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EDITED BY
Ankures Bhattacharya
West Bengal University of Animal and Fishery Sciences

REVIEWED BY
Dr. Surya Kanta Sau
West Bengal University of Animal and Fishery Sciences

Dr. Asik Ikbal
Government of West Bengal

*CORRESPONDENCE
Inain Jaies
inainjaies@gmail.com

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Cold water Aquaculture and its Nutritional Benefits

Inain Jaies[1*] and Feroz A. Shah[1]

[1]Division of Aquatic Animal Health Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST) of Kashmir, Rangil-190006, Ganderbal.

Cold water aquaculture, the practice of cultivating aquatic organisms in environments characterized by lower water temperatures, has gained prominence as a viable solution to meet the increasing global demand. This article explores the nutritional benefits associated with cold water aquaculture products, focusing on the unique qualities of species such as salmon and trout, which thrive in these conditions. The nutritional attributes of cold water aquaculture products extend beyond taste and texture, encompassing essential nutrients such as omega-3 fatty acids, high-quality protein, and micronutrients. These products contribute significantly to human health, particularly in terms of cardiovascular well-being, brain development, and immune function. The environmentally conscious practices often employed in cold water aquaculture further enhance its appeal as a sustainable source of nutrient-rich food.

Keywords
Cold water, Omega-3, protein, Aquaculture, Health.

Introduction

Aquaculture, the aquatic counterpart to agriculture, has expanded quickly in recent years. It is an economic activity that uses and transforms natural aquatic resources into commodities valued by society. By doing this, aquaculture may have an impact on biodiversity, primarily because it consumes resources, transforms them, and produces waste (Diana, 2009). Among other parameters, temperature is one of the important factors that govern the life of aquatic organisms (Singh *et al*., 2013). Cold water aquaculture represents a pivotal facet of modern aquaculture practices, focusing on the cultivation of aquatic organisms in environments characterized by lower water temperatures. The success of cold water aquaculture is underpinned by a combination of advanced technologies, responsible management strategies, and careful consideration of environmental impacts. One of the defining features of cold water aquaculture is the unique environmental conditions in which it operates. The water temperatures in these locations often range from 0 to 20°C and those species are not able to tolerate temperature above 25°C (Boyd, 2018), presenting distinct challenges and opportunities for aquaculture production. Unlike warm water aquaculture, where species benefit from higher temperatures, cold water aquaculture necessitates a more nuanced understanding of the biological and ecological dynamics at play.

Aquaculture in cold waters

Central to the success of cold water aquaculture is the selection of species that are naturally suited for such environments. Salmonids, including salmon and trout, have been at the forefront of cold water aquaculture (Yu *et al.*, 2022) due to their evolutionary adaptations that enable them to thrive in colder waters. These species exhibit growth and reproductive patterns well-suited to the lower temperatures. Technological innovation is a cornerstone of successful cold water aquaculture operations. Given the temperature sensitivity of cold water species, maintaining optimal conditions becomes a complex task. To address this challenge, the industry has embraced advanced systems like recirculating aquaculture systems (RAS) and flow-through systems. RAS are particularly noteworthy as they allow for precise control over water quality and temperature (Lindholm-Lehto, 2023). Moreover, these systems minimize water consumption and waste, contributing to the sustainability of cold water aquaculture operations.

Nonetheless, cold water aquaculture is not without its challenges. The species cultivated in cold water environment demand meticulous precise temperature management (Mugwanya *et al*., 2022). Fluctuations can induce stress in the organisms and hinder their growth, necessitating rigorous monitoring and control measures. Furthermore, the energy intensity of maintaining suitable temperatures in colder environments is a concern, as it can impact the overall environmental footprint and sustainability of the operation. Additionally, the slower metabolic rates and growth rates associated with lower temperatures extend production cycles and time-to-market, posing economic challenges to aquaculture enterprises. Despite these challenges, cold water aquaculture offers a range of sustainability benefits. The cooler water temperatures reduce the prevalence of certain diseases and parasites, decreasing the need for antibiotics and other chemical treatments that can have adverse environmental and human health effects. Moreover, the inherently robust nature of cold water environments often leads to reduced ecological impacts, safeguarding local ecosystems from potential harm. In regions where other forms of agriculture might be limited, cold water aquaculture can contribute to local economies and food security.

