ZINPRO®

ADVANCING PERFORMANCE TOGETHER

Advancing Shrimp Performance

With Zinpro® Performance Minerals®

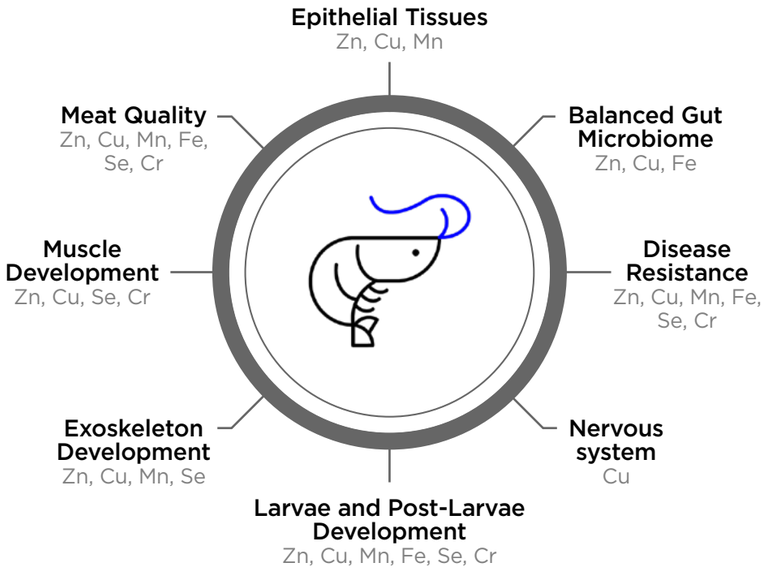
Zinpro® Performance Minerals® Deliver Proven Benefits for Shrimp Performance, Health and Meat Quality

Trace minerals are fundamental to cellular function and metabolic activity, making them essential for the nutrition, performance and overall health of shrimp.

Zinpro Performance Minerals® (ZPM) are uniquely designed to deliver key trace minerals— including zinc, manganese, copper, iron, selenium and chromium— in forms that shrimp can absorb and utilize efficiently. Extensive research demonstrates that incorporating ZPM into aquaculture diets supports optimal growth, strengthens immune function and enhances product quality.

Providing the right source of trace minerals, with high bioavailability, is critical to meeting the nutritional needs of shrimp in a sustainable and productive way throughout their entire life cycle.

Trace Mineral Benefits in Shrimp



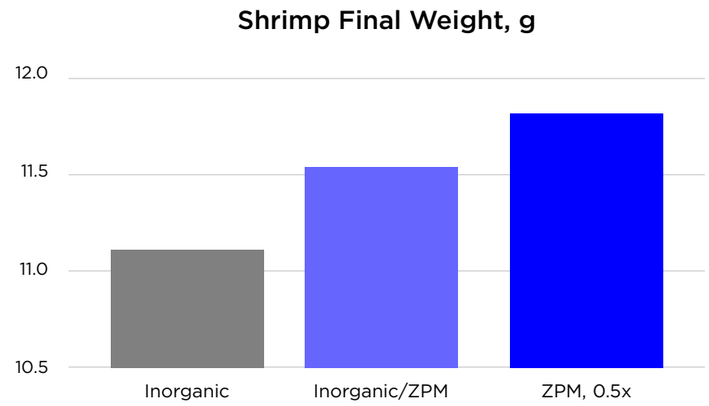
Study 1

Performance, Health and Meat Quality of Whiteleg Shrimp Receiving Inorganic Minerals or Zinpro Performance Minerals

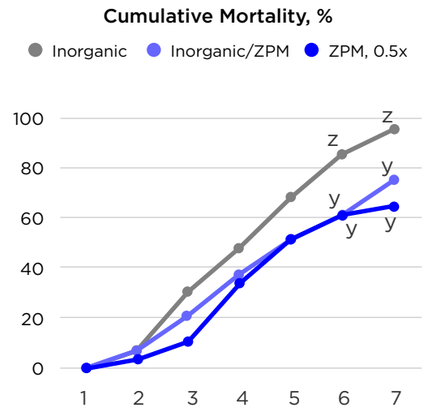
Key Findings

- Zinpro Performance Minerals (ZPM) supplemented at 50% of inorganic mineral levels resulted in numerically higher final body weight (Fig. 1), indicating that ZPM is the more effective trace mineral source.
- After a *Vibrio harveyi* challenge, cumulative mortality of shrimp was significantly ($P < 0.05$) reduced with ZPM inclusion in the diet (Fig. 2). The lowest death loss was observed in the treatment with 50% of the inorganic mineral levels from ZPM.
- Meat quality was improved with ZPM minerals, as drip-loss of peeled whiteleg shrimp was significantly ($P < 0.05$) lower for shrimp consuming ZPM (Fig. 3). The treatment with 50% of the Inorganic minerals from ZPM had the least drip-loss among treatments.
- Compared to the Inorganic treatment, return on investment increased 16% for shrimp consuming 50% ZPM and 11% for those receiving a combination of inorganic and ZPM minerals.

Growth Performance Fig. 1

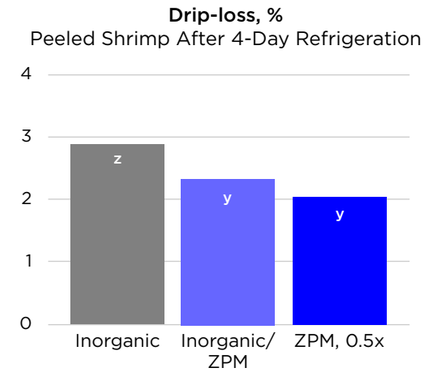


Health Fig. 2



Days after challenge with *Vibrio harveyi*

Meat Quality Fig. 3



Study Criteria

This study compared the efficacy of Zinpro Performance Minerals and inorganic minerals on the growth performance, resistance to bacterial challenge and meat quality of whiteleg shrimp.

Mineral, ppm	Inorganic	Inorganic/ZPM		ZPM, 0.5x
Zinc	120	70	50	60
Copper	32	22	10	16
Manganese	60	40	20	30
Iron	100	50	50	50
Selenium	0.3	0	0.3	0.15

Initial body weight: 4.4 g
Stocking density: 70 shrimp/m²
Feeding: 4x/day
Replications: 6
Duration: 8-week feeding period; 7-day health challenge
Salinity: 12 ppt

35.5% CP/7.5% Fat
25% fishmeal
3% shrimp meal
2% squid meal
20% SBM
5% poultry by-product meal

Location:
Kasetsart University
Thailand

Source: Jintasataporn, et al., 2015. Aquac. Indones. 16:33-37.

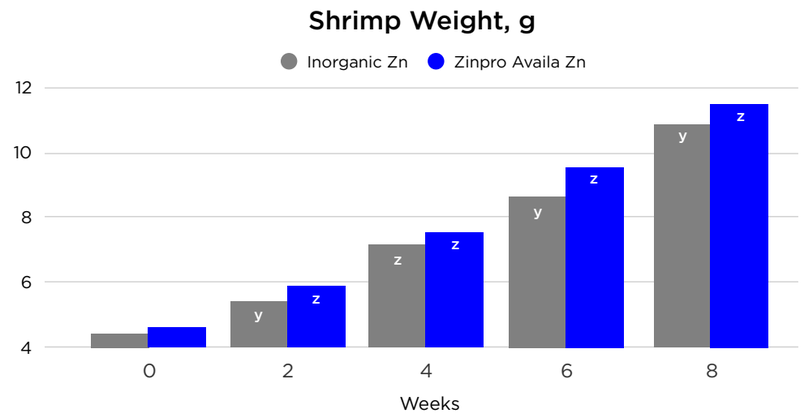
Study 2

Zinpro® Availa® Zn and Zinpro® Availa® Se Improve Growth, Health and Meat Quality of Whiteleg Shrimp

