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Sparing effect of pond water on vitamins in shrimp diets

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Abstract

A 10-wk experiment was conducted to determine whether shrimp pond water has a sparing effect on vitamins, trace minerals, and protein levels in diets fed to juvenile Pacific white shrimp, *Litopenaeus vannamei*. Twenty-four 52-L aquaria were stocked with 0.7-g shrimp at a density of 24 shrimp/aquaria (100 shrimp/m^2 equivalent). Shrimp were exposed to flow-through seawater from one of two sources: clear well water from a seawater aquifer or organically rich water from a pond used for intensive shrimp culture. In addition, four diets were evaluated in each of the two water sources (three replicates/treatment), including: 1) a 35%-protein diet with vitamin and trace mineral premixes, 2) the same 35%-protein diet minus the vitamin premix, 3) the 35%-protein diet minus the trace mineral premix, and 4) a 25%-protein diet with vitamin and trace mineral premixes. Shrimp grown in well water without vitamins in their diet had a significantly lower ($P<0.05$) final weight, growth rate, and survival, and a significantly higher FCR, than shrimp grown in well water with vitamins. However, there was no significant difference in final weight, growth rate, survival, or FCR between pond-water reared shrimp with and without vitamins, indicating that removal of vitamins from the diet of pond water-reared shrimp had no effect on shrimp performance. In contrast to vitamins, there was no sparing effect of pond water on trace minerals or protein levels. As expected, growth rates of shrimp reared in pond water were greater than those in well water for each of the four diets. The largest difference in growth rate was seen with the 35%-protein diet minus vitamins. Shrimp fed this diet grew 306% faster in pond water than in well water. It appears that the growth enhancing effect of pond water is more pronounced when shrimp are fed diets of inferior quality. Results from this study indicate that pond water has a sparing effect on vitamins in shrimp diets, and microbes likely contributed significantly to this effect. By exploiting endogenously produced microbes and associated detritus, shrimp farmers and feed manufacturers can reduce substantially vitamin levels in shrimp feeds, resulting in reduced feed costs without compromising shrimp growth, survival, or FCR.

Keywords: Vitamins; Minerals; Protein; Shrimp; Diet; Pond water; Sparing effect

1. Introduction

Although qualitative requirements for vitamins and minerals have been elucidated for several commercially important penaeid shrimp species, quantitative requirements for these nutrients are not well defined (Conklin, 1997; Davis and Lawrence, 1997). Difficulties in quantifying water-soluble vitamin requirements for shrimp exist because of challenges associated with delivering these nutrients to aquatic organisms. Shrimp are slow eaters and feed pellets can remain submerged in water for several hours prior to ingestion. Once a pellet is located, it is grasped by the shrimp's pereiopods and transferred to the mouthparts (Hindley and Alexander, 1978). Small particles are placed directly in a pre-oral cavity, whereas larger items are held to the mouthparts by the third maxillipeds for

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further manipulation (Alexander et al., 1980). As a result of prolonged submersion and handling by the shrimp, water-soluble vitamins can leach out of the feed, thus making inferences about quantitative requirements difficult (Goldblatt et al., 1980; Gadient and Schai, 1994). Similarly, there are difficulties in quantifying mineral requirements because of the way shrimp eat and their ability to use minerals dissolved in seawater (Davis et al., 1990; Davis and Lawrence, 1997).

