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**Evaluation of protein-rich feed ingredients for the organic production of freshwater prawns
Macrobrachium rosenbergii by smallholders in the inlands of Costa Rica**

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Abstract

In Costa Rica, there are many freshwater bodies appropriate for aquaculture purposes, but remaining unused so far. They are particularly suitable for the cultivation of the freshwater prawn *Macrobrachium rosenbergii*. Such cultivation has the potential to raise the income of smallholders, especially in the case of organically produced prawns that are high-value-products. The aim of this study was to test protein-rich feed ingredients for organic production of freshwater prawns. These ingredients were fish meals of the spotted flounder, *Hippoglossina bollmani*, the Peruvian mora, *Physiculus talarae*, and the speckled scorpionfish, *Pontinus cf sierra* from regional by-catch and shrimp head meal of the northern nylon shrimp, *Heterocarpus vicarius*, which is a locally occurring processing waste.

Material and Methods

Chemical analysis of feed ingredients

Fish meals and shrimp head meal were prepared at the facilities of the University of Costa Rica (UCR). These samples were used for the quantitative determination of dry matter, lipid and ash content according to the AOAC standard methods (1990), protein content with a C/N-Analyzer and gross energy content by bomb calorimetry at the University of Hohenheim.

Feed production

There were two different test diets prepared with 20% fish meal at the most according to the guidelines of “Nurland – Verband für ökologischen Landbau” as a potential certifier and based on the preliminary results of the chemical analysis. Test diet 1 (F1) contained only 15% fish meal

(*Physiculus talarae*) and test diet 2 (F2) contained 20% fish meal (15% *Pontinus cf sierra* and 5% *Hippoglossina bollmani*). Additionally shrimp head meal (*Heterocarpus vicarius*) was added into both experimental diets (10% into test diet 1 and 5% into test diet 2). Further ingredients were integral wheat meal, sunflower oil, gelatin and a commercial premix of vitamins and minerals. Feed ingredients were weighed, mixed thoroughly in a food mixer, made into dough by adding 40% water and finally put in a meat grinder through a 3 mm-die. The lines were cut by hand into 5 mm long pellets which were dried over night at 30 – 50°C. Feed composition analysis was conducted to determine the dry matter, lipid, ash, protein and gross energy content. The dry matter, lipid, ash, protein and gross energy content of the four experimental diets are presented in Table 1.

Table 1: Composition of the different experimental diets

Diet	Dry matter % DM	Crude Protein % DM	Crude Lipid % DM	Crude Ash % DM	Gross Energy kJ/g
F1	92.3	25.4	8.1	10.6	18.3
F2	94.1	26.9	8.3	9.8	18.3
CN	90.3	35.5	9.1	8.2	19.6
CH	90.9	15.5	4.7	7.0	18.2

Aquaria trial

A preliminary aquaria trial was conducted at the CIMAR (“Centro de Investigación del Mar y Limnología”) Institute of the University of Costa Rica for a period of 16 days to evaluate the water stability and the sink ability of the test diets, the acceptability and the digestibility of the test diets by the prawns. The test diets were compared to (1) a control feed (CN) used for the cultivation of marine shrimp (“Nicovita”) and to (2) a pellet feed (CH) for horses used in the only existing prawn farm in Costa Rica.

Field trial

For the field a randomized set-up of three outdoor ponds at the “Enrique Jiménez Núñez Aquatic Experimental Station” of the Costa Rican Fishery and Aquaculture Institute (INCOPECA) in Taboga in the province of Guanacaste in Costa Rica was chosen. Each pond contained four net

cages of 2 m². The grow-out experiment was designed for a period of 28 days to determine the effect of the diets on growth performance and feed utilization parameters of *Macrobrachium rosenbergii*. The feeding frequency was twice a day. The feeding quantity was about 10% of the body mass respectively. A sample of five prawns of every net cage was weighed at intervals of one week. The body composition of the prawns and their changes were analyzed in the same way as the fish meals and shrimp head meal in the preliminary analysis. A stomach dissection and microscopically identification of stomach contents was realized to detect the food spectrum of *M. rosenbergii* in the experiment. The water quality parameters temperature, dissolved oxygen (DO) and pH were measured thrice daily. Ammonia, nitrate, nitrite, phosphate and chlorophyll a were measured to determine the primary production of the ponds. Turbidity of the pond waters were detected by using a Secchi-disc and Plankton samples were taken.

