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Aquafeeds

Evaluation of a fishmeal analog in biofloc culture of Pacific white shrimp

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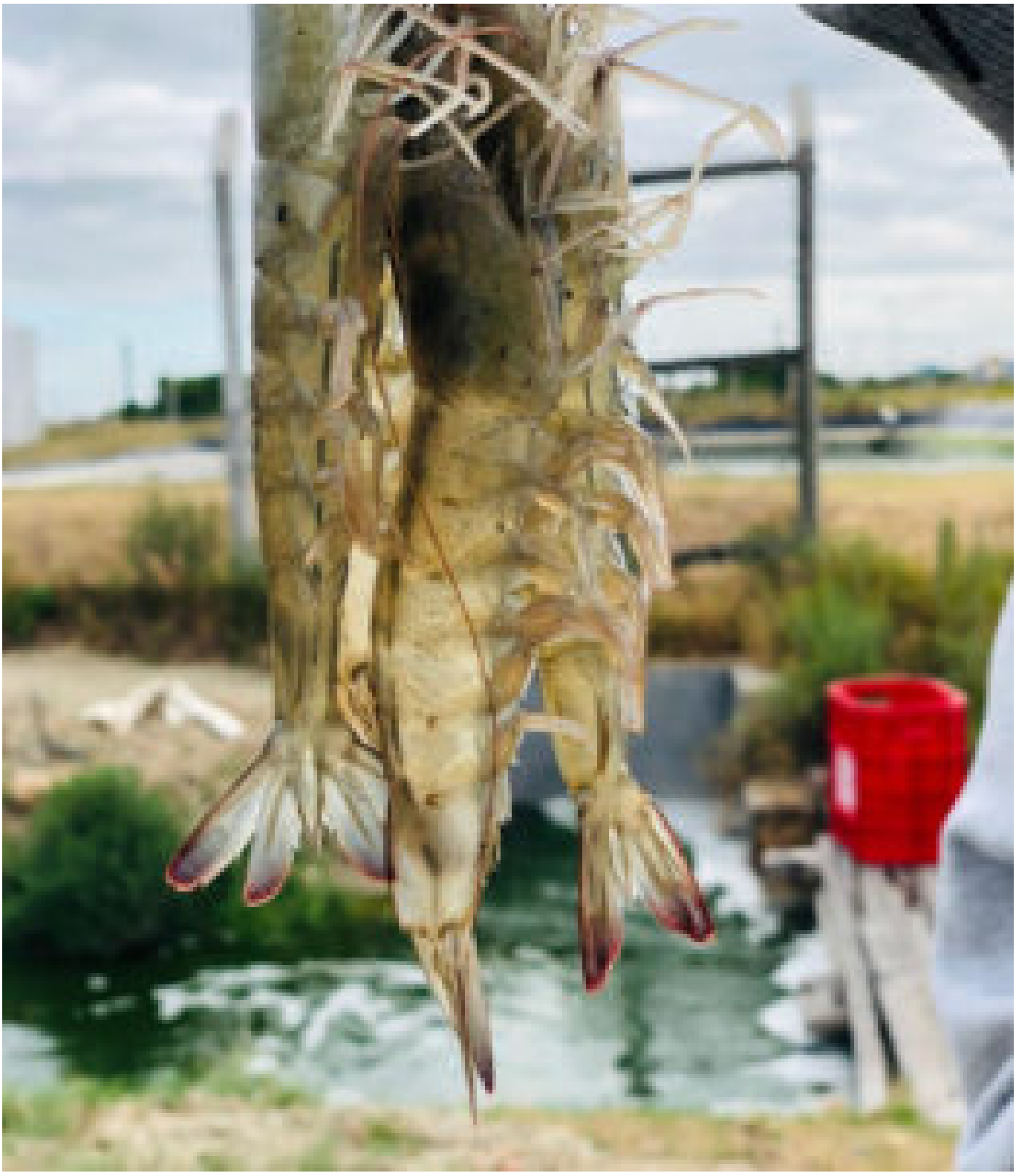
Results show replacement levels of 50 percent, 28 percent protein possible

In recent years, the Biofloc Technology System (BFT) has demonstrated its high efficiency by combining high productivity and minimal impacts on the environment, combining high productivity and low effluent emissions. Although the system has been relatively successful due to good productivity indices, demand for inputs can be a limiting factor for the further development of these systems.

