be involved in soybean meal-induced enteritis.

Saponins: soybean saponins reported to increase intestinal epithelial permeability in Atlantic salmon and play key role in soybean-induced enteritis; have the ability of binding to membrane cholesterol - forming holes and allowing the uptake of macromolecules, including allergens, antigens, and/or opportunistic bacteria and their toxins - and also of forming complexes with bile acids and cholesterol during digestion.

Plant allergens: proteins with capability of stimulating antigenic effects or immunological activity, and capability of inducing gastrointestinal hypersensitivity, including intestinal mucosal lesions, specific and non-specific immune responses, and alterations in nutrient digestibility and reduced growth. Soybean glycinin also found to disrupt intestinal structural integrity in grass carp.

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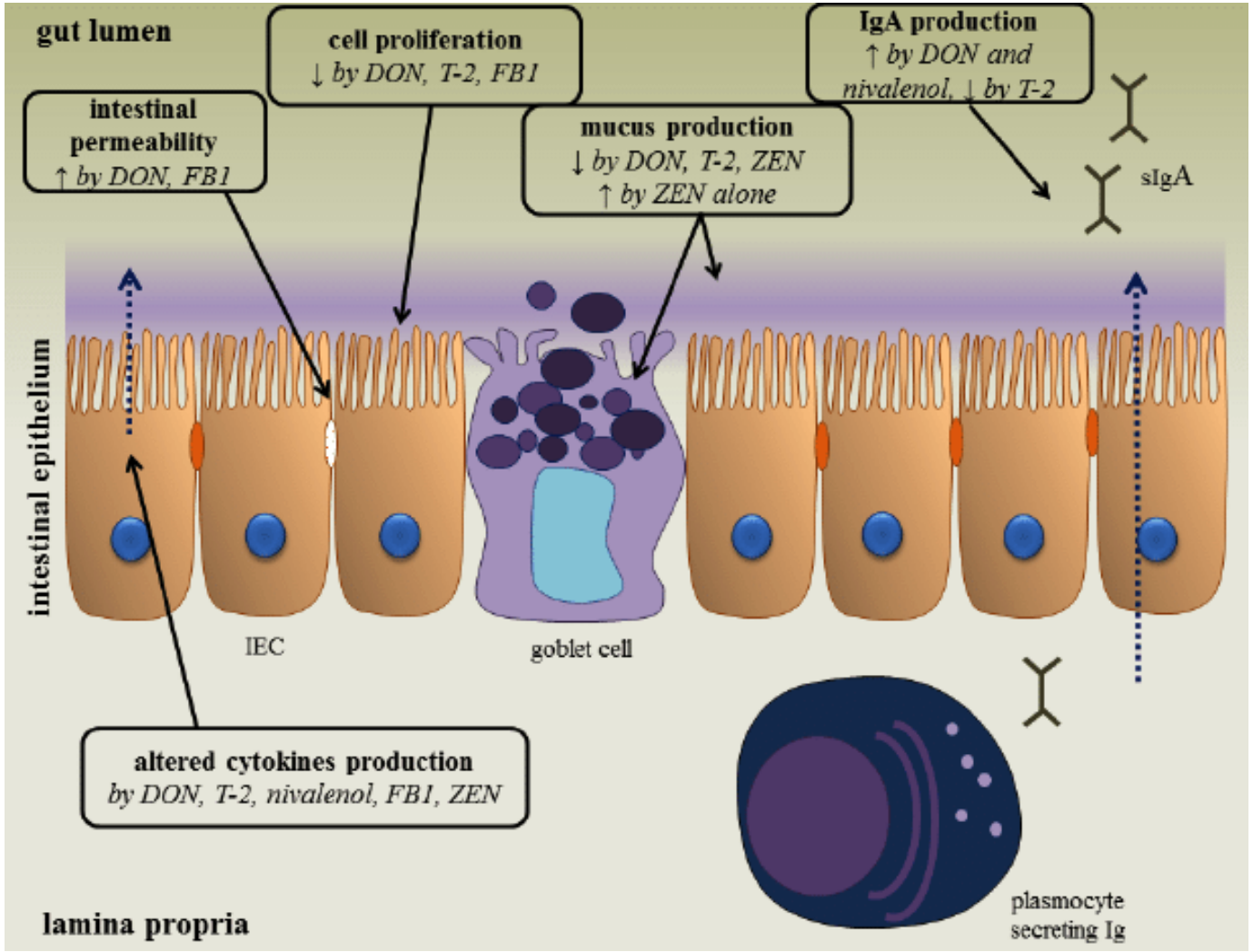
The effect of *Fusarium* mycotoxins on the intestinal epithelium.

