MEDWIN PUBLISHERS
Committed to Create Value for Researchers

Journal of Ecology and Natural Resources
ISSN: 2578-4994

Aquaculture: A Boon to Today's World-A Review

Seema Joshi[1]* and Dharmesh Trivedi[2]

[1]Assitant Professor, Faculty of Basic and Applied Sciences, Madhav University, India

[2]Professor and Head, Dept. of Pharmacy, Madhav University, India

Corresponding author: Seema Joshi Assistant Professor, Faculty of Basic and Applied Sciences, Madhav University, Pindwara, Rajasthan, India, Email: drseemajoshi11@gmail.com

Review Article

Volume 7 Issue 2

Received Date: April 17, 2023

Published Date: May 11, 2023

DOI: 10.23880/jenr-16000335

Abstract

Aquaculture is the farming of aquatic organisms that has gained a significant share in the global food industry. The growth of aquaculture has led to economic development, job creation, and improved food security in many countries. Aquaculture production now rivals wild fish capture, and it is expected to continue growing in the future. Despite its potential benefits, aquaculture is still facing various challenges such as disease outbreaks, environmental degradation, and access to resources. This review article provides insights into the current state of aquaculture, its importance, and challenges in ensuring sustainable production. Aquaculture is a significant contributor to the world's supply of protein-rich food. However, the demand for fishmeal and fish oil as feed ingredients for farmed fish has a significant impact on wild fish stocks, particularly forage fish. This review article examines alternative feed ingredients that could replace forage fish as a major source of protein and oil for aquaculture feed, with a focus on their nutritional value, sustainability, and economic feasibility.

Keywords: Aquaculture; Fishmeal; Forage

Introduction

Aquaculture is an important source of food production; it accounts for over half of the fish consumed globally [1]. Advances in technology and management practices have made it possible to produce a diverse range of aquatic species such as fish, mollusks, and crustaceans in different aquatic systems. Aquaculture has become increasingly popular due to its numerous benefits, including economic growth, employment opportunities, and improved food security [2].

Importance of Aquaculture

Aquaculture has become an important source of food and income for coastal communities worldwide [3]. In many developing countries, aquaculture has played a critical role in poverty alleviation, providing employment and generating income for smallholder farmers [4]. Aquaculture also helps to address the increasing demand for seafood, providing a sustainable source of high-quality protein that helps to improve food security [5]. Furthermore, it can minimize pressure on wild fish populations, protect biodiversity, and improve natural resource management [6].

Challenges to Sustainable Aquaculture:

Despite the benefits, aquaculture still faces some significant challenges that must be addressed to ensure sustainable production. One of the significant challenges is disease outbreaks, which can cause significant economic losses for farmers and affect food security. Disease outbreaks result from overcrowding, poor water quality, and the

introduction of diseased animals. Various innovations, including the use of vaccines, biosecurity measures, and improved management practices, have been developed to prevent or limit disease outbreaks [7].

Environmental degradation is another major challenge in aquaculture [8]. Intensive systems may result in the release of nutrients and antibiotics into local water bodies, leading to water pollution and decreased dissolved oxygen levels. This may damage nearby ecosystems, including wetlands, mangroves, and coral reefs. The industry must develop strategies to minimize the environmental impact of aquaculture, including the use of more sustainable feeds, improved waste management practices, and environmentally friendly systems [9].

Access to resources such as land, water, and feed is another major challenge to sustainable aquaculture. The cost of inputs such as feed, land, and water remains high, and the increasing demand for aquafeeds has also driven up their cost. Innovations in feed manufacturing, including the use of alternative ingredients, and the development of improved aquaculture systems can help reduce the costs of production [10].

Aquaculture is seen as a significant means of supplementing declining wild fish stocks and providing food security to the increasing world population. Aquaculture is also a significant source of employment and income for many coastal communities around the world. Its potential for fulfilling the need for food security and economic development is enormous. However, the success of aquaculture is limited by several challenges, like disease outbreaks, environmental degradation, and access to resources [11].

Environmental Degradation

The environmental degradation caused by aquaculture, mainly in intensive systems, is a major concern in the industry. Aquaculture activities may lead to eutrophication, which is caused by excessive nutrient loading into the surrounding environment, resulting in the production of harmful algal blooms and decreased dissolved oxygen levels. Excessive use of antibiotics also contributes significantly to water pollution and antibiotic resistance [12].