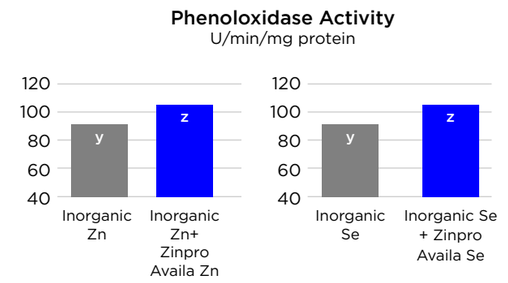
Key Findings

- Partial replacement of inorganic Zn with Zinpro Availa Zn significantly ($P < 0.05$) improved shrimp weight (Fig. 1).
- Partial replacement of inorganic Zn and Se with Zinpro Availa Zn and Zinpro Availa Se significantly ($P < 0.05$) increased hemocyte count (data not shown) and phenoloxidase activity, key biomarkers of shrimp immune response (Fig. 2). Modulation of the immune response by ZPM resulted in reduced cumulative mortality of shrimp when challenged with *Vibrio harveyi* (data not shown).
- Zinpro Availa Se significantly ($P < 0.05$) improved red coloration of shrimp chilled for 72-hr prior to (data not shown) and after boiling (Fig. 3a). Zinpro Availa Se also significantly ($P < 0.05$) improved shrimp meat redness after a 14-day freeze (data not shown).
- Whole shrimp meat rancidity (data not shown) and drip-loss (Fig. 3b) were both significantly ($P < 0.05$) reduced by partial replacement of inorganic Se with Zinpro Availa Se. The effect of partially replacing inorganic Zn with Zinpro Availa Zn on drip-loss was more evident between treatments where solely inorganic Se was used (Fig. 3b).
- Accumulation of Zn and Se significantly ($P < 0.05$) increased in the exoskeleton and hepatopancreas of shrimp fed Zinpro Availa Zn and Zinpro Availa Se (data not shown).

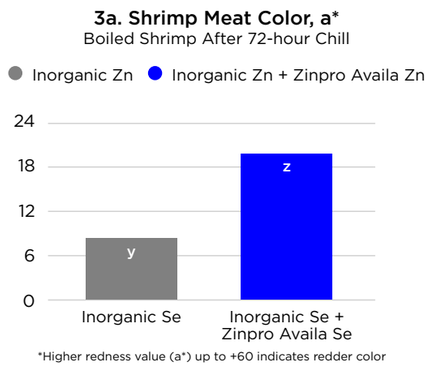
Growth Performance Fig. 1



Health Fig. 2



Meat Quality Fig. 3



Study Criteria

This study evaluated the effects of a partial replacement of inorganic Zn and Se with Zinpro Availa Zn and Zinpro Availa Se on growth performance, health and meat quality in whiteleg shrimp.

Mineral, ppm	Inorganic Zn + Se	Zinpro Availa Zn + Inorganic Se	Inorganic Zn + Zinpro Availa Se	Zinpro Availa Zn + Zinpro Availa Se
Zinc sulfate	120	70	120	70
Zinpro Availa Zn		50		50
Sodium selenite	0.30	0.30	0.15	0.15
Zinpro Availa Se			0.15	0.15

Initial body weight: 4 g
Stocking density: 60 shrimp/m^2
Feeding: 4x/day
Replications: 6
Duration: 8 weeks
Salinity: 30 ppt

36.5% CP/8% Fat
25% fishmeal
3% shrimp meal
2% squid meal
20% SBM
5% poultry by-product meal

Location:
Kasetsart University
Thailand

Source: Sun, et al., 2018. ISFNF, June 3-7, 2018, Gran Canaria, Spain. | 20127007

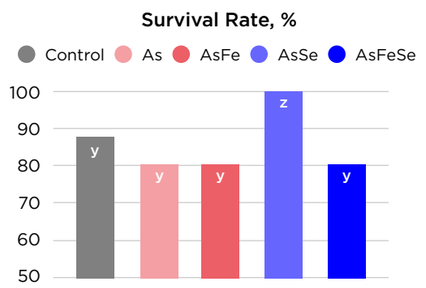
Study 3

Zinpro® Availa® Fe and Zinpro Availa Se are Key Promoters of Coloration in Whiteleg Shrimp

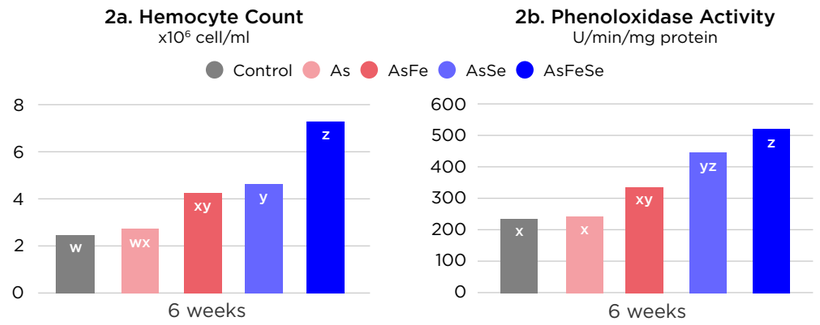
Key Findings

- Diets supplemented with Zinpro Availa Se showed greater survival rate (Fig. 1) and FCR (not shown).
- Hemocyte count (Fig. 2a) and phenoloxidase activity (Fig. 2b) were significantly ($P < 0.05$) increased when shrimp consumed astaxanthin (As), Zinpro Availa Se and Zinpro Availa Fe for 6 weeks.
- Diets supplemented with 75 ppm As, 200 ppm Zinpro Availa Fe and 0.3 ppm Zinpro Availa Se (AsFeSe) significantly ($P < 0.05$) improved red coloration of shrimp meat and total carotenoid content of cooked shrimp shell and flesh (Figures 3a-c).

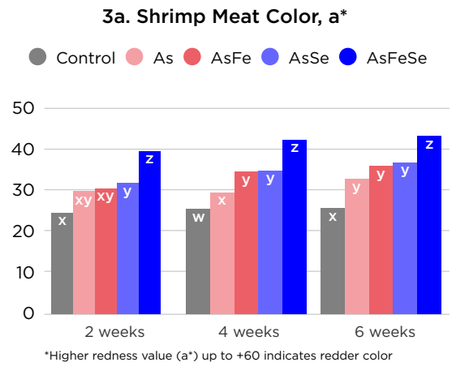
Growth Performance Fig. 1



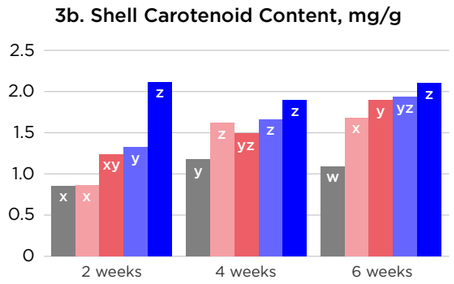
Health Fig. 2

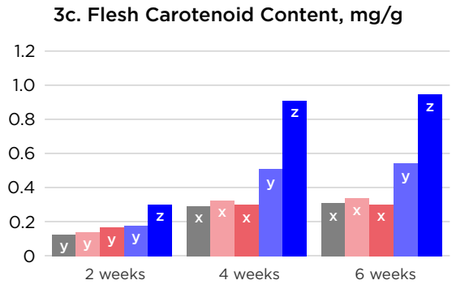


Meat Quality Fig. 3



Higher redness value (a) up to +60 indicates redder color





Study Criteria

This study was conducted to investigate shrimp coloration and immune response when astaxanthin was added to the diet alone or in combination with either iron or selenium, or with both iron and selenium.

Treatments	Astaxanthin, ppm	Zinpro Availa Fe, ppm	Zinpro Availa Se, ppm
Control	-	-	-
As	75	-	-
AsFe	75	200	-
AsSe	75	-	0.3
AsFeSe	75	200	0.3

Initial body weight: c.a. 6.5 g
Stocking density: 10 shrimp/tank (100 L)
Feeding 3x/day
Replications: 4
Feeding period: 6 weeks

12.5% fishmeal
3% squid meal
25% SBM
7.5% soy protein concentrate
3% yeast
10% wheat gluten
22% wheat flour

Location:
Kasetsart University
Thailand

Source: Jintasataporn, et al., 2018. ISFNF, June 3-7, 2018, Gran Canaria, Spain.