A variety of *Fusarium* mycotoxins alter the different intestinal defense mechanisms including epithelial integrity, cell proliferation, mucus layer, immunoglobulins (Ig) and cytokine production. (IEC: intestinal epithelial cell)

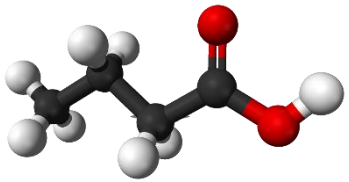
Based on Bouhet, S.; Oswald, I.P. The effects of mycotoxins, fungal food contaminants, on the intestinal epithelial cell-derived innate immune response. *Vet. Immunol. Immun.* 2005, *108*, 199–209.



Numerous feed additives to improve gut health & integrity

Butyric acid & Tributyrates

- **Short chain fatty acid: C4**
- **Occurs naturally in the intestine**
- **Multiple benefits related to gut Health**
- **Preferred energy source of intestinal mucosa cells**
- **Use in terrestrial animal nutrition since the 1980's**

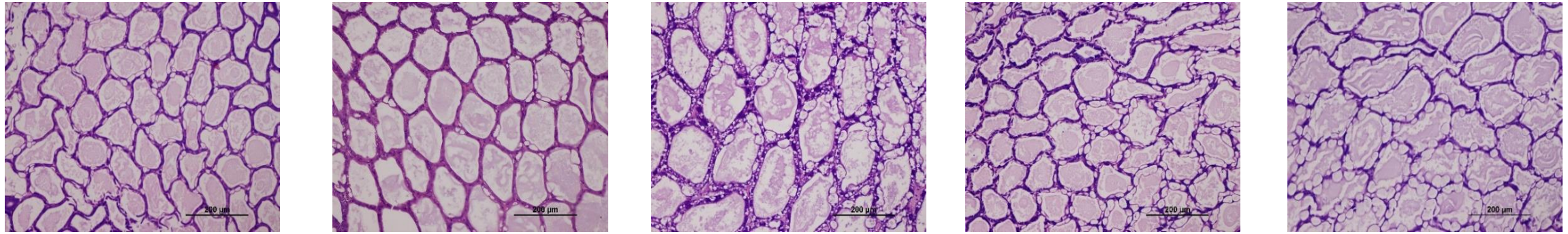


Reported benefits

Gut biota	Supports microbiota development
Pathogen control	Increases gut resilience
Gut integrity	Strengthens tight junctions Reduces necrosis lesion severity
Digestion	Supports enterocyte function Improves villi length & crypt depths
Immune response	Supports immune system Anti-inflammatory

Histopathology of Hepatopancreas/Intestine of Pacific White Shrimp at 10 wks

more lipid vacuole

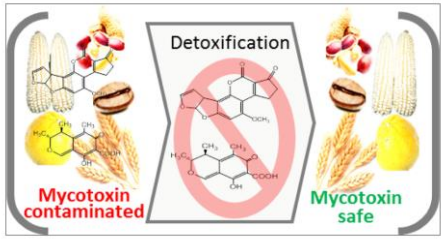


Less inflammation

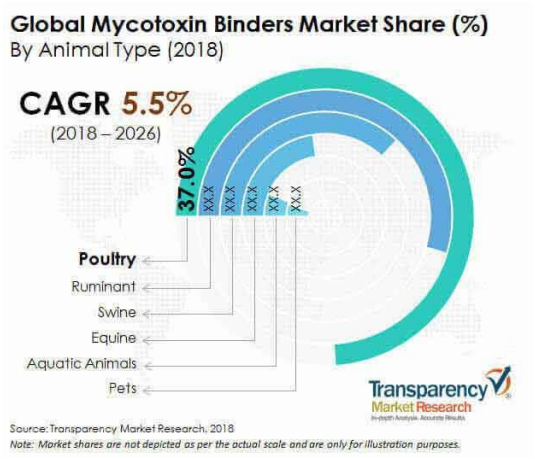
SBM50%	SBM50% +SR130 0.05%	SBM50% +SR130 0.10%	SBM50% +SR730 0.03%	SBM50% +SR730 0.07%

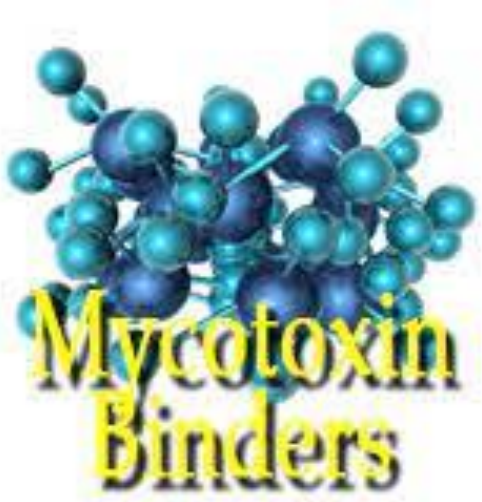
Soughing off hepatopancreas cells / epithelial cells & inflammation of the subcuticular epithelium cells
Beneficial effect on hepatopancreas structure/morphology & immune capability – Loc Tran pers comm