Increased Disease Prevalence

Another significant challenge for aquaculture is the increased prevalence of diseases due to overcrowding, inadequate water quality, and the introduction of non-native species. Disease outbreaks lead to economic losses for farmers across the world, contributing to significant impacts on food security. Aquaculture systems must be designed to limit the transmission of diseases. This involves enhancing stock management practices and monitoring the quality of water in culture systems [13].

Access to Limited Resources

Finally, access to limited resources like water, feed, and land has become another challenge in the aquaculture industry. Feed accounts for over 50% of aquaculture production costs, making up a significant share of operational expenses. Innovations are necessary to reduce the use of non-renewable resources, allowing farmers to meet the rising demand for food while minimizing their impact on the environment [14].

Benefits and Limitations

Aquaculture has emerged as a crucial source of food production in recent years, with its global market value exceeding $250 billion. The sector has provided a range of economic, social, and environmental benefits, including improved nutrition, job creation, and ecosystem conservation. However, the growth and expansion of the aquaculture industry also raise concerns regarding the sustainability and the impact on natural resources [15].

Benefits of Aquaculture

Aquaculture presents a sustainable solution for increasing the global supply of fish while reducing the pressure on wild fish populations. The sector helps to maintain biodiversity by reducing overharvesting of wild fish populations and providing opportunities for conservation efforts. Additionally, aquaculture has become a critical source of income for coastal communities worldwide, creating job opportunities and supporting the livelihoods of small-scale farmers and fishermen. The practice also provides healthier and safer food alternatives, as farmed fish are often free from harmful toxins and impurities compared to wild-caught ones [16].

Limitations of Aquaculture

Aquaculture also presents significant limitations, including the spread of infectious diseases, environmental degradation, and access to resources. Disease outbreaks may occur due to overcrowding and the lack of effective biosecurity measures, adversely affecting fish health and economic losses for farmers. Unplanned expansion of farms may result in habitat degradation, ecosystem fragmentation, and pollution, diminishing the viability of natural resources. Additionally, the production of feed and the use of pesticides

in aquaculture farming may increase nutrient loading, contaminating soil, water, and air resources [17].

Pharmaceutical Applications

Aquaculture is the farming of freshwater and marine organisms, including fish, crustaceans, and shellfish, in controlled laboratory or outdoor environments. Although the industry has numerous benefits, achieving profitable and sustainable production can be challenging. Fish diseases and infections are a significant challenge and can cause significant economic and environmental losses. The use of pharmaceuticals in aquaculture has been essential in managing and preventing diseases [18].

Applications of Pharmaceuticals in Aquaculture

Pharmaceutical interventions in aquaculture include a wide range of medical treatments administered through feed, injection, or immersion. Antibiotics, antifungal agents, antiparasitic agents, and vaccines are commonly used to prevent, treat, and control disease outbreaks common in aquaculture. In addition, probiotics and nutrient supplements are used to enhance the immune system of fish, promote growth and overall health. The use of these interventions depends on the pathogens' susceptibility, the severity of the disease, and the welfare of the fish [19].

Benefits of Pharmaceutical Applications in Aquaculture

The application of pharmaceuticals in aquaculture is essential in maintaining the health and productivity of fish populations. Many diseases can cause severe economic and environmental losses, including high mortality, reduced growth rates, and poor aquaculture management practices. The use of antibiotics and vaccines can prevent and control bacterial infections and limit the transmission of diseases between fish populations. The use of probiotics and nutrient supplements also improves the gut microflora of fish and increases nutrient absorption, resulting in better growth and overall health [20].

Limitations of Pharmaceutical Applications in Aquaculture

Despite their benefits, the use of pharmaceuticals in aquaculture has limitations. The misuse of antibiotics can result in the development of antibiotic-resistant bacteria, leading to the transfer of antibiotic resistance genes to humans through contaminated food and water. Overuse and indiscriminate use of antibiotics can also cause environmental contamination and contribute to the overall rise in antibiotic resistance. Antibiotic residues in fish products can also pose a threat to human health [21].

Economic Considerations

Aquaculture is a rapidly growing sector that plays a critical role in meeting the increasing global demand for fish and seafood. It is a source of protein and income for millions of people worldwide, providing significant economic benefits to both developed and developing economies. As with any industry, the economic considerations of aquaculture are complex and multifaceted. Understanding these economic factors is essential to achieve sustainable and profitable production [22].