According to a recent (2020) **publication** (http://www.fao.org/state-of-fisheries-aquaculture) by the Food and Agriculture Organization (FAO) of the United Nations, during the period from 1990 to 2018 the aquaculture sector expanded globally by 527 percent, and the demand for protein ingredients used in the diets of many cultured species has increased proportionately. Consequently, many researchers and other members of the aquaculture production chain have been and continue looking for new, suitable protein ingredient alternatives to help support the sustainable growth of fed aquatic species, including marine shrimp.



Results of this study showed that *L. vannamei* can be adequately grown in a BFT system on diets where a fishmeal analog from terrestrial byproducts replaces up to 50 percent of the fishmeal.

Terrestrial animal byproducts are a source of protein with the potential to replace fishmeal in aquaculture feeds. These byproducts include blood meal, meat and bone meal, hydrolyzed feather meal and poultry meal, and generally contain a good percentage of crude protein (45 to 65 percent) compared to plant sources, and byproducts of terrestrial animals have a more complete profile of amino acids.

Here we present the results of a study carried out at the at the Marine Station of Aquaculture (Federal University of Rio Grande, FURG, in Southern Brazil) to determine the efficiency of using a fishmeal analog (FMA) in different protein levels in diet of Pacific white shrimp (*Litopenaeus vannamei)* reared in a BFT culture system.

The FMA was developed by Guabi Nutrition and Animal Health (Guabi Nutrição e Saúde Animal LTDA) using a balanced mixture of terrestrial animal byproducts supplemented with commercial amino acids, minerals and vitamins (Table 1), to maintain a composition equivalent to that of conventional fishmeal as used for shrimp diet production.

Krummenauer, fishmeal analog, Table 1

Ingredient	Nutritional profile (%)
Protein (CP)	57.18
Linoleic acid	2.4
Phospholipids	4.0
Cholesterol	0.3
HUFA	1.7
Fiber	0.9
Calcium	6.0
Phosphorus	3.0
Lysine	3.9
Cystine	0.9
Methionine	1.4

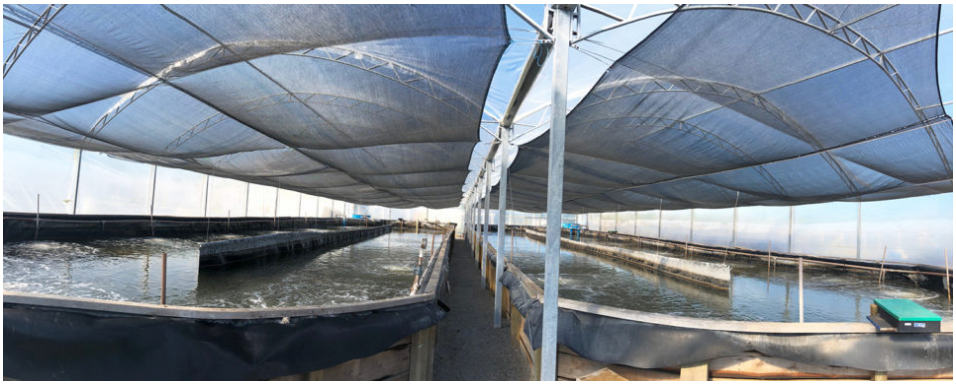
Table 1. Nutritional profile of the fishmeal analog used in the trial.

Our special thanks to Guabi Nutrition and Animal Health S.A. for plan and providing the experimental diets. We are also grateful for the financial support provided by the National Council for Scientific and Technological Development (CNPq), Coordination for the Improvement of Higher-Level Personnel (CAPES), INVE Technologies, Aquatec, Trevisan Agroindustrias and All Aqua for supporting this research.

Aerial view of the Marine Station of Aquaculture, Federal University of Rio Grande (FURG).

Study setup

The 70-day grow-out study was carried out at the Marine Station of Aquaculture, Federal University of Rio Grande (FURG) in Southern Brazil using nine, 35,000-liter, lined raceways enclosed in a greenhouse. *L. vannamei* juveniles (1.02 ± 0.11 grams) were stocked in the raceways at a density of 400 shrimp per square meter.



View of the lined, greenhouse enclosed raceways used in this study.

We used three different diets with different protein levels (28, 33 and 38 percent crude protein, CP). All diets included 50 percent fishmeal analog (FMA) and 50 percent conventional fishmeal in their protein content (Table 2).

Krummenauer, fishmeal analog, Table 2

Treatment	Total fishmeal (%)	Total fishmeal analog (%)	Total crude protein (%)
28	14.0	14.0	28.0
33	16.5	16.5	33.0
38	19.0	19.0	38.0

Table 2. Proportion of fishmeal and fishmeal analog used to prepare the experimental diets, and their total crude protein.

