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Cost and Performance Challenges in Evaluating Fish-Free Feeds, Novel Ingredients and Additives

Abstract

There has been a number of advances in nutritional research for aquafeed, including in the full replacement of fishmeal and fish oil in fish and shrimp diets. Research has demonstrated that fishmeal and fish oil can be replaced by using alternative ingredients without any negative impact on the growth performance, crop yield or cost. Many new ingredients have been tested successfully including concentrated corn protein, fermented soybean meal, poultry meal, single-celled protein, insect meal, algae meal, algae oil, etc.

In collaboration with F3 (Fish-Free Feed) Team, ShrimpVet Laboratory has been working to validate the performance of a complete fishmeal and fish oil-free shrimp feed. The research carried out in Vietnam has clearly demonstrated that with improved formulation of shrimp feed, multiple goals can be achieved. Improved formulation could significantly improve the shrimp resilience resulting in significantly higher tolerance against important shrimp diseases. A commercial scale trial demonstrated that shrimp fed with a fish-free diet showed better performance in terms of growth rate, FCR, survival, as well as pond water quality, resulting in better economic returns for farmers.

With regards to disease management, our research show that there are many beneficial effects to shrimp health by using fermented ingredients, insect meal, single-celled proteins, and additives. These know-how allows us to formulate diets that not only satisfy the demand for growth performance but also health improvement and disease management in shrimp. Several research also show that improving shrimp resilience by the supplementation of anti-stress additives, antioxidants, and by enhancing digestability such as using enzymes can significantly reduce the impact of disease outbreaks. Additionally, these novel feed ingredients and additives allow the industry with an improved buffer from supply chain and cost increase concerns of the traditional feed materials from the abundance of their availability.

In reality, the most important aspect for any innovation is its economics. The use of new ingredients or additives must prove to be profitable to end users – the farmers. Several research and economical analyses show that some changes in feed formulation using new ingredients or additives may result in significant economic gains for farmers from improving shrimp survival and yield, to reduction of FCR, and shortening of the crop cycle time. If the changes in feed formulation result in a reduction of formulation cost (cost saving) it will be relatively easy to adapt. However, if the changes result in an incremental increase in formulation cost, a fair share of economic gains and cost must be arranged among the stakeholders. This model requires a strong collaboration and high level of transparancy among the stakeholders including ingredient suppliers, feedmillers, farmers, and processors. If this model works, there would be substantial value addition across the production chain.

Our ongoing research clearly demonstrates that with innovation, we can significantly improve the shrimp farming industry towards improved sustainability and profitability.

Cost and Performance Challenges in Evaluating Fish-Free Feeds, Novel Ingredients and Additives

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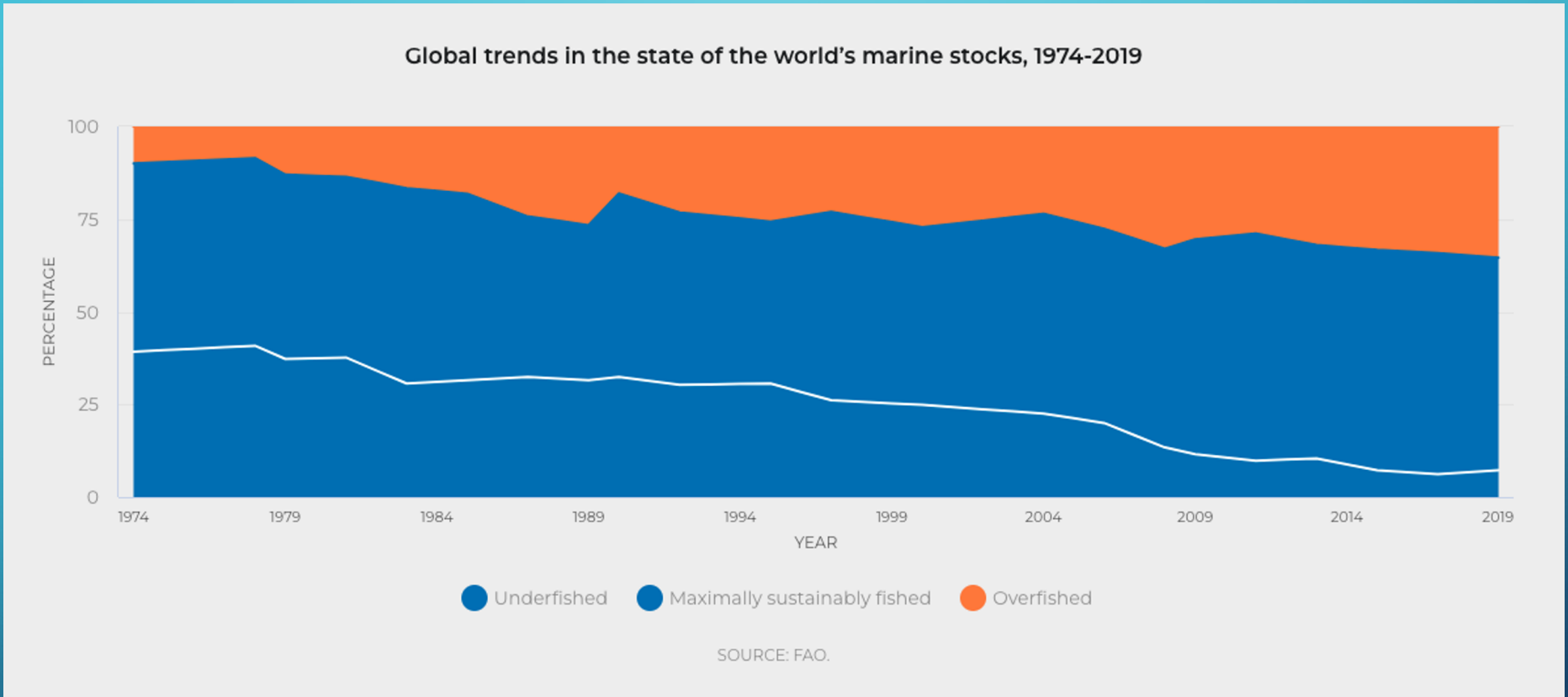
We need more ingredients in the pantry