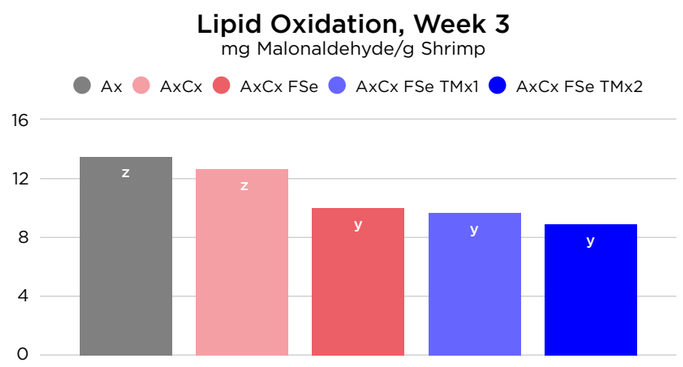
Study 4

Zinpro Performance Minerals Spare Carotenoids For Shrimp Pigmentation

Key Findings

- Reducing astaxanthin from 75 ppm to 25 ppm, in combination with 25 ppm cantaxanthin (AxCx), had no effect on lipid oxidation (Fig. 1), but it did reduce redness of meat and shell as indicated by a* value (Fig. 2) and SalmoFan™* scores (Fig. 3).
- Supplementation with ZPM reduced ($P < 0.05$) lipid oxidation (Fig. 1), highlighting the antioxidant functions of trace minerals as cofactors of key antioxidant enzymes.
- SalmoFan™ scores of shrimp shell decreased ($P < 0.05$) from 27 to 24.4 in just 3 weeks of the AxCx diet, without ZPM.
- Supplementing 100 ppm Zn as Zinpro Availa Zn, 20 ppm Cu as Zinpro® Availa® Cu®, 40 ppm Mn as Zinpro® Availa® Mn, 100 ppm Fe as Zinpro Availa Fe and 0.3 ppm Se as Zinpro Availa Se to the AxCx diet returned ($P < 0.05$) SalmoFan™ score of shrimp shell to that of the Control diet containing 75 ppm astaxanthin.
- Results indicate that supplementing ZPM (AxCx FSe TM2x) can boost antioxidant capacity of shrimp as rapidly as 3 weeks, allowing astaxanthin to be reserved for pigmentation purposes instead of antioxidant functions (a sparing effect), saving $66 USD/ton of feed.
- Supplementation with ZPM can effectively and economically support the reduction of astaxanthin while maintaining cooked shrimp color, performance and health parameters.

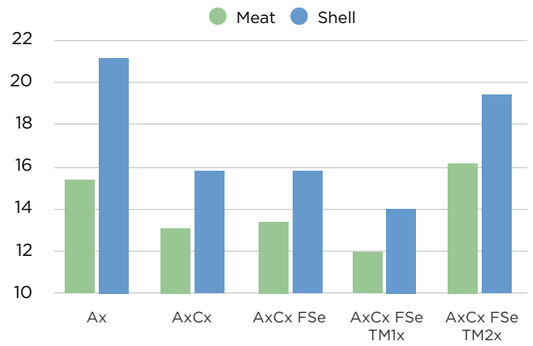
Meat Quality Fig. 1



*SalmoFan™ is a trademark of dsm-firmenich.

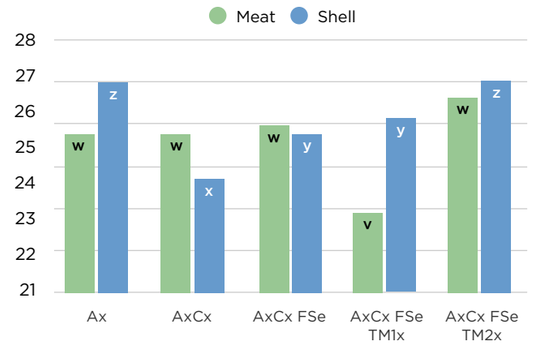
Meat Quality Fig. 2

Fig. 2a. Week 3 Colorimeter Value of Shrimp, a*



Higher redness value (a*) up to +60 indicates redder color

Fig. 2b. Week 3 SalmoFan™ score



Study Criteria

Trace minerals participate as cofactors of important enzymes related to the antioxidant defense mechanism. This study evaluated their effect on sparing carotenoids for pigmentation purposes.

Treatment	Caratenoids[a], ppm ASTX	Caratenoids[a], ppm CANX	ZPM[b], ppm Zinpro Availa Fe	Zinpro Availa Se	Zinpro Availa Zn	Zinpro Availa Mn	Zinpro Availa Cu
Ax	75	-	-	-	-	-	-
AxCx	25	25	-	-	-	-	-
AxCx FSe	25	25	100	0.3	-	-	-
AxCx FSe TMx1	25	25	100	0.3	50	20	10
AxCx FSe TMx2	25	25	100	0.3	100	40	20

[a] Wisdom pink 10%, Wisdom red 10%; ASTX = astaxanthin, CANX = canthaxanthin
[b] ZPM were supplemented on top of basal diet that included inorganic premix (mg/kg diet) : 0.2 Co, 25 Cu, 1 I, 30 Fe, 30 Mn, 0.35 Se, 100 Zn.

Initial body weight: 7–8 g
Stocking density: 20 shrimp/tank (300 L)
Feeding: 3x/day
Replications: 5
Feeding period: 3 weeks
Salinity: 10-15 ppt

38% CP/6% Fat
12.5% fishmeal
3% squid meal
25% SBM
7.5% fermented soy meal
3% yeast
10% wheat gluten
22% wheat flour

Location:
Kasetsart University
Thailand

Source: Boggino, et al., 2020. WAS Aquaculture America, February 9-12, Honolulu, Hawaii.

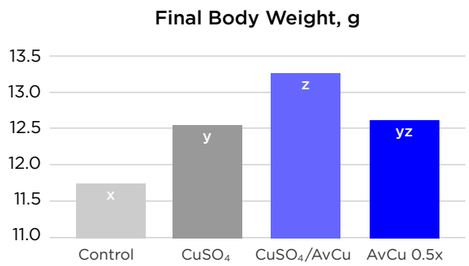
Study 5

A. Effect of Copper Source on Growth and Intestinal Microbial Communities of Whiteleg Shrimp

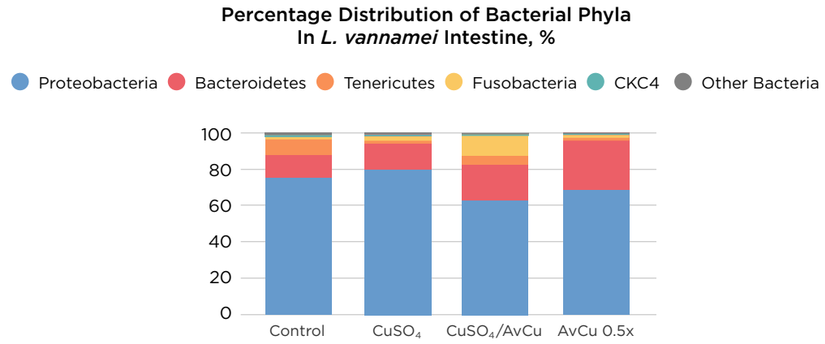
Key Findings

- Cu supplementation positively ($P < 0.05$) affected growth of shrimp.
- Zinpro Availa Cu at a half-rate (15 ppm Cu) of $CuSO_4$ (30 ppm Cu) maintained shrimp FBW (Fig. 1), showing Zinpro Availa Cu is more effective than inorganic Cu.
- Marked trends in microbial phyla suggest microbial communities were being influenced by copper source (Fig. 2).
- Combination of Zinpro Availa Cu + $CuSO_4$ (total 30 ppm Cu) resulted in numerically better growth than the half-rate of solely Zinpro Availa Cu, indicating higher Cu supplementation may be required for maximized shrimp performance.
- The reduction on *Proteobacteria* phylum which includes the *Vibriocaceae* family is related to overall shrimp health when fed a combination of $CuSO_4$ and Zinpro Availa Cu or Zinpro Availa Cu at a half-rate.