Looking to the future, ongoing research and innovation continue to drive the development of cold water aquaculture. Selective breeding programs aim to produce strains of fish that exhibit enhanced cold tolerance and faster growth rates, ultimately improving the efficiency and productivity of aquaculture operations. Advances in renewable energy sources and energy-efficient technologies hold promise for mitigating the energy-intensive nature of cold water aquaculture. By embracing these approaches, the industry can work towards more sustainable and economically viable solutions.

Health benefits of Cold water Fish

Cold water fishesare known for their exceptional nutritional content and numerous health benefits. These fishes thrive in colder environments and are rich sources of essential nutrients, particularly omega-3 fatty acids, which confer a range of advantages for human health. Cold water fishes such as salmon, mackerel, herring, trout, and sardines are prized for their high levels of omega-3 fatty acids, notably eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Gammone *et al*., 2019). These polyunsaturated fats play a pivotal role in reducing inflammation, enhancing cardiovascular health by lowering triglycerides and supporting heart rhythm stability, and promoting brain health and cognitive function. The omega-3 fatty acids in cold water fishes have shown to lower blood pressure, reduce the risk of irregular heartbeats, and lessen the likelihood of plaque development in arteries, reducing the risk of heart disease.EPA and DHA are crucial components of brain cell membranes and play a significant role in brain development and function. DHA, a specific omega-3 fatty acid found in cold water fishes, is a major component of the retina (Querques *et al*., 2011). Regular consumption of these fishes has been linked to a lower risk of age-related macular degeneration and better overall eye health. In addition to this, cold water fish are an exceptional source of high-quality protein, offering essential amino acids crucial for building and repairing tissues, supporting muscle growth, and maintaining optimal body functions (Church *et al*., 2020). The protein content in fish is easily digestible (Erbay and Yesilsu, 2021). and well-absorbed by the body. Unlike some land-based protein sources, fish provide protein without the added saturated fats commonly found in red meats. This nutrient-rich protein source not only aids in maintaining muscle mass and promoting overall body health but also contributes to improved weight management and reduced risk of chronic diseases.

Regular consumption of cold water fish, which are rich in beneficial fats, can lead to an array of benefits, including improved brain development, reduced risk of chronic diseases such as heart disease and certain neurological conditions, and overall better immune system regulation.Consuming cold water fishes rich in these fatty acids has been associated with improved cognitive performance, memory retention, and a potentially reduced risk of neurodegenerative disorders.The healthy fats in cold water fishes can positively impact blood lipid profiles by increasing high-density lipoprotein (HDL) cholesterol levels and lowering triglycerides, contributing to a healthier cardiovascular profile.Some studies suggest that the consumption of omega-3-rich fishes may be linked to a reduced risk of depression and mood disorders, as these fatty acids are involved in brain chemistry and neurotransmitter function.The omega-3 fatty acids in cold water fishes have shown some promise in reducing the risk of certain types of cancer, such as breast cancer, due to their anti-inflammatory and cell-regulating properties.

Incorporating cold water fishes into a balanced diet can yield a range of health benefits, making them an important component of a nutritionally sound eating pattern. However, it's important to consider

sustainability and potential contaminants when selecting fish sources. Opting for sustainably sourced fish and considering any advisory related to any pollutant is crucial for reaping the full benefits of these nutritional powerhouses.

Conclusion

As we move forward, continued research and innovation in the field of cold water aquaculture hold the potential to further enhance the nutritional profiles of these products. By refining breeding techniques, optimizing feed formulations, and exploring alternative protein sources, the industry can continue to improve the nutritional benefits of cold water aquaculture products while simultaneously reducing their environmental footprint. In sum, the nutritional benefits of cold water aquaculture are undeniable. From heart-healthy omega-3s to essential proteins and micronutrients, these products offer a comprehensive array of nutrients crucial for human health. As societies strive to address both dietary and sustainability challenges, cold water aquaculture emerges as a model of responsible food production, promising not only a bountiful harvest from the water but also a healthier, more sustainable future for all.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Conflict of interest

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