Production Costs

Production costs in aquaculture can vary depending on factors such as production type, location, species, and technology used. Capital investments in infrastructure, equipment, and workforce can be significant, making cost management crucial. Feed costs are the most significant expenses in aquaculture, accounting for up to 80% of production costs. Other expenses include labor, energy, water, and veterinary services. Reducing production costs through efficient management practices, technology adoption, and resource optimization can significantly improve the industry's economic sustainability [23].

Market Demand

Market demand is a crucial economic factor in aquaculture. Consumers worldwide are increasingly preferring fish and seafood as a source of protein due to their health benefits. The industry's growth is expected to continue, driven by the increasing global demand for seafood. Market demand also affects the pricing strategy of aquaculture products. Aquaculture producers must balance their production costs with market prices while considering the availability of substitutes, regulatory requirements, and customer preferences [24].

Pricing Strategies

Product pricing is an essential consideration in aquaculture. Underpricing can result in financial losses, while overpricing can lead to lower market demand and reduced revenue. Pricing strategies can vary, depending on the production type, customer segment, and location. In some cases, certification schemes, such as the Aquaculture Stewardship Council (ASC) or the Global Aquaculture Alliance's Best Aquaculture Practices (BAP), can increase the value of aquaculture products by assuring consumers of environmental and social sustainability [25].

Aquaculture and traditional agricultural practices are the two primary methods of food production worldwide. While traditional agriculture focuses on cultivating crops and raising animals on land, aquaculture entails the cultivation of aquatic organisms such as fish, shellfish, and seaweed. The choice between these two methods of food production depends on several factors such as availability, accessibility, production costs, environmental impacts, and cultural preferences. This review article aims to provide an overview of the differences between aquaculture and traditional agricultural practices, including their respective advantages and disadvantages [26].

Aquaculture offers several advantages over traditional agricultural practices. First, it has a smaller environmental footprint, requiring less land and water compared to traditional farming practices. Aquaculture can also be carried out in environments that are not suitable for traditional agriculture, such as coastal or marine areas. Additionally, aquaculture products have a high nutritional value and are a rich source of essential fatty acids, proteins, and other micronutrients [27].

Challenges of Aquaculture

Despite its advantages, aquaculture poses several challenges that need to be addressed. One significant challenge is the potential for environmental pollution from fish waste and the use of chemicals and antibiotics. This can lead to the degradation of water quality, proliferation of fish diseases, and negative impacts on the surrounding ecosystems. There is also the risk of escapes of farmed fish, which can harm wild populations and disrupt local food webs. Managing these risks requires proper regulatory frameworks and sustainable management practices.

Advantages of Traditional Agricultural Practices

Traditional agricultural practices have been the primary source of food production for thousands of years and have several advantages. They provide a wide variety of crops and animal products, including grains, fruits, vegetables, and meat. Traditional agriculture also supports rural livelihoods, contributing to income generation and poverty reduction in many communities worldwide. Additionally, traditional agriculture promotes biodiversity, preserves cultural landscapes, and is an essential part of many cultural practices.

Challenges of Traditional Agricultural Practices

A significant challenge of traditional agriculture is its impact on the environment. Land-use changes, deforestation, and intensive farming practices can lead to soil degradation, water depletion, loss of biodiversity, and increased greenhouse gas emissions. Traditional agriculture also faces challenges related to food safety and security, as changing weather patterns and natural disasters can lead to crop failures and food shortages.

Potential for Sustainable Food Production

Both aquaculture and traditional agricultural practices have the potential for sustainable food production. Sustainable aquaculture practices can help reduce pressure on wild fish populations, preserve marine ecosystems, and contribute to food security. Similarly, sustainable traditional agricultural practices that promote soil health, biodiversity, and water conservation can mitigate environmental impacts and support food security. Achieving sustainable food production requires a holistic approach that considers social, economic, and environmental factors while harnessing the benefits of both aquaculture and traditional agricultural practices.

Utilization of Marine Resources

Aquaculture is increasingly recognized as an essential means of meeting the growing demand for seafood products, given the depletion of wild fish stocks and the need for sustainable food systems. The efficient use of marine resources is critical to the success of the aquaculture industry, requiring consideration of factors such as site selection, feed sources, and disease management. This review article examines the role of marine resource utilization in aquaculture, including the benefits and challenges of this approach.

