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Perspective

Hemocyte Profiling for Health Assessment in Crustacean Aquaculture

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DESCRIPTION

Crustacean hemocytes are circulating cells that participate in many physiological and defensive processes in shrimp, crabs, lobsters, and other cultured crustaceans. Their abundance, morphology, biochemical properties, and functional activity can change in response to environmental conditions, nutrition, pathogens, handling, and physiological development. For this reason, hemocyte profiling has become an important approach for evaluating the condition of cultured crustaceans. Unlike vertebrates, crustaceans do not possess an adaptive immune system based on circulating antibodies and specialized lymphocytes in the same manner. Their protection from infectious agents depends largely on innate cellular and humoral responses, with hemocytes performing several major functions within these responses.

Hemocytes circulate through the haemolymph and can also migrate toward tissues where cellular defence is required. In penaeid shrimp, commonly recognized hemocyte categories include hyaline cells, semi-granular cells, and granular cells. The proportions and characteristics of these cell types can vary among species and may also be influenced by developmental stage, environmental conditions, sampling procedures, and disease status. Hyaline cells generally contain fewer visible cytoplasmic granules and are associated with processes such as phagocytosis and cellular repair. Semi-granular and granular cells contain different quantities of cytoplasmic granules that store molecules involved in immune reactions, coagulation, and antimicrobial activity.

Total hemocyte count is one of the simplest measurements used in crustacean health assessment. It provides an estimate of the number of circulating hemocytes within a defined volume of hemolymph. Changes in this measurement may occur during infection, exposure to poor water quality, nutritional deficiency, temperature variation, salinity changes, or physical stress. A decrease in circulating cells may result from migration toward infected tissues, cellular destruction, or changes in hemocyte production. An increase can occur when the animal responds to particular stimuli or when cells are released from tissues into circulation. Therefore, total hemocyte count is most informative when interpreted together with other physiological and environmental measurements.

Differential hemocyte count provides additional information by estimating the proportion of different cell categories. Microscopic examination can identify differences in cell size, nuclear characteristics, granulation, cytoplasmic appearance, and cell shape. However, classification can be difficult because hemocyte categories may show transitional characteristics. Cells can also change their appearance after collection or during activation. Standardized staining and observation procedures can improve consistency between samples.

Flow cytometry offers another approach for hemocyte profiling. This technique can measure cellular characteristics based on light scattering and fluorescent signals. Researchers can use selected fluorescent probes to examine cell viability, membrane integrity, reactive oxygen species production, intracellular components, and other cellular properties. Flow cytometry can evaluate thousands of cells rapidly, making it useful when large experimental groups are involved. Proper controls are required because fluorescent signals may vary with probe concentration, incubation conditions, cell density, and instrument settings.

Hemocyte function can also be assessed through phagocytic activity. Phagocytosis is a process in which hemocytes recognize, engulf, and process foreign particles or microbial cells. Laboratory assays may use fluorescent beads or selected microorganisms to estimate the proportion of hemocytes capable of engulfing particles. A high phagocytic response does not always indicate better health because cellular activation can occur during severe stress as well as during normal defence. Interpretation therefore requires information about survival, growth, feeding, water quality, and other biological measurements.

Phenol oxidase-related activity is another frequently examined component of crustacean immunity. The prophenoloxidase system participates in reactions associated with melanisation and defence against invading organisms. Hemocyte activation can initiate enzymatic processes that ultimately produce melanin

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around damaged or infected areas. Measurement of phenoloxidase activity can provide information about changes in immune responsiveness.

Hemocytes are also involved in coagulation. When a crustacean experiences tissue damage, cellular and plasma components contribute to the formation of a clot that limits hemolymph loss and can help restrict microbial entry. Changes in hemocyte condition may therefore affect both defense and wound response.

CONCLUSION

Fish muscle lipid remodeling is consequently a dynamic process controlled by interactions among nutrition, metabolism, environment, growth, and physiological demand. The muscle continuously adjusts its lipid stores and membrane composition in response to changing conditions. Studying these responses can improve knowledge of fish metabolism while supporting better feed formulation and product quality management. A detailed understanding of lipid deposition and fatty acid transformation Examination of cell morphology, aggregation behavior, and viability can provide additional information about the physiological status of cultured animals.