Growth Performance Fig. 1



Health Fig. 2

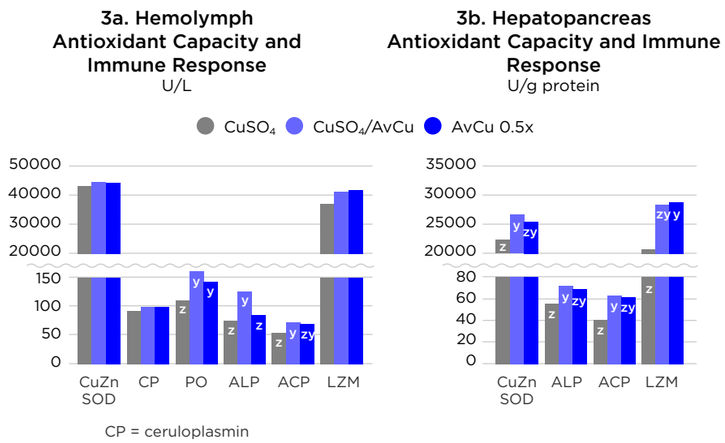


B. Effect of Copper Source on Shrimp Antioxidant Capacity and Immune Response

Key Findings

- Partial or complete replacement of $CuSO_4$ with Zinpro Availa Cu at a half-rate significantly ($P < 0.05$) improved phenoloxidase (PO) activity in hemolymph (Fig. 3a).
- Partial or complete replacement of $CuSO_4$ with Zinpro Availa Cu at a half-rate increased hepatopancreatic Cu/Zn superoxide dismutase (SOD), alkaline phosphatase (ALP; $P < 0.05$) and acid phosphatase (ACP; $P < 0.05$) indicating better antioxidant capacity and immune response in shrimp fed Zinpro Availa Cu.
- Activity of hepatopancreatic lysozyme (LZM) was significantly ($P < 0.05$) increased in shrimp fed Zinpro Availa Cu at a half-rate (Fig. 3b).
- Activities of hepatopancreatic Cu/Zn SOD, ALP and ACP were highest when the treatment was combined, but not statistically different from Zinpro Availa Cu at the half-rate.
- The inclusion of optimal levels of Cu in shrimp diets improved shrimp health biomarkers, demonstrating that robust shrimp can be grown under commercial conditions.

Health Fig. 3



CP = ceruloplasmin

Study Criteria

This study evaluated effects of dietary copper source on shrimp growth, intestinal microbial communities, antioxidant and immune response.

Treatment, ppm added to Control

Trace Mineral	Control	$CuSO_4$	$CuSO_4$ / AvCu	AvCu 0.5x
Cu	0	30	15/15	15

Note: Diet contains 10 ppm of Cu coming from raw material.

Initial body weight: 1.86 g
Stocking density: 30 shrimp/tank
Feeding: 3x/day
Replications: 3
Feeding period: 8 weeks
Salinity: 25-28 ppt

43% CP/8% Fat
30% fishmeal
3% krill meal
22% SBM
6% poultry by-product meal
6% peanut meal

Location:
Ningbo University
China

A. Source: Yuan, et al., 2019a. Aquac. Nutr. 25:828-840. | 20147011

B. Source: Yuan, et al., 2019b. Fish and Shellfish Immunology 84:1059-1067. | 20147011

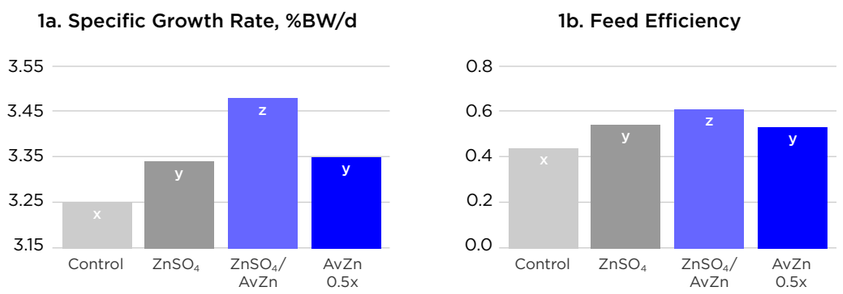
Study 6

Effect of Zinc Source and Level on Shrimp Growth Performance, Meat Quality, Antioxidant and Immune Capacity

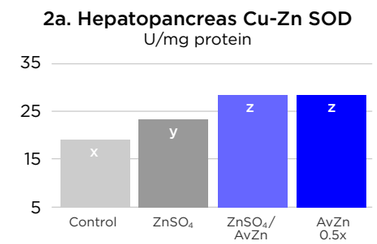
Key Findings

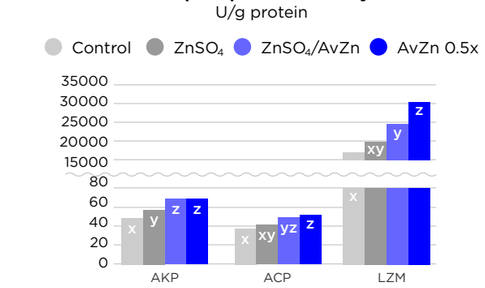
- Zinpro Availa Zn at a half-rate (60 ppm Zn) of $ZnSO_4$ maintained SGR (Fig. 1a) and FE (Fig. 1b), showing Zinpro Availa Zn is more effective than inorganic Zn.
- The combination of 60 ppm Zinpro Availa Zn + 60 ppm $ZnSO_4$ improved shrimp survival rate (data not shown), SGR ($P < 0.05$) and FE ($P < 0.05$) by 4.3, 3.1 and 20%, respectively.
- Hepatopancreas antioxidant (Fig. 2a) and immune-related enzymes (Fig. 2b) were higher ($P < 0.05$) in shrimp fed a combination of $ZnSO_4$ and Zinpro Availa Zn or Zinpro Availa Zn at a half-rate.
- Zinpro Availa Zn in combination with $ZnSO_4$ or at a half-rate, reduced drip loss in muscle (Fig. 3a; $P < 0.05$) and drip loss and thaw loss in whole shrimp (Fig. 3b; ($P < 0.05$).
- Zinpro Availa Zn in combination with $ZnSO_4$ or at a half-rate translated into an economic advantage over the Control of 45.6% and 24.5%, respectively.
- The best performance observed was with the combination of 60 ppm Zn as $ZnSO_4$ + 60 ppm Zn as Zinpro Availa Zn, which indicates higher Zn supplementation may be required for maximized shrimp performance.
- Return on investment (ROI) for Zinpro Availa Zn at a half-rate is underestimated due to the difficulty in attributing economic value to benefits seen on antioxidant defense, immune response and product quality. Higher ROI is expected in the field and under more challenging conditions.

Growth Performance Fig. 1



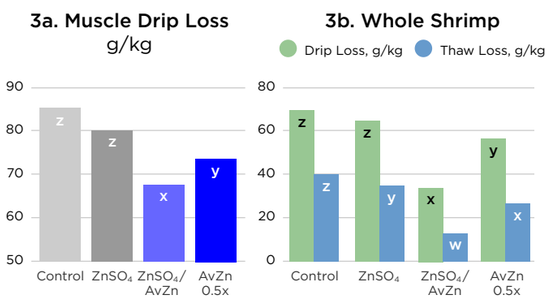
Health Fig. 2





AKP = alkaline phosphatase
ACP = acid phosphatase
LZM = lysozyme

Meat Quality Fig. 3



Study Criteria

This study aimed to provide novel insight into how the supplementation and level of a Zn source affected whiteleg shrimp: growth response, meat quality, oxidation resistance and innate immunity.

