

sediment accumulation rates around 35.5 cm/year and markedly higher carbon burial than low-loading ponds, suggesting that persistent overfeeding accelerates pond infilling and long-term organic enrichment of sediments (Kunlapapuk et al., 2019).

6.3 Effects on disease risk and immune status

Feeding strategies interact with health management by shaping both environmental stressors and the nutritional support for immunity. Excess feed inputs elevate ammonia and nitrite, which can compromise shrimp condition and increase susceptibility to disease; high TAN associated with an 81.2% increase in feed load was linked with 40% mortality in a recirculating system, demonstrating how feed mismanagement can directly trigger health crises (Mohammed et al., 2024). Broader analyses of shrimp aquaculture wastewater identify excess feeding as a major source of organic and nutrient pollution, and recommend careful feed control as part of preventive health and environmental management to avoid eutrophication and related disease risks (Iber and Kasan, 2021).

Conversely, diet composition and functional feed additives within a given feeding strategy can enhance immune status and disease resistance. Probiotic-supplemented diets, such as those containing *Lactobacillus plantarum* Ep-M17 or *Pediococcus acidilactici*, improved growth, lowered feed conversion ratio, and significantly reduced mortality after *Vibrio parahaemolyticus* or *Fusarium solani* challenges, reflecting strengthened immune and antioxidant responses under routine feeding schedules. Similarly, herbal or functional additives such as artemisinin and lysozyme-based supplements enhanced antioxidant capacity, immune enzyme activities, and resistance to *Vibrio* infections, indicating that appropriately formulated and scheduled feeding can be a key tool in integrated health management strategies (Figure 3).

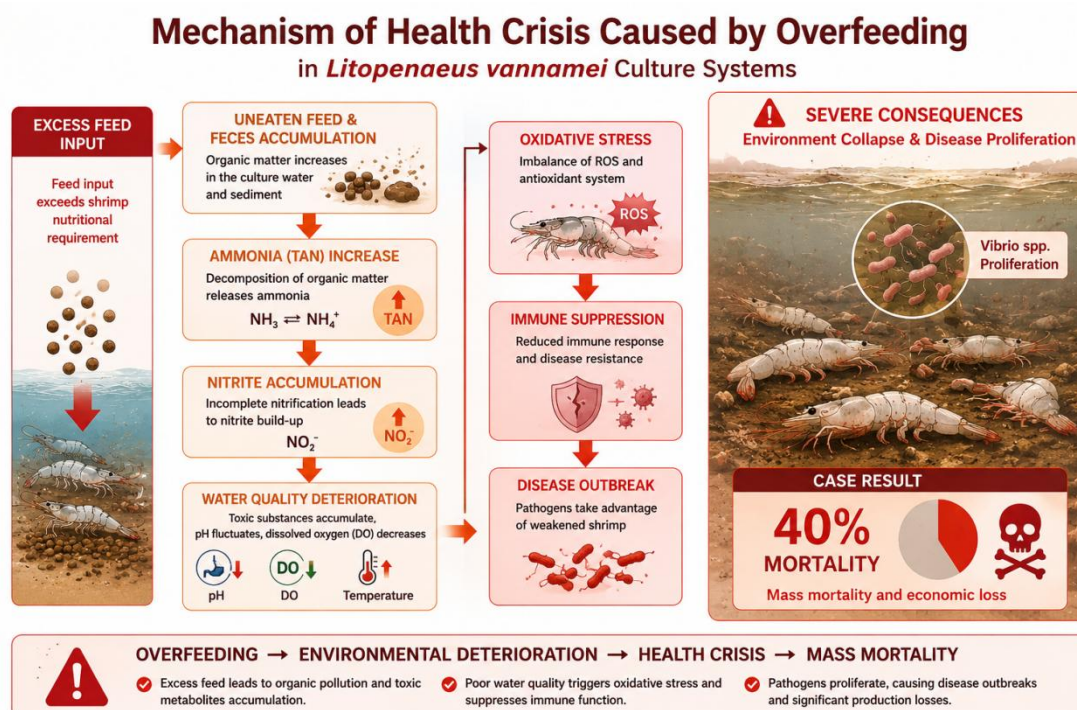


Figure 3 Mechanistic pathway linking excessive feeding to environmental deterioration and disease risk in Pacific white shrimp (*Litopenaeus vannamei*)

7 Effects of Different Feeding Strategies on Economic Benefits of Shrimp Farming

7.1 Analysis of feed costs and production costs

Feed is consistently identified as the largest component of variable production costs in Pacific white shrimp culture, so feeding strategy directly shapes overall cost structure. In Indian farms, feed accounted for about 69% of total variable costs, greatly exceeding other inputs such as seed, energy, and labor, which together represented less than one-third of variable expenditure. Similar analyses comparing *L. vannamei* and *P. monodon* across intensification