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Aquafeeds

New ingredients for shrimp feeds, Part 1

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Yeast glucans provide protein, vitamins, viral resistance

New technology is making the addition of brewer's yeast to aquaculture feed both more practical and affordable.

New aquaculture feed ingredients and processes are figuring prominently in the production of more-nutritious and better-balanced "specialty feeds." Increasing demand for specialty feeds has also spurred the growth of specialty ingredients that enhance the quality of the feed.

The largest sales and fastest growth in this segment are expected to be among those ingredients that serve special purposes and/or provide advantages such as cost savings. Of these ingredients, fishmeal replacements will likely lead because they provide feed manufacturers both cost and functional advantages, and have wide applicability.

Brewer's yeast

Providing less-expensive sources of protein supplements for aquaculture has been a goal of numerous studies that examined plants, agricultural processing wastes, and brewery wastes. Brewer's and baker's yeast are high in protein and readily digestible, but were historically expensive. However, new bioreactor technology has lowered the cost of yeast to the point that it now may be cost-effective as a feed ingredient.

Yeast is often taken as a vitamin supplement because it is 50 percent protein and a rich source of the B vitamins niacin and folic acid. The cell wall of Saccharomyces yeast is made of a "yeast cellulose" with beta-1,3-glucan and beta- 1,6-glucan linkages, which is similar to the cellulose in the cell walls of most higher plants that contain only beta-1,3- glucan linkages.

About 30 to 35 percent of the cell wall is composed of glucan, while another 30 percent is mannan, a water-soluble polysaccharide of the sugar D-mannose. The remaining components are 1 to 2 percent chitin, 10 percent lipids and a small percentage of inorganic molecules. The fatty acid compositions of yeasts show a significant lack of the 20:5 omega-3 and 22:6 omega-3 polyunsaturated fatty acids required for the good nutrition of shrimp.

Nearly half the dried weight of brewer's yeast is protein. The yeast contains 18 amino acids, 10 of which – including valine, leucine, lysine, arginine and threonine – are essential. Yeast also contains phosphorous and potassium as the main minerals and it is the richest known natural source of the water-soluble B vitamin group.

Beta-glucans

In 1999, Dugger and Jory reviewed the applications of beta-1,3-glucan in shrimp aquaculture. In haemocytes and macrophages, they found, the glucan molecules activate the synthesis of a broad range of substances which act as natural antibiotics, antifungals, and antivirals.

The glucans stimulate the production of additional haemocytes, raise wound-healing capacity, and increase the coagulation of blood and hemolymph. They also increase antitumoral and stress agents, and the transport of important nutrients, vitamins, and pigments. The glucans effectively prime the nonspecific immune system to a higher level of readiness. When a pathogen challenge occurs, the immune system is already in high gear and ready to fight.

Prophenoloxidase system

Invertebrates are not known to have a system of acquired or specific immunity. Host defense is nonspecific and mainly mediated by circulating haemocytes. In arthropods, the prophenoloxidase system (proPO) is an enzymatic cascade system involved in the recognition of microbial molecules. It resides in intracellular vesicles of the haemocytes.

In research, extracted proPO from crayfish haemocytes was transformed to its active form phenoloxidase by a serine protease. This activation was affected by Ca+2 (a calcium ion) concentration.

Maximal spontaneous activation was observed at a Ca+2 concentration of 5 mM. Beta-1,3-glucan was also effective in activating the proenzyme. Lipopolysaccharides from Gram-negative bacteria activated the system after a lag of 25 to 30 minutes.

Other research with the proPO system has indicated its involvement in penaeid shrimp resistance to vibriosis, the stimulation of cell adhesion factor, and the effectiveness of glucans and calcium in promoting the proPO activation. As seen in other aspects of immunostimulation by glucans, the heightened activity of proPO appears to last about two weeks.

Incorporation

Feed incorporation is the most cost-effective application method for beta-glucans, which can be incorporated into any feed formulation. Beta-1,3-glucan in commercial premixes typically performs better than nonpremix additions.

Bioencapsulation involves the feeding of insoluble beta-1,3-glucan in the form of a purified powder to live food organisms like brine shrimp. The feeder animals ingest the glucan powder and are then fed to the cultured organism, which might not otherwise accept nonanimated feeds.

Dose

Optimum glucan doses are in the range of 0.5 ppt, regardless of the mode of delivery. Again, the most cost-effective manner to administer this immunostimulant is by incorporation at about 0.5 grams per kilograms feed.

Exposures to glucans at much higher concentrations did not result in significant increases in nonspecific immune response, nor did they exhibit any toxicity. Single exposures to beta-1,3-glucan have produced short periods of heightened immune responses, as measured by secretory products such as prophenol oxidase.

Enhancing resistance

In 2000, Chang et al. reported that beta-glucans have successfully been used to enhance the resistance of crustaceans against bacterial or viral infections. Using beta-1,3- 1,6-glucans extracted from yeast cell walls, Sung et al. (1994) and Song et al. (1997) demonstrated enhanced resistance of *Penaeus monodon* to vibriosis and White Spot Syndrome Virus (WSSV) infection.

In another study, adult spawning *P. monodon* females were injected with baker's yeast glucans and the released young were challenged with a virus associated with WSSV. The results showed a significant increase in survival for larvae derived from groups of glucan-injected spawners compared to controls. This was the first documented demonstration of a maternal transmission of immunity in invertebrates.

Note: This article summarizes a presentation by the authors at the World Aquaculture 2003 conference in Salvador, Brazil. Cited references are available from the authors.

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