Treatment, ppm added to Control

Trace Mineral	Control	$ZnSO_4$	$ZnSO_4$ / AvZn	AvZn 0.5x
Zn	0	120	60/60	60

Note: Basal diet contains 51 ppm of Zinc coming from raw material.

Initial body weight: 1.84 g
Stocking density: 30 shrimp/tank
Feeding: 3x/day
Replications: 4
Feeding period: 8 weeks
Salinity: 25-28 ppt

43% CP/7.6% Fat
30% fishmeal
3% krill meal
22% SBM
6% poultry by-product meal
6% peanut meal

Location:
Ningbo University,
China

Source: Yuan, et al. 2020. Aquaculture 522, 735120. | 20147011

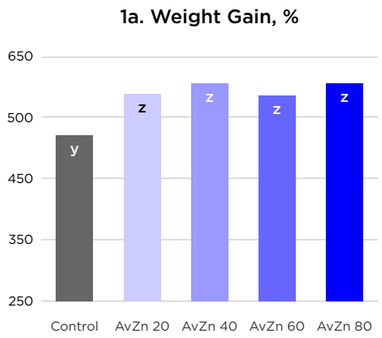
Study 7

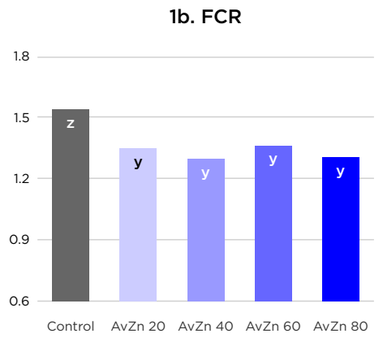
Availa Zn Positively Impacts Pacific White Shrimp Culture

Key Findings

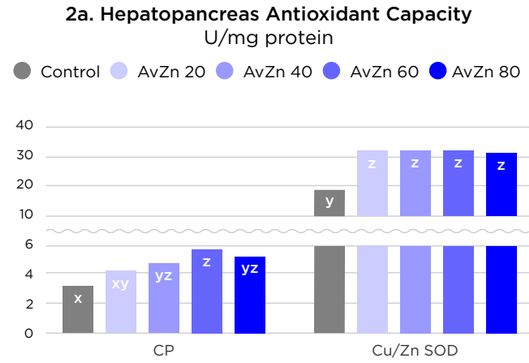
- Growth performance was significantly improved ($P < 0.05$) by Availa Zn supplementation, with shrimp fed 60 to 80 ppm Zn showing higher weight gain (Fig. 1a) compared to the Control, indicating that 60 ppm Availa Zn meets dietary Zn requirements for shrimp.
- Improvements in growth efficiency were supported by increased SGR (data not shown) and reduced FCR ($P < 0.05$; Fig. 1b).
- Zinc deposition in shrimp tissues (data not shown) increased with dietary Availa Zn, reaching the highest levels in shrimp supplemented with 60 to 80 ppm Zn, confirming enhanced Zn bioavailability at these inclusion rates.
- Availa Zn enhanced antioxidant capacity, as evidenced by increased Cu/Zn-SOD activities ($P < 0.05$; Fig. 2a) and reduced malondialdehyde level ($P < 0.05$; Fig. 3), with the strongest responses observed in shrimp fed 60 to 80 ppm Zn.
- Immune responses were maximized at 80 ppm Zn from Availa Zn, with higher phenoloxidase ($P < 0.05$; Fig. 2b-c) and lysozyme (data not shown) activities, and upregulated mRNA expression of immune-related genes (data not shown).
- Overall, 60 to 80 ppm supplemental Availa Zn positively impacted shrimp performance, Zn deposition, antioxidant capacity, hepatopancreas Zn availability, and immune enzyme activity.
- Economic returns improved with Availa Zn supplementation, resulting in an economic advantage over Control of 7.7% at 60 ppm Zn and 12.5% advantage over Control at 80 ppm Zn.

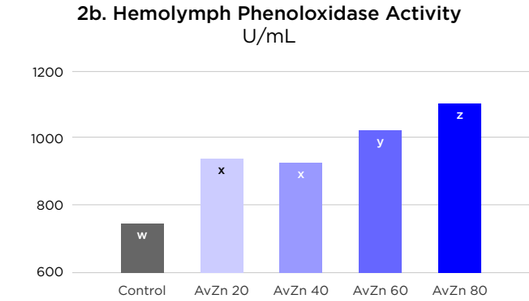
Growth Performance Fig. 1

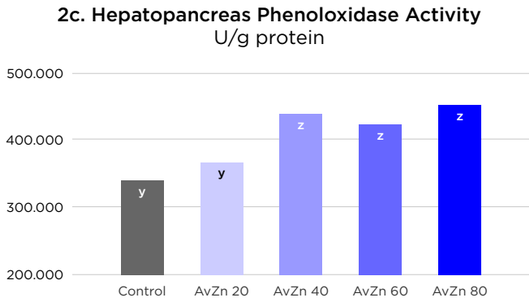




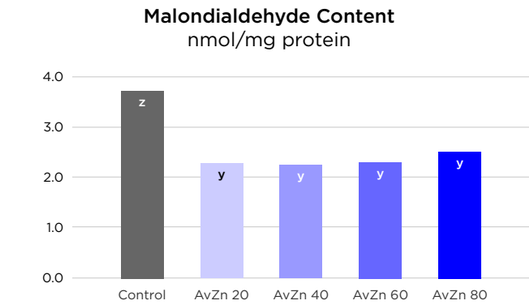
Health Fig. 2







Meat Quality Fig. 3



Study Criteria

The objective of this study was to quantify the dietary Zn requirement of whiteleg shrimp when feeding a commercial diet and to gather information on antioxidant capacity and immune response of shrimp receiving different levels of a highly bioavailable Zn source.

	Supplemental Zn, ppm	Total Feed Zn, ppm
Control	0	46.4
AvZn 20	20	65.5
AvZn 40	40	85.9
AvZn 60	60	108.4
AvZn 80	80	130.6

Initial body weight: 1.33 g
Density: 30 shrimp/tank (300 L)
Replications: 5
Feeding period: 8 weeks
Feeding: 3x/day (6-8% biomass)
Salinity: 23-27 ppt

43% CP/8.2% Fat
20% fishmeal
3% krill meal
23% SBM
6% soy protein concentrate
6% poultry by-product meal
5% peanut meal

Location:
Ningbo University
China

Source: Shi, et al., 2021. Aquac. Rep. 19:100638. | 20187026

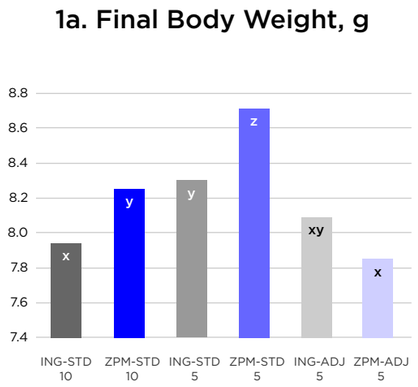
Study 8

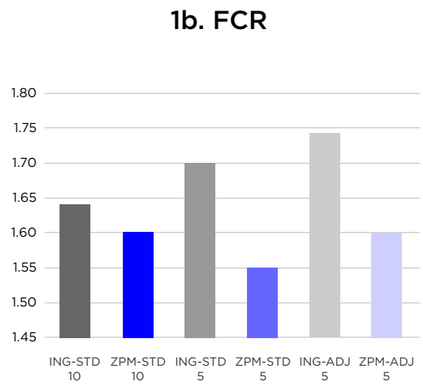
Zinpro Performance Minerals Contribute to the Cost-Effective Reduction of Fishmeal Level in Shrimp Feeds