Water quality parameters were measured regularly: water temperature, dissolved oxygen (DO), pH and salinity were assessed daily with commercial instruments; and alkalinity (measured by titration) once per week. The pH and alkalinity were corrected with calcium hydroxide additions whenever the pH was lower than 7.2 and when alkalinity was ≤ 100 mg $CaCO_3$ per liter. Monitoring of TA-N, NO_2^-N, NO_3^-N and PO_4^{+3}-P was done every day, and total suspended solids (TSS) were measured three times per week. Organic fertilization with molasses from sugar cane as the carbon source was carried out when ammonia concentrations surpassed 1.0 mg per liter.

The experimental diets evaluated had different protein levels formulated using the fishmeal analog and were fed using auto-feeders.

Results and discussion

During the experiment, water quality parameters in the three dietary treatments evaluated – including nitrogen metabolite compounds – were maintained within normal/suitable ranges for *L. vannamei* culture, with no differences between treatments (Table 3).

Krummenauer, fishmeal analog, Table 3

Parameters	Recorded levels
Temperature (C)	24.46 ± 0.83
DO (mg/L)	5.42 ± 0.40
pH	7.61 ± 0.12
Salinity	33.33 ± 1.30
TSS (mg/L)	387.63 ± 88.90
TA- N (mg/L)	0.17 ± 0.15
NO2- N (mg/L)	0.78 ± 0.47
NO3- N (mg/L)	31.46 ± 5.36
PO4- P (mg/L)	5.03 ± 1.13
Alkalinity (mg CaCO3/L)	116.06 ± 12.9

Table 3. Water quality parameters monitored during the experiment. Results shown as mean ± standard deviation.

Regarding shrimp performance, no significant differences were observed among treatments for shrimp survival and growth. Although there were no differences among the different levels of protein, shrimp performance was similar to those reported by other studies in super intensive systems. The results of survival and growth obtained after 70 days of experiment confirms the possibility of the use of a diet with lower protein level in a super-intensive BFT system, using the FMA we tested (Figs. 1-2).

Fig. 1: Survival of *L. vannamei* fed experimental diets including different protein and fishmeal analog levels in a biofloc system. Results shown as mean ± standard deviation.

Fig. 2: Final weight of *L. vannamei* fed experimental diets including different protein and fishmeal analog levels in a biofloc system. Results shown as mean ± standard deviation.

In recent years, several researches have reported shrimp production in super-intensive BFT systems ranging from 5 to 10 kg per cubic meter. However, commercial-scale producers typically report yields in super-intensive systems ranging from 2 to 5 kg per cubic meter. In our study, we were able to achieve production levels ranging from 3.5 to 4.5 kg per cubic meter (Fig. 3) while using experimental diets that included only 50 percent of the conventional fishmeal levels normally used.

Fig. 3: Productivity (kg per cubic meter) of *L. vannamei* fed experimental diets including different protein and fishmeal analog levels in a biofloc system. Results shown as mean ± standard deviation.

In BFT systems, the FCR is typically lower by 15 to 30 percent compared to other, more conventional culture systems for shrimp. Even using the fishmeal analog at a 50 percent inclusion level in the experimental feeds we tested, it was possible to get FCR values of around 1.2, with no significant differences among dietary treatments.

Results of this study strongly suggested that a significant reduction in crude protein levels is possible using FMA in shrimp diets for culture in biofloc systems.

The low values obtained for feed conversion rates demonstrate that the alternative feed had adequate attractiveness for the shrimp. Results also strongly suggest a significant possibility for reducing the levels of crude protein using the FMA in biofloc systems (Fig. 4).

Fig. 4: Feed conversion rates (FCR) of *L. vannamei* fed experimental diets including different protein and fishmeal analog levels in a biofloc system. Results shown as mean ± standard deviation.

Perspectives

The results of our study confirm the possibility to replace 50 percent of conventional fishmeal inclusion levels in *L. vannamei* diets with the fishmeal analog (FMA) in super-intensive BFT culture, without negatively affecting water quality and shrimp growth. Our results also show the potential to reduce protein levels down to 28 percent crude protein in *L. vannamei* BFT systems.

And our study demonstrated that the use of FMA based on byproducts of terrestrial animals can be a viable alternative for efficient aquafeeds for shrimp, supporting good aquaculture practices and responsible production.

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