- Fluctuating fish stocks = FMFO supply chain disruptions = increased feed costs
- Reliance on few aquafeed ingredients = threat to food security
- FMFO alternatives are crucial to the future of aquaculture feed.

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Shrimp case study

Future of Fish Feed

F3 Challenge

Carnivore Edition

Hundreds of studies have evaluated tens of alternatives of dietary proteins for Pacific whiteleg shrimp

Comparatively few have evaluated complete replacement of fishmeal

Fewer still have transferred experimental findings to a production setting

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Shrimp case study #1: - objectives

A) Compare the performance of Pacific whiteleg shrimp fed on
1. An open-source F3 fishmeal/fish oil free diet
2. A referent commercial feed in Vietnam

B) 2x2 800m^2 circular ponds

C) Stocking density at 150 pcs/m^2

SHRIMPVET RESEARCH FARM
HO CHI MINH - VIETNAM

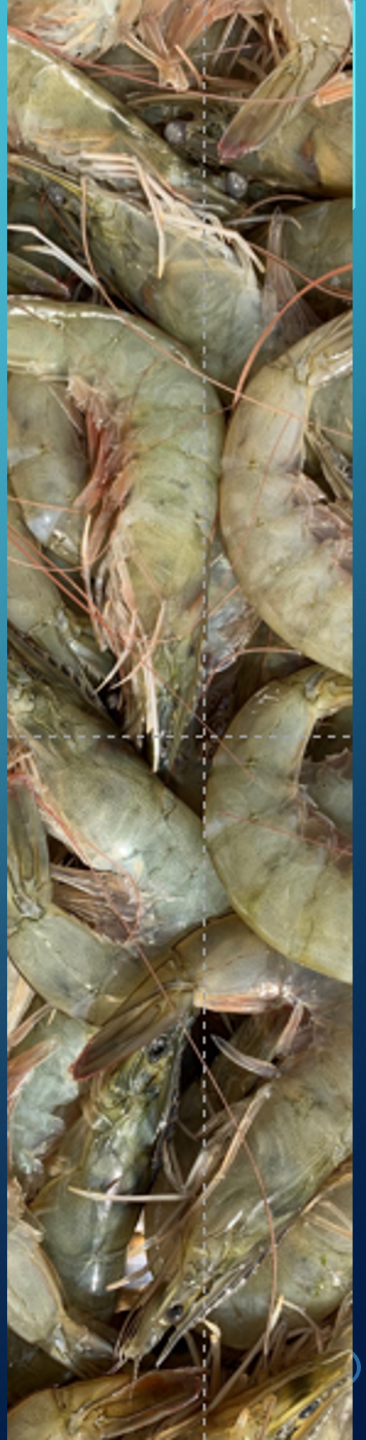
Shrimp case study#1 - growth

	Commercial Feed	F3
Initial biomass (kg)	56.40±0.00	56.40±0.00
Final biomass (kg)	2045.5±45.96	2302.5±28.99
Final mean wt (g)	18.03±0.24	23.25±0.84
SGR (%/d)	6.63±0.02	7.09±0.07
Feed consumption (kg)	2278.9±56.57	2306.9±7.07
FCR	1.15±0.00	1.03±0.01
Survival	85.76±16.49	75.48±6.73

Red = significantly different $P < 0.05$

Shrimp case study#1 - economics

	Commercial	F3
Avg. size (g)	18	23
Price/kg	4.81	5.20
Total biomass (kg)	1843	2039
Total feed	2319	2307
FCR	1.26	1.13
Survival rate (%)	85.75±16.49	75.48±6.73
Revenue	8835.83	10477.01
Production cost (US$)	5844.12	6064.20
Production cost (US$/kg)	3.19	2.97
Profit (US$)	2951.71	4412.81
ROI (%)	**50.16**	**72.77**