Key Findings

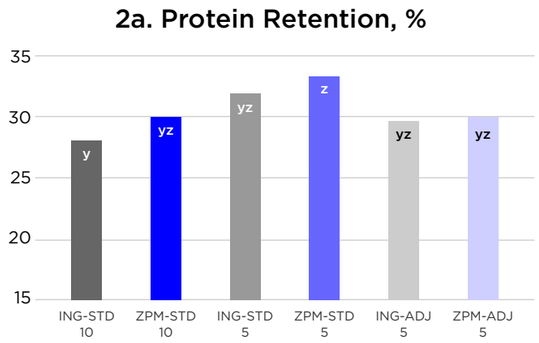
- Shrimp grew equally well on 10% and 5% FM diets, suggesting that all nutrients were properly balanced.
- The adjustment of trace mineral level for Zn, Fe and Se in 5% FM diets to equal those in 10% FM diets did not show any shrimp performance advantages and requires further investigation.
- At a standard TM level, regardless of FM level:
  - Supplementation with ZPM resulted in significantly ($P < 0.05$) higher FBW (Fig. 1a) and lower FCR (Fig. 1b) compared to ING, despite Zn and Se levels being provided at 50% the level (60 ppm Zn, 0.2 ppm Se) of inclusion in the ING premix (120 ppm Zn, 0.4 ppm Se). Trace minerals from ZPM reduced FCR by 2.4% and 8.8% in shrimp fed 10% and 5% FM diets, respectively.
  - Protein (Fig. 2a), Zn and Mn (Fig. 2b), and Cu (Fig. 2c) retention efficiencies were higher ($P < 0.05$) in shrimp fed ZPM than ING. Results indicate that supplementation of shrimp feed with ZPM constitutes an effective strategy to reduce mineral excretion into environmental water.
- Se retention efficiency was greatest ($P < 0.05$) in shrimp fed ZPM at the adjusted level, indicating that this mineral may require particular attention when balancing the TM profile of low FM diets.
- Reduction of FM inclusion level from 10% to 5%, along with the use of ZPM, resulted in a 13% economic advantage over diets supplementing inorganic minerals.

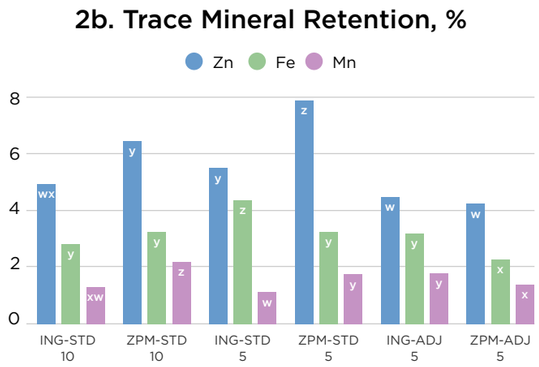
Growth Performance Fig. 1

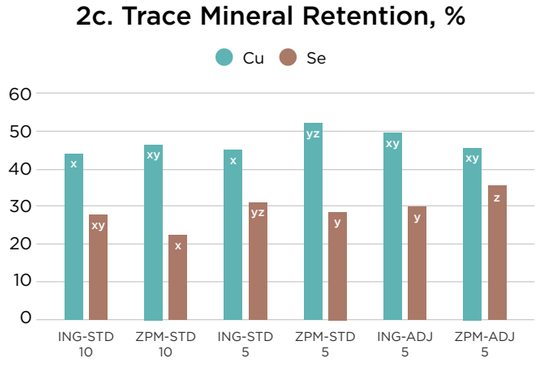




Nutrient Retention Fig. 2







Study Criteria

Evaluate the possibility of reducing fishmeal (FM) inclusion level in shrimp feed by 50%, through the optimization of trace mineral (TM) level [Standard (STD) vs Adjusted (ADJ)] and source [Inorganic (ING) vs Zinpro Performance Minerals (ZPM)]. Trace mineral levels were adjusted to achieve similar TM content in feeds with either 5% or 10% FM.

	FM, %	TM Source	TM level
ING-STD 10	10	INORG	STD
ZPM-STD 10	10	ZPM	STD
ING-STD 5	5	INORG	STD
ZPM-STD 5	5	ZPM	STD
ING-ADJ 5	5	INORG	ADJ
ZPM-ADJ 5	*5*	ZPM	ADJ

Initial body weight: 0.28 g
Density: 175 shrimp/m^2
Replications: 8
Feeding period: 63 days
Feeding: 4x/day using feeding trays
Salinity: 19 ppt

37.5% CP/7% Fat
5% or 10% fishmeal
2% squid meal
45-52% SBM
6.4% poultry by-product meal

Location:
Labomar - Marine Sciences Institute
Federal University of Ceará
Brazil

Source: Nunes, et al., 2024. ISFNF, June 5-9, Puerto Vallarta, Mexico. | 20211528

Study 9

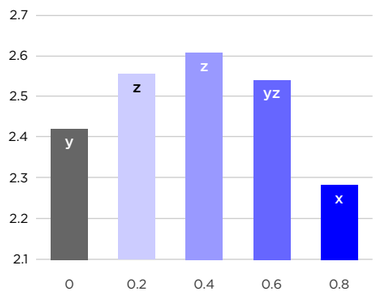
Zinpro® Chromium Methionine* Supplementation Promotes Shrimp Performance, Carbohydrate Utilization and Stress Response

Key Findings

- Supplementation with 0.4 ppm Cr from Zinpro Chromium Methionine increased SGR ($P < 0.05$; Fig. 1a) by 8% and reduced FCR ($P < 0.05$; Fig. 1b) by 16%, translating into a 21% economic advantage over the Control treatment.
- Supplementation with Zinpro Chromium Methionine improved carbohydrate utilization for energy purposes, through promotion of glucose uptake and utilization by the cell observed in reduced hemolymph glucose concentration ($P < 0.05$; Fig. 2a) and increased activity of the glycolytic enzyme, hexokinase (HK; $P < 0.05$; Fig. 2b). The glycolysis pathway upregulation was corroborated by a downregulation in gluconeogenesis (data not shown), offering a protein sparing effect of chromium methionine.
- Shrimp fed up to 0.6 ppm Cr as Zinpro Chromium Methionine improved oxidative stress response through increased activity of antioxidant defense enzymes, superoxide dismutase (SOD; Fig 3a) and catalase (data not shown), in the hepatopancreas. The increased ability of hepatopancreas cells to cope with oxidation products and peroxidation also resulted in reduced malondialdehyde content (MDA; Fig. 3b) of the hepatopancreas.

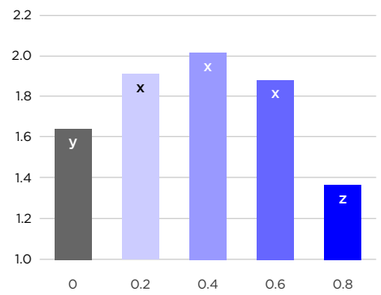
Growth Performance Fig. 1

1a. Specific Growth Rate, % BW/d



Zinpro Chromium Methionine Level, ppm Cr

1b. FCR

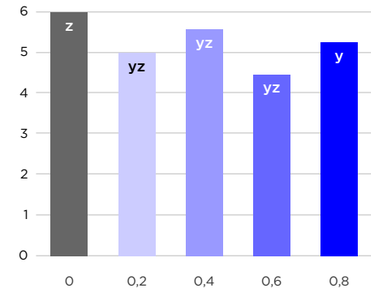


Zinpro Chromium Methionine Level, ppm Cr

* Zinpro Chromium Methionine is sold as either Zinpro® Availa® Cr or Zinpro® MICROPLEX® depending on the region.