Despite a paucity of quantitative information about dietary vitamin and mineral requirements for penaeid shrimp, vitamin and mineral supplements typically are added to commercial shrimp feeds (Akiyama et al., 1992). These feeds often are over-fortified with vitamins to mitigate concerns about vitamin loss associated with feed processing and storage (especially ascorbic acid), as well as from leaching during feeding (Castille et al., 1996; Conklin, 1997). Similarly, shrimp feeds typically contain a significant amount of minerals from premixes and other feed ingredients, such as binders (Davis and Lawrence, 1997). There are disadvantages in using shrimp feeds containing excessive amounts of vitamins and minerals. Vitamin premixes can account for as much as 15% of total feed ingredient cost, so the inclusion of excessive vitamins can be costly (Akiyama et al., 1992). In addition, over-fortification of certain vitamins (e.g. riboflavin, niacin, and vitamin B_6) can result in reduced shrimp growth (Deshimaru and Kuroki, 1979; Catacutan and De la Cruz, 1989; Conklin, 1997), and this can negatively impact production and profitability for the farmer. With regard to over-fortification of minerals, this can also increase feed cost, enhance phosphorus pollution, and reduce the bioavailability of other minerals (Davis and Lawrence, 1997). Also, excessive inclusion of certain minerals (e.g. iron) can reduce shrimp growth (Deshimaru and Yone, 1978), and certain minerals may accumulate to toxic levels in minimal- or zero-water exchange systems (Alcivar-Warren and Meehan, 2001).

Penaeid shrimp cultured in extensive and semi-intensive production systems depend on natural pond biota as a direct nutritional source (Moss, 2002). Food items consumed by shrimp in these systems are similar to those in the wild and include plant and animal matter, as well as microbes and detritus. These food items contain vitamins and minerals that, if available in sufficient quantities, could preclude the need for nutrient supplements in exogenously supplied shrimp feeds (Phillips, 1984; Brown et al., 1999). In fact, the sparing effect of natural pond biota on vitamins and minerals has been documented for the tiger prawn, *Penaeus monodon*, reared under extensive culture conditions (Triño and Sarroza, 1995). Growth and survival were not significantly different between shrimp fed two different diets; one with vitamin and mineral supplements and one without supplements. It is important to note that this study was conducted in extensive ponds stocked at 7.5 shrimp/m^2, so there was abundant natural pond biota and insignificant grazing pressure by the shrimp. However, under intensive culture conditions, many meiofaunal and macrofaunal prey become rare or absent during the growout period (Hopkins et al., 1988; Visscher et al., 1988), and this could reduce or eliminate the potential sparing effect of natural pond biota on vitamins and minerals, as well as other nutrients.

The primary objective of this study was to determine whether natural pond biota had a sparing effect on vitamins and trace minerals in diets fed to juvenile Pacific white shrimp, *Litopenaeus vannamei*, reared under intensive culture conditions. A secondary objective was to determine whether natural pond biota had a sparing effect on protein levels. Although previous research has shown a protein-sparing effect of natural pond biota on postlarval shrimp (Otoshi et al., 2001), it is unclear whether this effect occurs in larger shrimp.

2. Materials and methods

2.1. Experimental design and protocols

The indoor laboratory used in this experiment was equipped with 52-L, glass aquaria (76 cm × 31 cm × 31 cm) that received flow-through seawater from one of two sources; clear well water pumped from a seawater aquifer or pond water pumped from a 337-m^2 round pond used for intensive shrimp culture. Well water was the source water for the round pond, so any differences in water quality between well and pond water resulted from inputs into and management strategies affecting the round pond. Previous studies indicate that water from the round pond can contain high concentrations of suspended organic matter, including microalgae and microbial–detrital aggregates, whereas well water typically has low concentrations of organic matter and is devoid of microalgae (Moss and Pruder, 1995; Otoshi et al., 2001; Divakaran and Moss, 2004). Water in the pond was mixed by a 1-HP paddlewheel that operated nightly, and pond water was transferred into the laboratory by a 1/4-HP submersible pump placed 0.5 m below the water surface at the outer perimeter of the pond. The round pond had a mean water depth of 1 m. (For more details about the round pond, see Wyban and Sweeney, 1989).

Twenty-four 52-L aquaria were stocked with 0.68-g (SD + 0.02 g) Pacific white shrimp, *L. vannamei*, at a density of 24 shrimp/aquaria (100 shrimp/m^2 equivalent). Shrimp were produced at the Oceanic Institute