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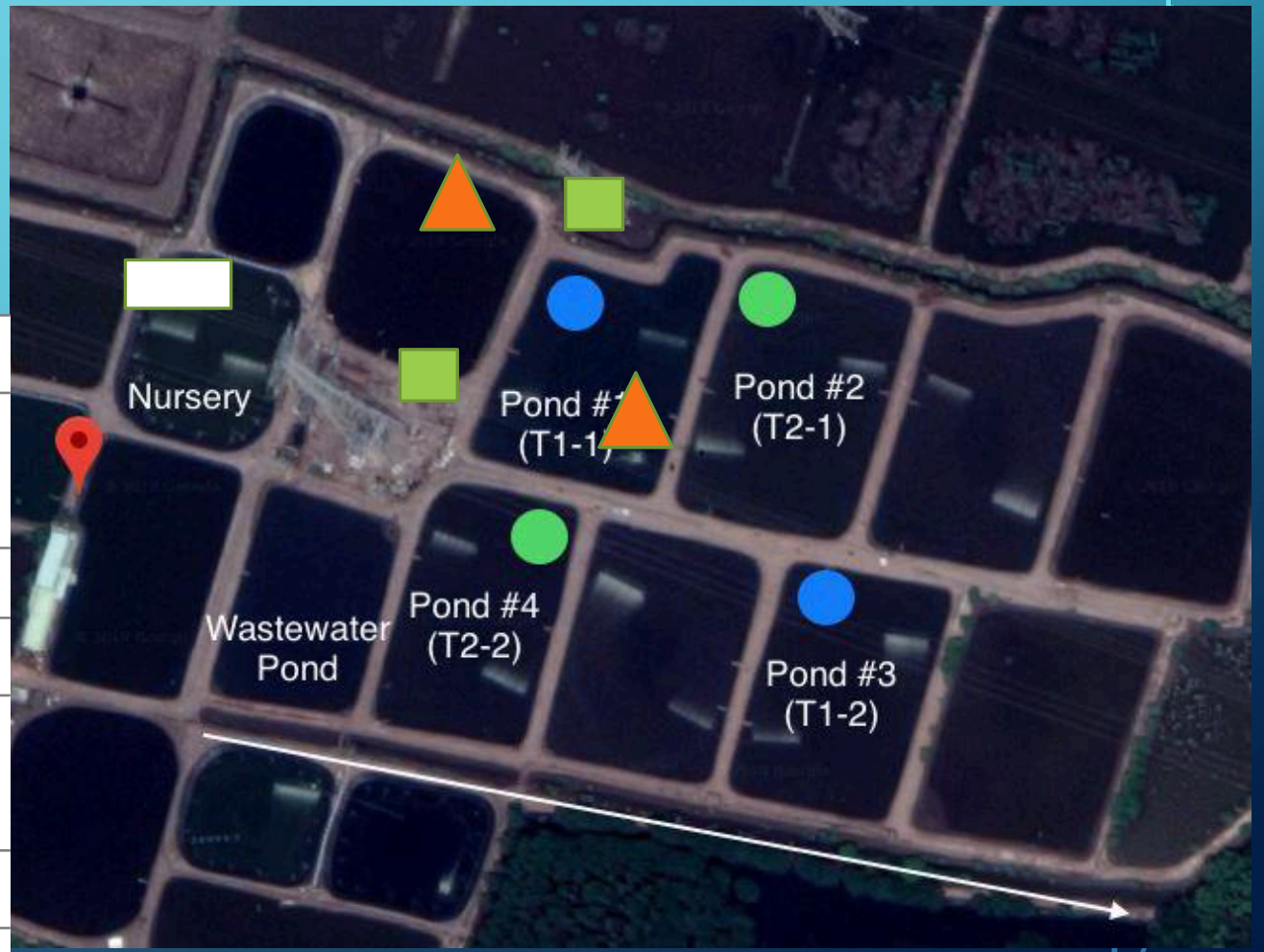
Case study #2. A POND TRIAL WITH FUNCTIONAL DIET

Location: Dong Nai, Vietnam
Duration: Dec-2017 – March-2018
DOC: 100: 70 days of grow out plus 30 days of nursery

Treatment	Control (T1)		Treatment (T2)	
Pond designation	Pond#1 (T1-1)	Pond#3 (T1-2)	Pond#2 (T2-1)	Pond#4 (T2-2)
Acreage (m^2)	2350	2380	2420	2180
Feed	Control		Functional diet	
Administration method	-		Incorporated in feed ingredients	
No. shrimp stocked	117.500	119.000	121.000	109.000
Density (pcs/m^2)	50	50	50	50

