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Energy balance of *Litopenaeus vannamei* postlarvae fed on animal or vegetable protein based compounded feeds

Luis Jiménez-Yan [a], Abelardo Brito [b], Gerard Cuzon [c], Gabriela Gaxiola [b], Tomás García [b], Gabriel Taboada [b], Luis A. Soto [d], Roberto Brito [e,*]

[a] *Universidad Juárez Autónoma de Tabasco, Extensión Universitaria de los Ríos, Tenosique de Pino Suárez, Tabasco, México*
[b] *Unidad Multidisciplinaría de Docencia e Investigación, Facultad de Ciencias UNAM, Sisal, Yucatán, México*
[c] *IFREMER, COP-Tahiti, France*
[d] *Laboratorio de Ecología del Bentos, Instituto de Ciencias del Mar y Limnología, UNAM, México*
[e] *Facultad de Ciencias Pesqueras, Universidad Autónoma del Carmen, Calle 56 No. 4, CP 24180, Cd. del Carmen, Campeche, México*

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Abstract

L. vannamei postlarvae are normally raised with a protein dense diet (50% protein) rich in fishmeal. Part of the protein is utilized for energy purpose instead of protein synthesis. Based on a previous energy partitioning study, the effects of two isoenergetic compounded feed treatments – animal protein (AP) and vegetable protein and carbohydrates (VPC) – upon growth efficiency and energy budget of shrimp postlarvae and early juveniles were determined. Recovered energy (RE) or production (*P*) after 50 days trial was similar (2 J day^{-1}) in both treatments, from PL_{14} to PL_{19}. However, early juveniles discriminated between animal protein (116 J day^{-1}) and vegetable protein and carbohydrates (88 J day^{-1}). The difference in respiration indicated a higher heat increment with AP compared to VPC. At maintenance level, energy used was lower with AP than VPC treatment. Postlarvae and early juveniles employed protein as a main energy substrate (O:N<20). Differences in the efficiencies observed in the calculated energy budget were attributed to the presence of carbohydrates in diet and not to the protein source. The advantage of incorporating vegetable protein source in the diet of harvesting shrimp may eventually contribute towards a reduction of fishmeal costs and waste products as well as to achieve sustainable shrimp farming.

Keywords: Postlarvae; Juvenile; Energy; Animal protein; Vegetable protein; Physiology; Shrimp

1. Introduction

Our current knowledge on the nutritional requirements of penaeid shrimp postlarval stages (PLs) is still limited. Few studies have been conducted on vitamins, lipids, proteins, and essential minerals needed for their development (Rees et al., 1994; Colvin and Brand, 1977; Camara et al., 1997; Sheen and Huang, 1998; Velasco et al., 1998; Immanuel et al., 2001). The digestive tract of postlarvae goes through several developmental stages (Lovett and Felder, 1989, 1990a,b,c) before reaching its definitive structure with numerous hepatopancreas diverticula and full physiological functions. At PL stages also the feeding habits change in relation with the shift from planktonic to benthic habitats (Garcia and Le Reste, 1981; Escobar Briones, 1988), as

* Corresponding author. Tel./fax: +52 938 3827815.
E-mail address: rbrito@pampano.unacar.mx (R. Brito).

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they immigrate from oceanic waters to the estuarine nursery grounds in coastal waters, particularly into mangrove systems (Dittel et al., 1997). In this environment, postlarvae adopt an opportunistic feeding strategy. However, there has been no strict determination of nutritional requirements in relation to their feeding activity under controlled conditions. Presumably, an opportunistic omnivorous invertebrate is capable of digesting most of the nutrients contained in its food, and shrimp postlarvae are not exception. Then, it would be highly relevant for the energy balance of PLs to establish possible differences in the digestion and absorption of food rich either in animal or plant protein and digestible carbohydrates (cbh).

There used to be a critical phase at M_{III}–PL_1 with a shift from live food sequence (algae–*Artemia*) to dry pellet (crumbles) (Aquacop, 1995). Since inert particles replace live food sequence during larval stages, the problem of weaning does not exist anymore. The obtainment of hardy postlarvae depends on feed quality and the feeding schedule applied at larvae stages (Gallardo et al., 2003). Whereas the adaptation to a category of protein sources and to a protein and carbohydrate balance at PL stages will depend primarily on the composition of microcapsules provided at larvae stages.

Inert particles can replace live food sequence without significant difference in development duration. However, a more critical situation may arise when animal protein is replaced with vegetable protein sources (Argue et al., 2001).

Postlarval stages provide a good material to measure energy budget and to evaluate the respective growth promotion effects of feeds (whether under moist form or extruded with animal and/or vegetable protein sources). Several studies (Lemos and Phan, 2001; Lemos et al., 2001; Brito et al., 2004) provided methodology and results on energy expenditure; energy partitioning at PL stages when replacing *Artemia* with inert particles or effect of salinities, proved feasible from a comparative point of view. Consequently, the PL's overall energy budget can be addressed in spite of an existing difficulty to assess feed intake with precision.

This paper addresses the comparative effects on growth efficiency and energy budget of *L. vannamei* postlarvae and early juveniles – previously weaned on inert particles – while being exposed to two types of diets: one composed of vegetable protein and carbohydrates (soybean soluble protein concentrate, *Spirulina* powder, wheat gluten, and wheat starch) and another containing animal protein sources (fish, squid, and shrimp meals, and fish soluble protein concentrate).

2. Materials and methods

2.1. Experimental shrimp

L. vannamei postlarvae from 8th generation farmed population obtained from a commercial hatchery (Grupo Pecis, Yucatan, Mexico) were transported to the laboratory as postlarvae 14 (PL_{14}, fourteen days after metamorphosis). Postlarvae (1.08 mg wet weight) were transferred to 25 L plastic tanks, stocked at a density of 30 PL per tank and acclimatized at 28±0.05 °C and 32.4±0.1‰ salinity, photoperiod (13 h:11 h, light:dark). Tanks were supplied with constant aeration maintaining oxygen near saturation levels (6.3±0.04 mg O_2 L^{-1}). Sand filtered seawater was filtered through 5 and 1 μm cartridges and UV sterilized before a 50% daily exchange.

2.2. Diet preparation and feeding schedule

Postlarvae were fed two artificial diets. One group was fed an animal protein based diet (AP), and the other was fed a vegetable protein concentrate plus carbohydrate (VPC). Proximate composition of both experimental feeds (Table 1) was similar. The experimental feeds were prepared in the laboratory by thoroughly mixing dry ingredients with oil and then adding water

Table 1
Composition (% dry weight) and analysis of experimental feeds

Ingredients	AP	VPC
Fish meal	19	–
CPSP-70*	9	5
Shrimp meal	5	–
Squid meal	30	–
Wheat starch	–	14
Soybean SPC**	–	20
Wheat gluten	–	10
Spirulina	–	21
Cholesterol	0.56	0.56
Super Selco^R	3.7	4
Soybean lecithin	2	2
Carophyll-red	0.02	0.02
Vitamin mix***	1	1.5
Sodium alginate	1	1
Filler	19	21
Protein %	51	40
Lipid %	11	11
Carbohydrate %	3	20
Digestible energy (J/mg)	16	16

Animal protein diet (AP) and vegetable protein and carbohydrate diet (VPC).
*Soluble fish protein concentrate (Sopropêche, Boulogne s/mer, France).
**Soy soluble protein concentrate.
***Rovimix # 1720; Roche, Bâle, Suisse.