PULSE CANADA

FEED TRIAL SUMMARY · AQUACULTURE

PEA STARCH CONCENTRATE IN SHRIMP DIETS

An 8-week feeding trial evaluating pea starch concentrate as a complete replacement for wheat flour in Pacific white shrimp diets.

STUDY AT A GLANCE

INSTITUTION
University of the Philippines Visayas
Iloilo, Philippines

SPECIES
Pacific White Shrimp
Penaeus vannamei

DURATION & SCALE
8 weeks · 300 shrimp
5 diets, in triplicate

WHEAT FLOUR REPLACED
0, 25, 50, 75, 100%
up to 20% of the diet

Wheat flour is included in shrimp feeds at 15–35% of total formulation, where it supplies dietary energy and binds the pellet. However, competition from livestock and food processing has driven prices up and tightened supply. Pea starch, produced as a co-product of yellow pea protein manufacture, is proposed as an alternative carbohydrate source. This study — conducted at the University of the Philippines Visayas — provides the first evaluation of **pea starch concentrate (PSC)** as a direct replacement for wheat flour in *Penaeus vannamei* diets.

A note on terminology: in this report, "pea starch concentrate" refers to a pea starch-rich flour used as a feed ingredient — not a purified starch isolate.

KEY FINDINGS

GROWTH PERFORMANCE

PSC replaced up to 100% of dietary wheat flour with no significant effect on survival, weight gain, specific growth rate, feed conversion ratio, or feed intake across the 8-week trial. Pellet integrity was maintained at all inclusion levels.

100%
Wheat flour replacement with no effect on growth performance

DIGESTIBILITY

The apparent digestibility coefficient for dry matter was 90.25% for PSC, against a published value of 50.62% for wheat flour in this species. Carbohydrate digestibility reached 95.95%.

90%
Dry matter digestibility, against 51% for wheat flour

IMMUNE MARKERS

Prophenoloxidase and serum lysozyme activity were significantly higher in all PSC groups than in the control, at inclusion levels as low as 25% replacement. Total hemocyte counts were unaffected, indicating immune activation without physiological stress.

Elevated immune health markers at all pea starch inclusion levels
proPO and lysozyme activity above control from 25% replacement

INTESTINAL MORPHOLOGY

Shrimp fed the 100% replacement diet developed significantly taller and more slender intestinal villi, expanding absorptive surface area. No evidence of gut tissue damage was observed at any inclusion level.

+39%
Villus height at full replacement (28.48 vs 20.49 µm)

WHY THIS MATTERS

These results demonstrate that pea starch concentrate can replace 100% of the wheat flour in Pacific White Shrimp diets without compromising growth performance or pellet integrity. Immune and intestinal benefits observed at higher inclusion levels represent added value beyond simple nutritional substitution.

METHODS & DIET FORMULATION

TRIAL DESIGN

ANIMALS

300 juvenile *P. vannamei* at 0.3 ± 0.01 g, obtained from a commercial hatchery in Iloilo and screened for pathogens before stocking.

HOUSING

Fifteen 75-L polyethylene aquaria, 20 shrimp per tank, individually aerated on a flow-through rearing system. Water parameters were optimized throughout.

FEEDING

Fed at 3% body weight, four times daily for 8 weeks. Treatments were allocated by complete randomized design, each in triplicate.

EXPERIMENTAL DIETS

Five diets were formulated to include 0, 5, 10, 15, or 20% pea starch concentrate (PSC), replacing 0, 25, 50, 75, or 100% of dietary wheat flour. All diets were isonitrogenous and isocaloric (CP 40%, DE 14 MJ/kg) and satisfied published nutrient requirements for *P. vannamei*. The basal formulation contained fishmeal (CP 70%), squid meal, wheat gluten, soybean meal (48%), yeast, fish oil, cholesterol, lecithin (70%), vitamin–mineral premix, and BHT.

DIET	CONTROL	2	3	4	5
Wheat flour portion replaced	0%	25%	50%	75%	**100%**
Pea starch concentrate in the diet	0%	5%	10%	15%	**20%**

INGREDIENT NUTRIENT COMPOSITION

AS FED (%)	WHEAT FLOUR	PEA STARCH CONCENTRATE
Dry matter	88.0	90.0
Crude protein	11.7	12.0
Carbohydrate	70.0–75.0	60.0 as starch
Crude lipid	1.2	3.0
Ash	0.4	4.0

APPARENT DIGESTIBILITY

A separate trial assessed PSC digestibility against a reference diet using 1% chromium oxide (Cr_2O_3) as an inert marker. PSC dry matter digestibility reached 90.25% and carbohydrate digestibility 95.95%, against a published wheat flour value of 50.62% for this species — indicating that close to half of wheat flour passes through the animal undigested.