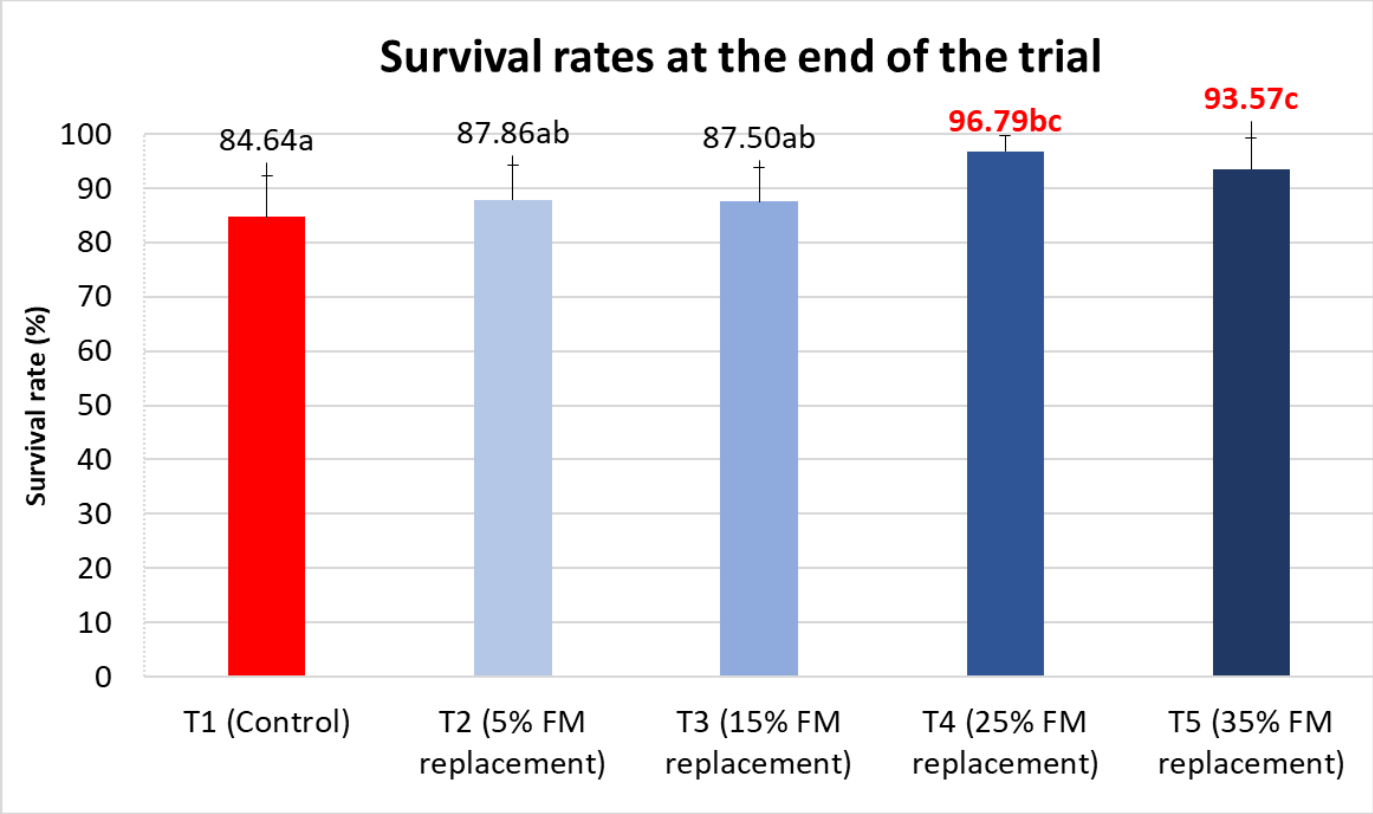


GROWTH and ECONOMICS PERFORMANCE

Parameters	Ctrl. T1-1 (Pond 1)	Ctrl. T1-2 (Pond 3)	T 2-1 (Pond 2)	T2-1 (Pond 4)
Initial weight (g)	1.14 ± 0.03a	1.14 ± 0.03[a]	1.14 ± 0.03[a]	1.14 ± 0.03[a]
Final weight (g)	17.30 ± 2.95	18.63 ± 3.21	23.77 ± 2.85	19.32 ± 3.85
Weight gain (g)	16.10[c]	16.72[c]	22.12[a]	18.86[b]
ADG (g/day)	0.22	0.24	0.31	0.25
Survival rate	75.30%	86.85%	96.44%	78.03%
FCR	1.60	1.38	1.20	1.40

Parameters	FUNCTIONAL FEED	CONTROL
Revenue (USD)	17,276	15,313
Total cost (USD)	10,681	11,302
Production cost (USD/kg)	3.53	4.13
Profit (USD)	6,595	4,011
Return On Investment (%)	61.75	35.49
Gross margin (%)	38%	10%

INGREDIENT STUDIES: black soldier fly meal



Treatment	Initial weight (g)	Final weight (g)	ADG (g/day)	SGR (%/day)	FCR
T1 (Control)	1.79 ± 0.54a	12.72 ± 0.88a	0.26 ± 0.01a	4.75 ± 0.56a	1.43 ± 0.11a
T2 (5% FM replacement)	1.80 ± 0.55a	12.64 ± 1.04a	0.26 ± 0.01a	4.73 ± 0.53a	1.34 ± 0.05ab
T3 (15% FM replacement)	1.78 ± 0.53a	13.14 ± 0.75a	0.27 ± 0.01a	4.84 ± 0.57a	1.35 ± 0.06ab
T4 (25% FM replacement)	1.79 ± 0.55a	12.96 ± 1.04a	0.27 ± 0.01a	4.80 ± 0.54a	1.19 ± 0.07d
T5 (35% FM replacement)	1.80 ± 0.55a	13.13 ± 1.12a	0.27 ± 0.01a	4.82 ± 0.53a	1.22 ± 0.10cd