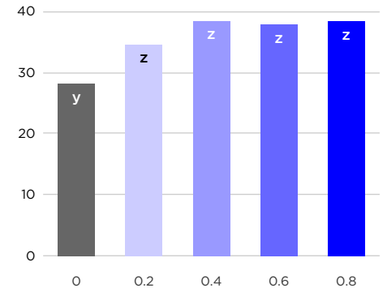
Health Fig. 2

2a. Hemolymph Glucose Concentration mmol/L



Zinpro Chromium Methionine Level, ppm Cr

2b. Hepatopancreas HK Activity U/mg prot



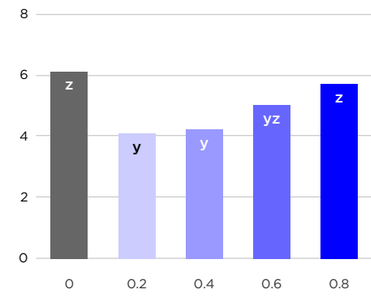
Zinpro Chromium Methionine Level, ppm Cr

Health Fig. 3

3a. Hepatopancreas SOD Activity U/mg protein

Zinpro Chromium Methionine Level, ppm Cr

3b. Hepatopancreas MDA Content nmol/mg protein



Zinpro Chromium Methionine Level, ppm Cr

Study Criteria

Evaluation of supplemental Zinpro Chromium Methionine on performance, carbohydrate utilization and oxidative stress in Pacific white shrimp.

0: 0 ppm Cr
0.2: 0.2 ppm Cr
0.4: 0.4 ppm Cr
0.6: 0.6 ppm Cr
0.8: 0.8 ppm Cr

Initial body weight: 3.2 g
Density: 30 shrimp/tank
Replications: 5
Feeding period: 8 weeks
Feeding: 3x/day (6-8% BW)
Salinity: 20-21 ppt

43% CP/8% Fat
20% fishmeal
3% krill meal
23% SBM
6% poultry by-product meal
5% peanut meal

Location:
Ningbo University
China

Source: Shi, et al., 2021. Aquatic Toxicology 240:105967.

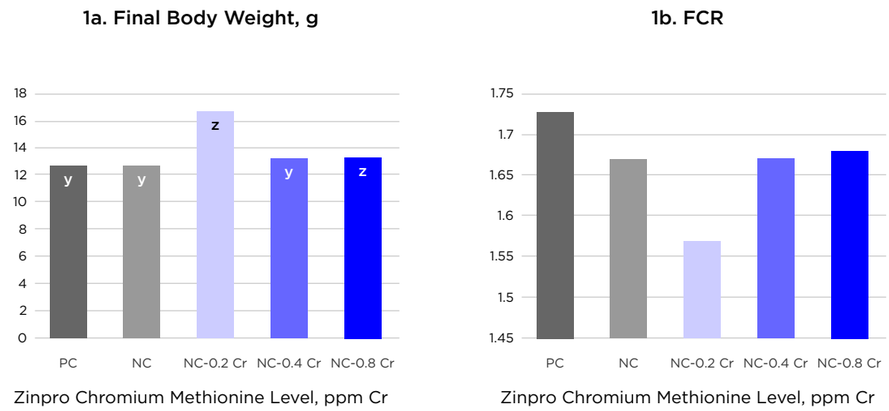
Study 10

Zinpro® Chromium Methionine* Can Cost Effectively Reduce Protein Content in Shrimp Diets

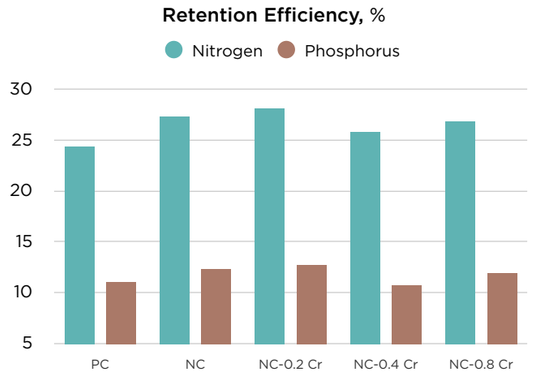
Key Findings

- Supplementation with 0.4 ppm Zinpro Chromium Methionine increased SGR (Fig. 1a) by 8% and reduced FCR (Fig. 1b) by 16%, translating into a 21% economic advantage over the Control treatment.
- Supplementation of 0.2 ppm Zinpro Chromium Methionine to the 32% CP diet (Fig. 1a-b; Fig. 2):
  - Increased FBW ($P < 0.05$) by 7% and reduced FCR by 6% compared to NC
  - Increased FBW ($P < 0.05$) by 7% and reduced FCR by 9% compared to PC
  - Increased retention efficiency of nitrogen (N) by 3% and of phosphorous (P) by 15% compared to NC
  - Increased retention efficiency of N by 15% and of P by 16% compared to PC
- Zinpro Chromium Methionine supplementation to low protein diets resulted in an economic advantage over the PC of 7% to 50%, being greatest at 0.2 ppm Cr.
- Zinpro Chromium Methionine improved growth performance, nutrient retention, and feed efficiency while delivering clear economic benefits—demonstrating that low-protein diets can maintain or exceed performance when strategically supplemented, with the greatest return observed at 0.2 ppm Cr.

Growth Performance Fig. 1



Nutrient Retention Fig. 2



* Zinpro Chromium Methionine is sold as either Zinpro Availa Cr or Zinpro MICROPLEX depending on the region.

Study Criteria

Evaluate supplementing Zinpro Chromium Methionine in shrimp feeds to reduce dietary protein content.

	CP% (DP%)	Cr, ppm
Positive Control (PC)	36 (28)	0
Negative Control (NC)	32 (25)	0
NC-0.2 Cr	32 (25)	0.2
NC-0.4 Cr	32 (25)	0.4
NC-0.8 Cr	32 (25)	0.8

Initial body weight: 1 g
Density: 85 shrimp/m^2
Replications: 6-8 (tanks with survival rate <70% were excluded)
Feeding period: 81 days
Feeding: 4x/day using feeding trays
Salinity: 16 ppt

PC: 36% CP (28% DP)/7% Fat
NC: 32% (25% DP)/7% Fat

Location:
Labomar - Marine Sciences Institute
Federal University of Ceará
Brazil

Source: Internal data. | 20244502

Study 11

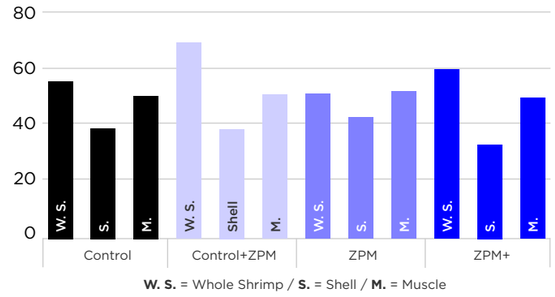
Replacing Inorganic Minerals with Zinpro Performance Minerals Benefits Shrimp Performance and Economic Investment In Commercial Setting

Key Findings

- In a commercial setting, replacing an inorganic trace mineral premix with ZPM in shrimp feed, improved performance, resulted in a > 120% return on investment (ROI), and suggested the need for further investigation on preferential mineral deposition.
- Replacing inorganic trace minerals with ZPM in shrimp feed, in a commercial setting:
  - Improved shrimp survival by 122 to 155% (Fig. 1a)
  - Increased biomass by 109 to 145% (Fig. 1b)
  - Decreased FCR by 14 to 22% ($P < 0.05$; Fig. 1c)
  - Revealed preferential distribution of Zn (Fig. 2a) and Se (data not shown) in muscle, Cu (Fig. 2b) and Mn (data not shown) in shell, and Fe (data not shown) in shell (Control, Control+ZPM) and muscle (ZPM, ZPM+).
- Further benefits reported by the producer included improved stress tolerance, color enhancement from A2 to A3 or A4, improved product shelf-life, and reduced soft shell problems.