Mycotoxin Mitigation Strategies



- Limiting use of lower cost/quality feed ingredients - cereal byproduct meals, use of expired ingredients, use of floor sweepings;
- Use of organic acids & feed additives to prevent/limit mold growth in finished feeds - propionic acid, sorbic acid, herbs and spices, essential oils, phenolic antioxidants;
- Use of mycotoxin binders to prevent the absorption of mycotoxins - clay minerals, bentonites, zeolites, activated charcoal, yeast and yeast cell wall derived products, algae extracts, chitin oligosaccharides, and synthetic polymers;
- Use of microorganisms/dietary enzymes to bio-transform mycotoxins in GI-tract;
- At the farm level - store feeds under cool well-ventilated conditions, use on a first-in first-out basis, not subjected to adulteration by top-dressing prior to use, ensure feed bags are not left outdoors (hours) prior to feeding, following good BMPs


Global Mycotoxin Binders Market Share (%)
By Animal Type (2018)
CAGR 5.5%
(2018 – 2026)
37.0%
XX.X
XX.X
XX.X
XX.X
XX.X
Poultry
Ruminant
Swine
Equine
Aquatic Animals
Pets
Transparency Market Research
Source: Transparency Market Research, 2018
Note: Market shares are not depicted as per the actual scale and are only for illustration purposes.


Mycotoxin Binders


Mycofix® Plus 5.Z
Absolute Protection
NEW
With ZENzyme®
Faster and Better
ADSORPTION
BIOTRANSFORMATION
BIOPROTECTION
Naturally ahead
Biomin


Multi-Binder
for Multi-Mycotoxins
Because each mycotoxin is unique and responds differently, this formula uses six mold-specific binders to remove toxins produced by mold from the GI tract*


Alltech
2024 Asia Import Risk Analysis
Mycotoxin insights to empower your nutritional strategy


MYCOTOXINS

Feed additives with reported health benefits – direct or indirect

Nutrients

Amino acids
Peptides
Nucleotides
Fatty acids
Sterols
Vitamins
Minerals

Additives

Antioxidants
Enzymes *
Emulsifiers
Essential oils
Organic acids *
Hydrolysates

Probiotics
Prebiotics
Alginates
Beta glucans
Carrageenans
Chitosans
Nanoparticles
Lactoferrin
Mannans
Peptidoglycan
Phytosterols
Yeast extracts *
Zeolites *
Activated charcoal *
Mycotoxin binders *

Ingredients with functional properties may improve health & survival but their use is not always a panacea to eliminate a disease problem – cost/benefit US $/tonne

Improving the utilization of feed ingredients

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

Stress

Environmental culture stress

Infectious disease agents

Imbalanced sub-optimal feed

parasites, injuries, toxins

Stress

The future

Open unstable environment
Sub-optimal water quality
Poor water management
Toxic sediment buildup
Algal blooms & crashes
Competing bacterial
flora & biota

Reduced Feed Intake

Reduced Nutritional Status

Reduced Shrimp Health

Sub-optimal feed
Poor ingredient quality
Antinutrients & toxins
Poor feed management
Over & under feeding
Viable pathogens
through feeds

Change in dietary nutrient requirements

Reduced gut health & nutrient absorption

Gut: first line of defense

Nutrition & Health Interactions

(modified after Tacon & Tran, 2022)

Benefits of farming Indoors

Biosecurity: pathogen exclusion

Environmental control

Minimise stress

Feeding to satiation 24/7

Out of public eye

The future – full biosecurity, environmental & stress control 24/7

Stress

Environmental culture stress

Infectious disease agents

Imbalanced sub-optimal feed

parasites, injuries, toxins

Stress

The future

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Next generation shrimp feeds

Designed to maximize feed intake, growth & shrimp health through

- Maximizing shrimp feeding response, feed intake & growth
- Optimizing shrimp disease resistance & immune response capability
- Optimizing shrimp stress control & antioxidant defense capability
- Maximizing shrimp digestive health & nutrient digestibility
- Faster shrimp growth, farm profitability & cycles/year

Hatchery → Farm → Broodstock

There is no nutrient in live foods that we cannot put in a formulated feed with equivalent performance

MAHALO

AQUAHANA

A'ohe hana nuí ke alu'ía ➸ No task is too big when done together

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20 anos FENACAM'24