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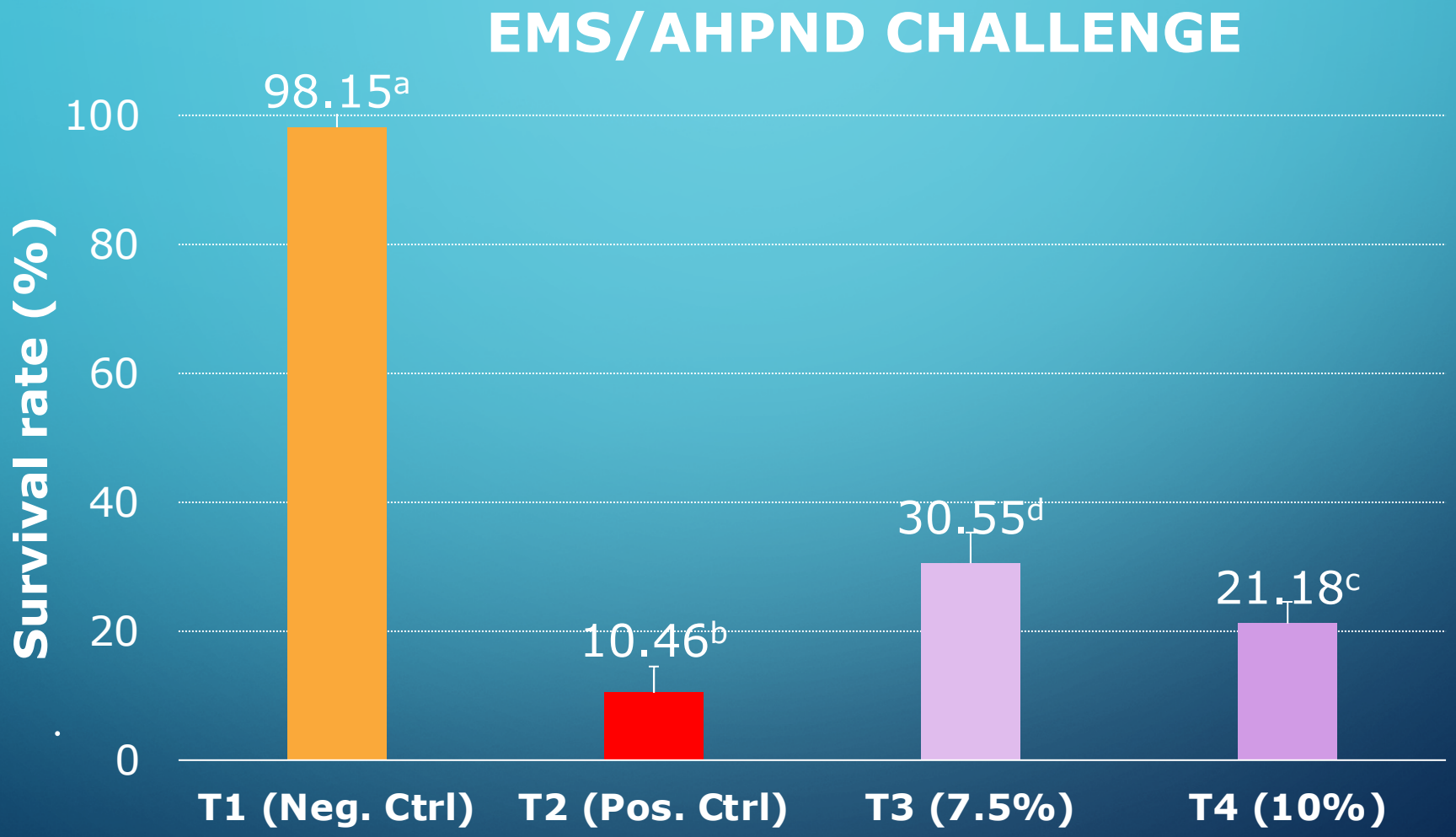
INGREDIENT STUDIES : FERMENTED CORN PROTEIN



INGREDIENT STUDIES : FERMENTED SOYBEAN

SURVIVABILITY & GROWTH PERFORMANCE

Variables	T1 (CONTROL)	T2 (5% Ingredient A)	T3 (10% Ingredient A)	T4 (20% Ingredient A)	T5 (30% Ingredient A)
Initial biomass (g)	388.00 ± 3.83a	382.75 ± 10.44a	387.25 ± 4.79a	390.00 ± 6.38a	383.25 ± 4.19a
Initial mean weight (g)	0.97 ± 0.01a	0.96 ± 0.03a	0.97 ± 0.01a	0.98 ± 0.02a	0.96 ± 0.01a
Final biomass (g)	7,740.75 ± 579.13ab	7,441.25 ± 493.93a	**8,054.50 ± 239.64b**	**8,160.50 ± 156.34b**	**8,127.25 ± 221.36b**
Final mean weight (g)	19.42 ± 1.46ab	18.89 ± 0.98a	**20.57 ± 0.96b**	**20.58 ± 0.50b**	**20.96 ± 0.85b**
Mean weight gain (g)	18.45 ± 1.46ab	17.93 ± 0.96a	19.61 ± 0.96b	19.61 ± 0.51b	20.00 ± 0.84b
ADG (g/day)	0.33 ± 0.03ab	0.32 ± 0.02a	**0.35 ± 0.02b**	**0.35 ± 0.01b**	**0.36 ± 0.02b**
SGR (%/day)	5.35 ± 0.14a	5.32 ± 0.07a	5.46 ± 0.10ab	5.45 ± 0.07ab	5.51 ± 0.06b
Total feed consumption (g)	9,928.50 ± 26.86ab	9,964.88 ± 35.36a	9,860.05 ± 100.09b	9,755.08 ± 81.89c	9,687.68 ± 49.16c
FCR	1.36 ± 0.10ab	1.42 ± 0.10a	**1.29 ± 0.05b**	**1.26 ± 0.03b**	**1.25 ± 0.04b**
Survival rates (%)	**99.63 ± 0.32a**	**98.44 ± 2.16a**	**97.94 ± 2.29a**	**99.13 ± 0.92a**	**97.00 ± 2.92a**