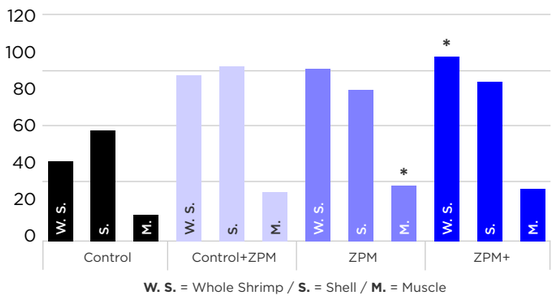
Nutrient Retention Fig. 2

2a. Zn Content of Whole Shrimp, Shell and Muscle, ppm



W. S. = Whole Shrimp / **S.** = Shell / **M.** = Muscle

2b. Cu Content of Whole Shrimp, Shell and Muscle, ppm

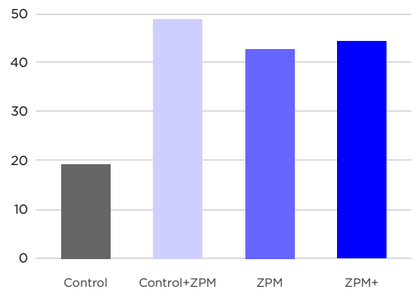


W. S. = Whole Shrimp / **S.** = Shell / **M.** = Muscle

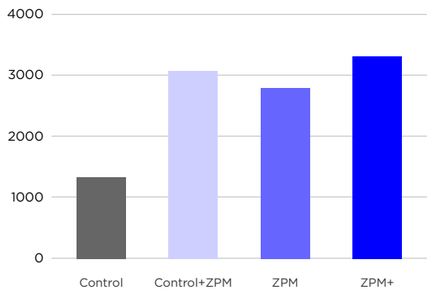
* $P < 0.05$

Growth Performance Fig. 1

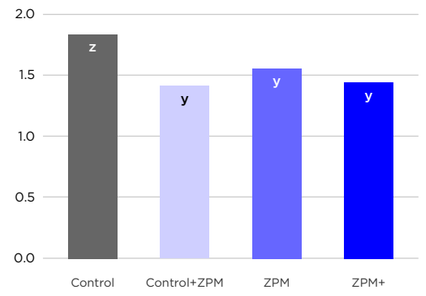
1a. Survival Rate, %



1b. Final Biomass, kg/0.5 ha



1c. FCR



Study Criteria

Assess benefits of replacing inorganic trace minerals with ZPM on shrimp performance, survival rate and economic advantage under commercial conditions.

Mineral, ppm	Control (inorganic)	Control+ZPM (iso both sources)	ZPM	ZPM+
Zn	60.5	60.5 + 60.5	60.5	80
Fe	48.6	48.6 + 48.6	48.6	50
Mn	47.2	47.2 + 47.2	47.2	40
Cu	21	21 + 21	21	40
Se	0.24	0.24 + 0.24	0.24	0.4
Cr				0.4

Initial Body Weight: 0.5 g
Density: 0.5 million PL/0.5 ha pond (100 PL/m^2)
Replications: 3
Feeding period: 100-120 days

Azteca commercial shrimp feed

Location:
Granja Acuicola Los Tucanes
Mexico

Source: Servin Arce, et al., 2022. WAS Aquaculture, February 28-March 4, San Diego, California. | C20207042

Study 12

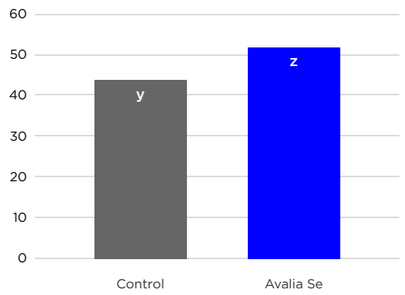
Benefits of Zinpro Availa Se Supplementation on Shrimp Performance in a Commercial Setting

Key Findings

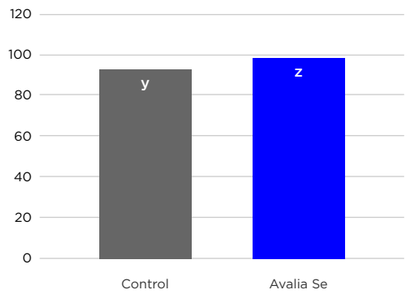
- Supplementation with 0.3 ppm Se as Availa Se:
  - Increased survival rate by 18% ($P < 0.05$; Fig. 1a)
  - Increased shrimp final biomass by 6.5% ($P < 0.05$; Fig. 1b)
  - Reduced FCR by 8% ($P < 0.05$; Fig. 1c)
- In a commercial setting, supplementation of shrimp feed with Availa Se resulted in an economic advantage over the inorganic Se Control, of 18%.

Growth Performance Fig. 1

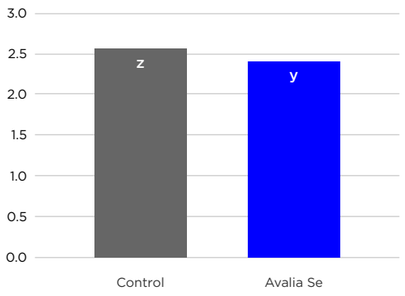
1a. Survival Rate, %



1b. Final Biomass, kg



1c. FCR



Study Criteria

Evaluate benefits of replacing inorganic Se with Availa Se on shrimp performance and survival rate under commercial conditions.

Control: 0.3 ppm Se as inorganic Se
Availa Se: 0.3 ppm Se as Availa Se

Initial Body Weight: 0.03 g
Density: 500 shrimp/m^3 (28 m^3 tanks)
Replications: 3
Feeding period: 110 days

Commercial shrimp feed

Location:
Commercial shrimp farm
Indonesia

Source: Internal data. | C20217049

Essential Trace Minerals for Shrimp

BENEFIT	TRACE MINERALS	HOW IT WORKS
Meat Quality	Zinc, Copper, Manganese, Iron, Selenium, Chromium	• Influences lipid and protein content • Enhanced meat color • Reduced drip loss • Improved product shelf-life
Muscle Development	Zinc, Copper, Selenium, Chromium	• Enzyme systems required for growth • Energy and protein metabolism • Cell membrane protects from peroxides • Influences carbohydrate, lipid, and protein metabolism • Oxygen carrying function
Exoskeleton Development	Zinc, Copper, Manganese, Selenium	• Exoskeleton formation, development and reconstruction during molting • Cell division and protein synthesis for normal tissue mineralization
Larvae and Post-Larvae Development	Zinc, Copper, Manganese, Iron, Selenium, Chromium	• Energy and protein metabolism • Cell proliferation • Normal tissue mineralization • Cell membrane protection • Hematopoiesis, the formation of hemocyanin (copper-containing protein that carries oxygen in hemolymph)
Disease Resistance	Zinc, Copper, Manganese, Iron, Selenium, Chromium	• Humoral immunity • Cell-mediated immunity • Non-specific immunity • Anti-oxidant activity to remove free radicals and protect cell membranes • Reduced mortality
Balanced Gut Microbiome	Zinc, Copper, Iron	• Reduction of pathogenic bacteria • Shift the balance of intestinal bacteria in favor of beneficial species
Epithelial Tissues	Zinc, Copper, Manganese	• Improves wound healing • Epithelial tissue integrity through maintaining of cell division, protein synthesis and antioxidant activity to remove superoxide radicals

Feeding Recommendations for Shrimp

Mineral	Zinpro Performance Minerals Products	Zinpro Recommendations Minimum Requirement ZPM, mg/kg diet
Zn	Zinpro® Availa® Zn Zinpro® ProPath® Zn	60
Cu	Zinpro® ProPath® Cu (replaced Zinpro® Availa® Cu)	40
Mn	Zinpro® Availa® Mn Zinpro® ProPath® Mn	40
Fe	Zinpro® Availa® Fe Zinpro® ProPath® Fe	50
I[a]		4
Se[b]	Zinpro® Availa® Se	0.3
Cr[c]	Zinpro® MICROPLEX® Zinpro® Availa® Cr	0.4

[a] Not a current ZPM source
[b] Note upper limit allowed in EU is of 0.2 ppm, provided as organic source
[c] Use where commercially available

Zinpro Performance Minerals solutions for shrimp production.

When animals and people experience better health and wellbeing, **we see a healthier, more productive and sustainable world for all.**

ZINPRO®

For more information: contact your Zinpro representative or visit **zinpro.com/aquaculture**

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