DIGESTIBILITY (%)	REFERENCE DIET	PEA STARCH CONCENTRATE	WHEAT FLOUR
Dry matter	89.23 ± 4.03	**90.25 ± 2.78**	50.62*
Protein	94.86 ± 1.87	**95.01 ± 0.70**	not reported
Lipid	88.97 ± 4.02	**90.89 ± 2.31**	not reported
Carbohydrate	95.22 ± 1.35	**95.95 ± 1.00**	not reported

*Published wheat flour value for this species, Davis and Arnold (1993).

GROWTH, DIGESTIBILITY & COMPOSITION

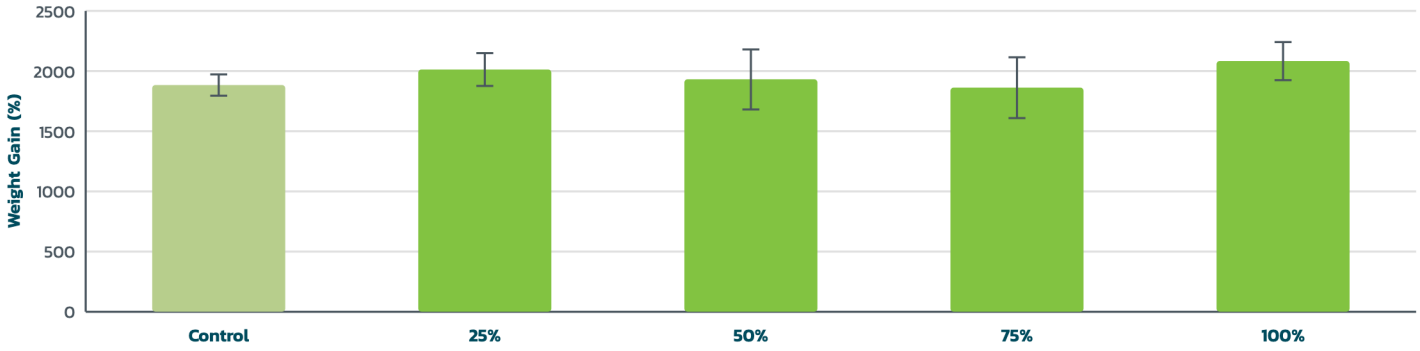
GROWTH PERFORMANCE

Survival, weight gain, specific growth rate, feed conversion ratio, and feed intake were statistically comparable across all five treatments ($P > 0.05$). The highest survival, weight gain, and specific growth rate were recorded numerically in the 100% replacement group, though the differences were not significant.

Percentages denote wheat flour replacement level. Values are mean ± SEM (n = 3 replicate tanks).

MEASURE	CONTROL	25%	50%	75%	100%
Survival (%)	88.33 ± 2.88	88.33 ± 2.88	83.33 ± 2.88	86.66 ± 2.88	90.00 ± 0.00
Weight gain (%)	1,883 ± 88	2,013 ± 137	1,931 ± 249	1,862 ± 253	2,083 ± 158
Specific growth rate (%/day)	2.92 ± 0.07	2.84 ± 0.04	2.73 ± 0.17	2.84 ± 0.22	3.37 ± 0.14
Feed conversion ratio	1.86 ± 0.16	1.60 ± 0.11	1.71 ± 0.25	1.93 ± 0.04	1.89 ± 0.07
Feed intake (g/shrimp)	12.75 ± 1.30	12.28 ± 0.34	11.88 ± 2.09	13.01 ± 1.80	14.26 ± 1.46

WEIGHT GAIN BY TREATMENT



No significant differences in weight gain were observed among treatments ($P > 0.05$); bars show group means ± SEM.

CARCASS COMPOSITION

Protein, lipid, and ash content of the harvested shrimp were statistically similar across all five diets, indicating that substituting the dietary carbohydrate source did not alter body composition.

CARCASS (%)	CONTROL	25%	50%	75%	100%
Protein	73.99 ± 1.37	73.33 ± 1.78	72.60 ± 0.44	74.63 ± 0.91	74.12 ± 0.92
Lipid	5.70 ± 0.37	5.89 ± 0.43	5.47 ± 0.35	5.60 ± 0.78	6.41 ± 0.30
Ash	12.37 ± 0.25	12.46 ± 0.06	12.04 ± 0.34	12.27 ± 0.86	10.60 ± 0.31

INTESTINAL MORPHOLOGY & IMMUNE RESPONSE

INTESTINAL MORPHOLOGY

Shrimp fed the 100% wheat replacement diet developed villi approximately 39% taller and significantly narrower than those in the control and 50% replacement groups. Increased villus height with reduced width expands absorptive surface area per unit of gut length, and is consistent with the digestibility results rather than with tissue damage.