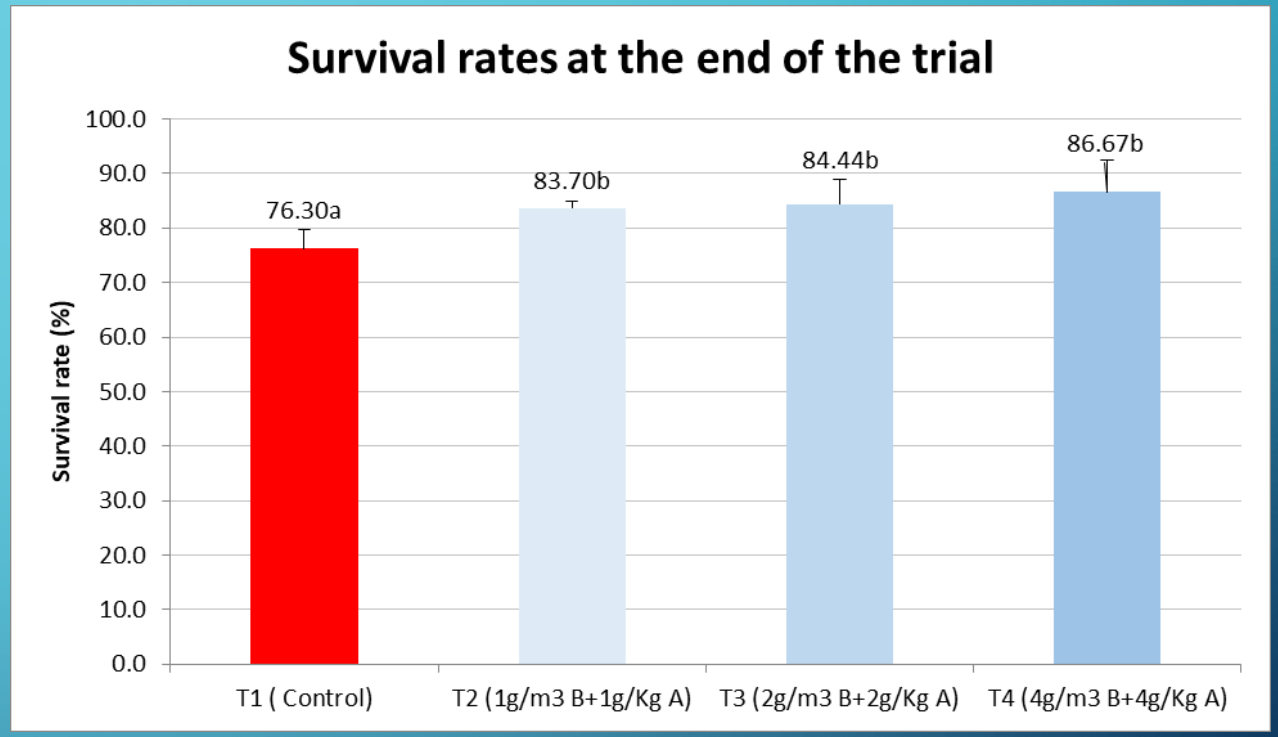
Survival rate was excellent in all the groups (>97%). All growth performance parameters of shrimp fed treatment diets are good as compared with control diet. In which, Feed conversion ratio (FCR) of diets with 10%, 20%, and 30% Ingredient A inclusion were better than the control.