Results and Discussion

Deficiencies were detectable in the physical properties water stability and sink ability of the test diets caused by the manual feed production with inadequate technical equipment. The observation of the acceptability by *M. rosenbergii* in the aquaria did not show any visible differences to the bare eye between the treatments. The apparent digestibility of the giant river prawns could not be determined because the total quantity of collected feces was too low in order to conduct an adequate analysis in the laboratory.

The pond water quality parameters showed that the ponds used in the experiment met the requirements of *M. rosenbergii*. The primary production of the ponds was relatively low but the stomach dissection showed that there was natural food available and ingested by the prawns. Freshwater ponds in Costa Rica are adequate locations for giant river prawn aquaculture.

The results of the growth and feed utilization parameters specific growth rate (SGR), feed conversion ratio (FCR) and feed efficiency ratio (FER) are presented in Table 2. The FCR and the FER were calculated assuming that no feed was left over because it was impossible to determine feed leftovers in the applied feeding regime. Considering SGR and FCR experimental diet F2 was the most appropriate diet used in this study. The SGR and FCR achieved by test diet F1 was close to F2 showing that even F1 was better in SGR and FCR than CN although the control diet had a higher dietary protein content and was produced by elaborate commercial processes. Feed efficiency ratio (FER) was the same for test diets F1, F2 and CN indicating that the test diets were appropriate for *M. rosenbergii*.

There were no significant differences found in the further growth and feed utilization parameters protein efficiency ratio (PER), protein productive value (PPV), apparent net lipid utilization

(ANLU) and energy retention (ER). However, PER showed again the same tendency as the previously mentioned parameters SGR, FCR and FER.

Table 2: Specific growth rate (SGR), feed conversion ratio (FCR) and feed efficiency ratio (FER) of the different treatments

Parameter	F1	F2	CN	CH	P
SGR (% d ⁻¹)	1.2 ± 0.3 ^a	1.3 ± 0.7 ^a	1.0 ± 0.5 ^a	0.2 ± 0.1 ^b	0.022
FCR	0.5 ± 0.2 ^a	0.5 ± 0.4 ^a	0.7 ± 0.7 ^a	5.3 ± 4.8 ^a	0.108
FER	0.1 ± 0.0 ^a	0.1 ± 0.1 ^a	0.1 ± 0.1 ^a	0.0 ± 0.0 ^a	0.371

Lines with common letters denote non-significant differences between treatments. One-way ANOVA *post-hoc* Tukey-B test ($P < 0.05$); significantly different; n = 3

Contrary to expectations in the body composition changes the crude protein (CP) of the prawns of all treatments decreased. Surprisingly the most considerable decrease was identified for CN although this diet contained the highest proportion of protein. This result indicates again that a dietary protein content of 35.5% in the feed for *M. rosenbergii* was above the required level in the used experimental system. The crude lipid (CL) in the body compositions of the prawns fed test diets F1, F2 and CN gained throughout the experimental period which reflected the oversupply of dietary lipid. The ash content increased in prawns of all treatments showing a negative impact on growth in general. The gross energy (GE) was sufficient in all experimental diets.

Conclusion

Based on this study the suitability of the used feed ingredients could be clarified. The results suggest that the use of regional fish meals (*Physiculus talarae*, *Hippoglossina bollmani*, *Pontinus cf sierra*) from by-catch and shrimp head meal (*Heterocarpus vicarius*), which is a locally occurring processing waste, in diets for *M. rosenbergii* yield the desired growth performance. There were no significant differences found between the test diets and the control diet for marine shrimp although the protein content of CN was higher than in F1 and F2. The fish meals and shrimp head meal constitute adequate protein sources for *M. rosenbergii* since the test diets met the nutritional requirements of *M. rosenbergii*. Hence, the evaluated fish meals and shrimp head meal are suitable for an organic production of *M. rosenbergii* in Costa Rica for raising the income of smallholders.