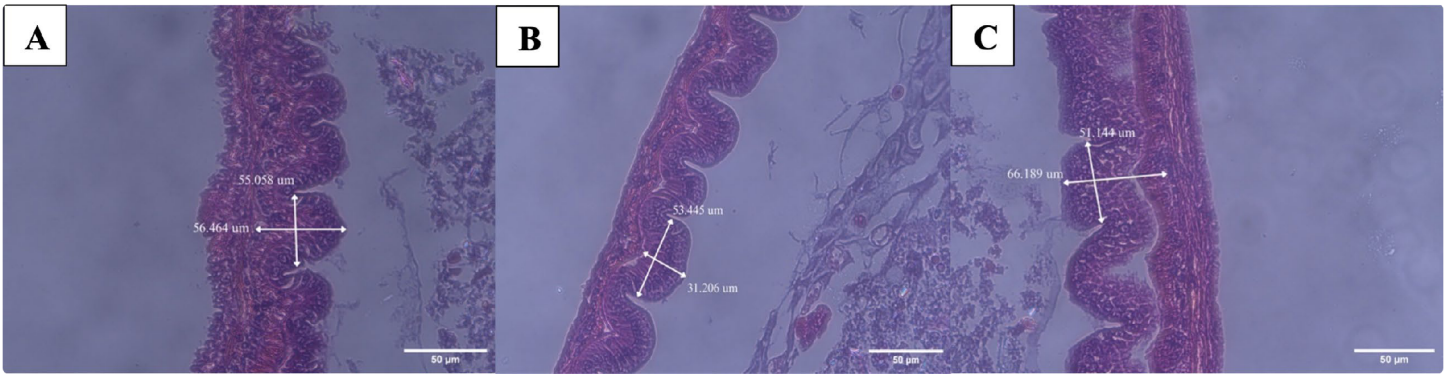


Figure 1. Intestinal villi histology. **(A)** control; **(B)** 50% wheat flour replacement; **(C)** 100% wheat flour replacement. Scale bars 50 µm.

VILLI	CONTROL	50%	100%
Height (µm)	20.49^{a} ± 0.53	20.23^{a} ± 2.04	**28.48^{b} ± 2.85**
Width (µm)	56.78^{a} ± 4.68	55.88^{a} ± 0.75	**45.25^{b} ± 2.21**

IMMUNE RESPONSE

Prophenoloxidase and serum lysozyme — two of the principal humoral immune responses in crustaceans — were significantly elevated in all PSC groups relative to the control, with no significant differences between the 25, 50, 75, and 100% replacement levels. Serum antibacterial activity was significantly enhanced at 75 and 100% replacement. Total hemocyte counts were unaffected throughout, indicating immune activation rather than physiological stress.

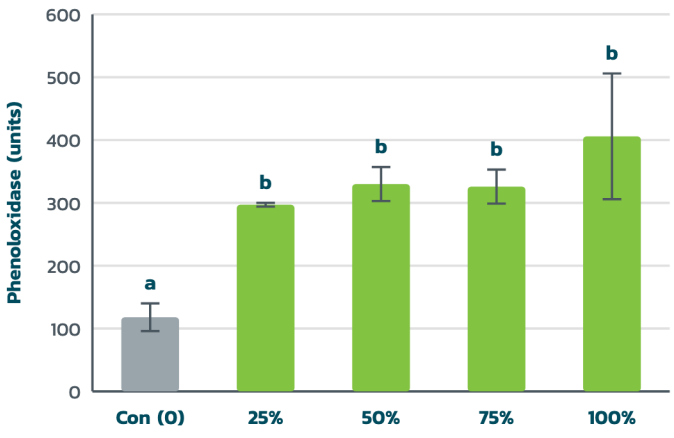


Figure 2. Prophenoloxidase activity. All pea starch diets were significantly above the control, with the highest value at 100% replacement.

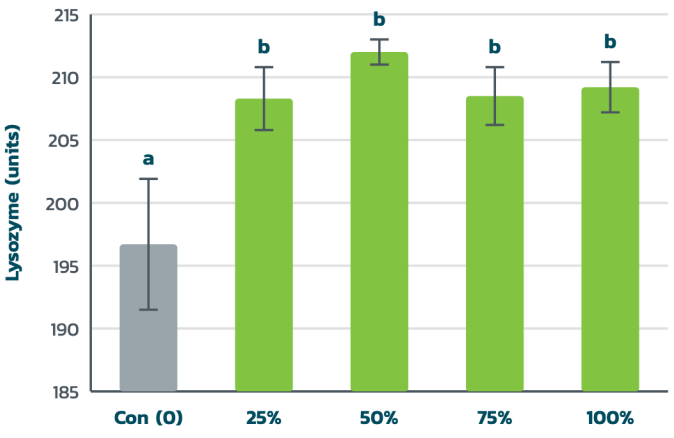


Figure 3. Serum lysozyme activity. Significantly elevated above the control at all four inclusion levels.

Trial conducted at the Institute of Aquaculture, University of the Philippines Visayas, with Pulse Canada. Published as Pagapulan et al. (2026), *Frontiers in Sustainable Food Systems* 10:1825738, open access under CC BY. Figures reproduced from the published article.