Internal

		Formula price [USD/MT]				
Ingredients	**Unit Price[USD/MT]***	**Control**	**5% Ingredient A**	**10% Ingredient A**	**20% Ingredient A**	**30% Ingredient A**
Fish Meal (Anchovy)	$1,300.0	$344.50	$326.30	$308.10	$260.00	$227.50
Krill meal	$2,288.0	$45.76	$45.76	$45.76	$45.76	$45.76
FERMENTED SOYBEAN	$800.0	$0.00	$40.00	$80.00	$160.00	$240.00
Soybean meal, USA, 48% CP	$650.0	$197.60	$165.10	$132.60	$67.60	$0.00
Wheat gluten meal, 78% CP	$2,230.0	$78.05	$78.05	$78.05	$78.05	$78.05
Wheat flour	$176.0	$46.38	$46.90	$47.54	$54.56	$58.08
Fish oil	$1,050.0	$18.90	$20.06	$21.32	$23.84	$25.73
Soy lecithin	$560.0	$8.40	$8.62	$8.85	$9.35	$9.80
Cholesterol, feed grade	$54,800.0	$54.80	$54.80	$57.54	$65.76	$71.24
Choline chloride, 60% choline	$400.0	$4.00	$4.00	$4.00	$4.00	$4.00
Rovimix-stay-C 35, ascorbyl-monophosphate	$10,580.0	$13.23	$13.23	$13.23	$13.23	$13.23
L-Lysine	$590.0	$1.48	$1.36	$1.24	$1.24	$0.94
DL-Methionine	$1,430.0	$2.29	$2.57	$2.72	$3.43	$3.86
L-Threonine	$880.0	$2.64	$2.46	$2.29	$2.11	$1.67
Mineral premix, general, shrimp	$4,600.0	$17.25	$17.25	$17.25	$17.25	$17.25
Mono calcium phosphate, MCP, Ca(H2PO4)2	$400.0	$8.00	$10.40	$12.80	$12.80	$13.20
Salt, NaCl	$2.3	$0.06	$0.07	$0.07	$0.06	$0.07
Carboxymethylcellulose (CMC)	$3,420.0	$34.20	$34.20	$34.20	$34.20	$34.20
Mold inhibitor (calcium propionate)	$1,580.0	$1.11	$1.11	$1.11	$1.11	$1.11
Anti-oxidant (BHT)	$6,060.0	$2.42	$2.42	$2.42	$2.42	$2.42
Total		**$881.05**	**$ 874.66**	**$ 871.07**	**$ 856.76**	**$ 848.11**
Cost reduced		**$ -**	**$ ↓ 6.39**	**$ ↓ 9.98**	**$ ↓ 24.29**	**$ ↓ 32.94**

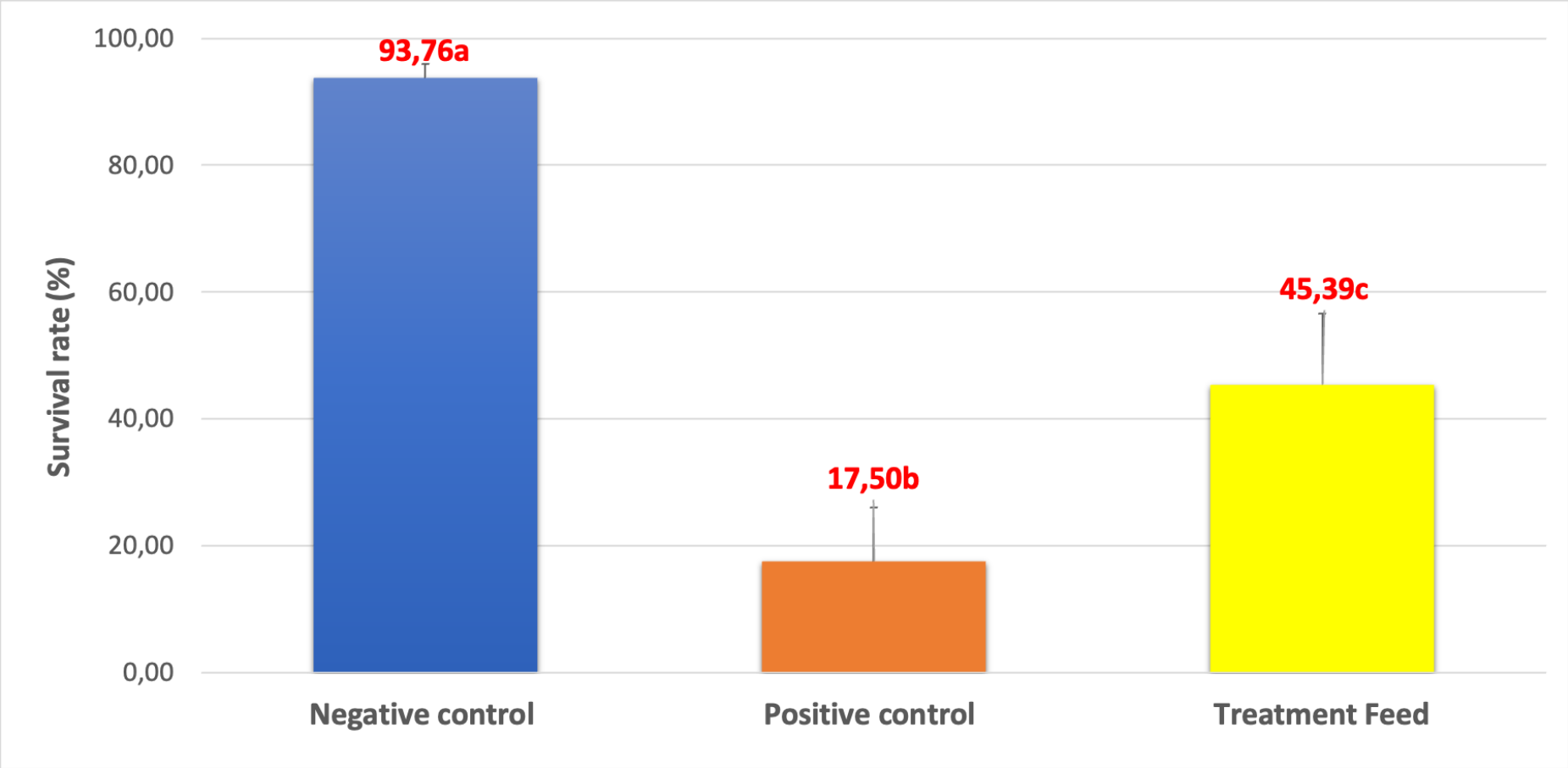
PROBIOTICS STUDIES: Effects of probiotics on growth performance

- **Duration:** 6 weeks
- **Test products: Gut probiotics (A) and water probiotics (B)**
- **Number of treatments and replicates:** 01 Control group + 03 treatment groups (3 dosages of test products) x 3 replicates/group.
- **Stocking density:** 50 shrimp / 350L tank



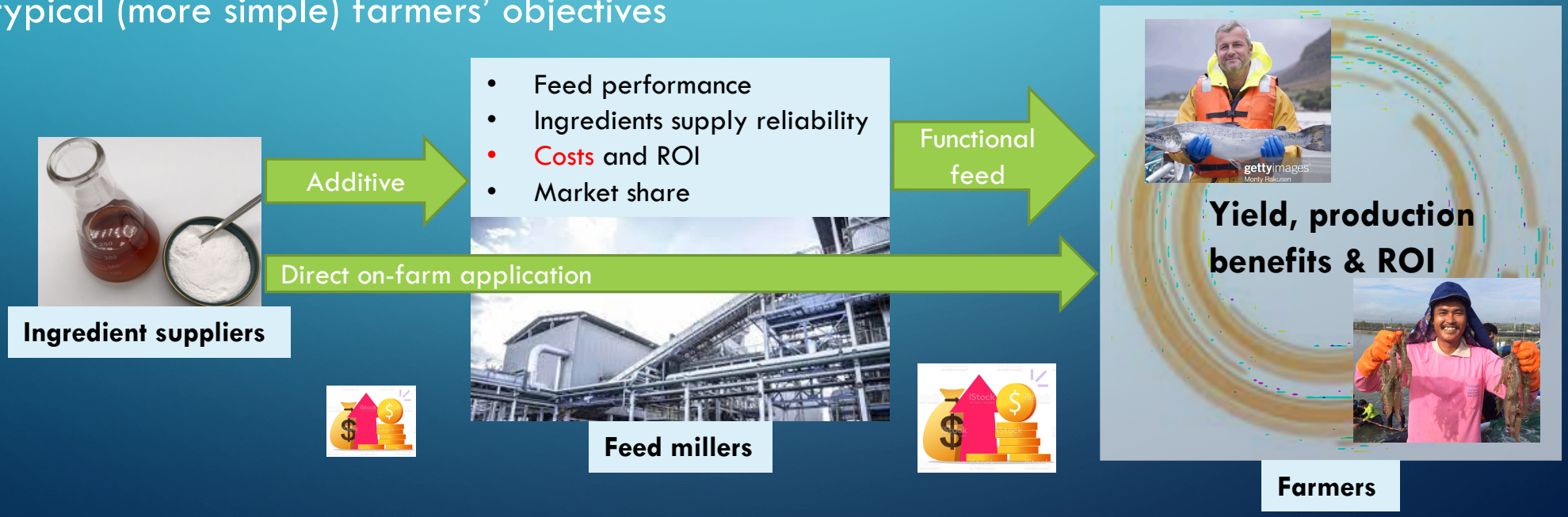
Treatment	Initial weight (g)	Final weight (g)	ADG (g/day)	SGR (%/day)	FCR
T1 (Control)	2.06 ± 0.16	14.41 ± 0.22a	0.29 ± 0.01a	4.63 ± 0.04a	1.23 ± 0.07a
T2 (1g/m3 B+1g/Kg A)		16.40 ± 0.03b	0.34 ± 0.00b	4.94 ± 0.00b	0.96 ± 0.02b
T3 (2g/m3 B+2g/Kg A)		16.16 ± 0.32b	0.34 ± 0.01b	4.91 ± 0.05b	0.97 ± 0.04b
T4 (4g/m3 B+4g/Kg A)		16.30 ± 0.51b	0.34 ± 0.01b	4.93 ± 0.07b	0.92 ± 0.04b

Survival rate on day 10 of post-challenge period (N = 10)				
Treatment	Mean	SD	Mean ± SD	Stats (DUNCAN test), P < 0,05
Negative control	93,76	2,25	93,76 ± 2,25	a
Positive control	17,50	8,47	17,50 ± 8,47	b
Treatment Feed	45,39	11,28	45,39 ± 11,28	c



ADOPTION OF VALUE-ADD

- Benefits to shrimp farmers: increased growth, cheaper alternative raw materials, increased ROI
- Alternatives raw materials to allow sustainable growth of aquaculture industry
- Several studies indicate that good ingredients, additives, and probiotics help improve growth performance, survivability, and economics performance
- Broader ingredient choice helps reduce risk of supply chain disruption
- "Functional feed" is viable but can face adoption challenges due to different considerations *vs.* the typical (more simple) farmers' objectives



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We create chemistry

THANK YOU!

Acknowledgement for **BASF Animal Nutrition** for shrimp production innovation.