The Importance of Sustainable Aquaculture

Sustainable aquaculture is essential to meeting global food security challenges by increasing seafood production and reducing pressure on wild fish populations. Marine resource utilization is central to this objective, focusing on the responsible use of aquatic resources to support ecosystem health and minimize environmental impacts. Sustainable aquaculture also has economic benefits, creating employment opportunities and contributing to trade opportunities for aquaculture products.

Environmental Impacts of Aquaculture

Despite the benefits of sustainable aquaculture, there are concerns surrounding the environmental impacts of the industry. The use of fishmeal and fish oil in aquaculture feed is one of the most significant environmental concerns, leading to overfishing, deforestation, and unsustainable aquaculture practices. Other environmental impacts include disease transmission, nutrient pollution, and habitat destruction.

Addressing these impacts requires innovative approaches, such as alternative feed sources, improved site selection and design, and disease-resistant fish strains.

Innovative Approaches to Marine Resource Utilization

Advances in aquaculture technology and management practices offer promising opportunities to address sustainability challenges associated with marine resource utilization. For example, integrated multitrophic aquaculture (IMTA) aims to maximize the productive use of aquatic resources by integrating different species at different trophic levels in the same system. Recirculating aquaculture systems (RAS) also offer potential benefits, including reduced water use, improved water quality, and disease control. Advances in genomics and selective breeding may also lead to the development of more disease-resistant fish strains and improve the efficiency of feed conversion.

Aquaculture is a vital component of the global food system, producing approximately half of the fish and shellfish consumed worldwide. The industry's sustainability relies on maximizing feed efficiency and livestock production while minimizing environmental impacts. Feed costs typically account for the largest proportion of production costs, making feed efficiency and livestock productivity essential for the long-term profitability and environmental sustainability of the industry.

Feed Efficiency and Livestock Production

Feed efficiency in aquaculture refers to the ability of fish to convert feed into body mass. Improving feed efficiency is essential to reducing feed costs, production costs, and environmental impacts. Livestock production in aquaculture is also critical, with a focus on maximizing growth, improving fish health, and reducing mortality rates. Achieving high levels of feed efficiency and livestock production requires meticulous attention to factors such as feed formulation, diet composition, feeding frequency, and water quality management [28].

Innovative Approaches to Improving Feed Efficiency

Advances in aquaculture technology and management practices offer promising opportunities to improve feed efficiency and reduce production costs. The inclusion of alternative feed sources, such as plant-based or microbial-based proteins, can significantly reduce feed costs and improve feed efficiency. The use of probiotics and prebiotics can also contribute to improved feed efficiency and livestock production by promoting gut health, improving digestion, and reducing disease susceptibility. Genetic improvement and selective breeding may also lead to the development of more efficient, fast-growing, and disease-resistant fish strains [29].

Environmental Sustainability and Feed Efficiency

Feed efficiency is critical to reducing the environmental impacts of the aquaculture industry. Increasing feed efficiency reduces the amount of feed and nutrients required for fish growth, minimizing the waste and pollution resulting from uneaten feed and fish excreta. Improving feed efficiency also reduces the amount of fishmeal and fish oil required in aquaculture feed, which has implications for overfishing and environmental degradation [30].

Alternates of Forage Fish

In aquaculture production, fishmeal and fish oil are essential feed ingredients for farmed fish. However, the high demand for these ingredients has led to overfishing and depletion of wild fish stocks, particularly forage fish. To maintain a sustainable industry, alternative feed ingredients must be identified as viable alternatives to forage fish [31].

Alternative Feed Ingredients

Several alternative feed ingredients could replace forage fish as a source of protein and oil in aquaculture feed. These include soybean meal, poultry by-product meal, and insect meal, among others. Soybean meal is a popular alternative in aquaculture due to its high protein content and wide availability. Poultry by-products also provide valuable nutrients for aquaculture, including protein, fat, and minerals. Insect meal is a relatively new alternative but is gaining popularity due to its sustainable production and good nutritional profile, including high protein and fat content [32].

Nutritional Value

Alternative feed ingredients must meet the nutritional requirements of farmed fish for growth and health. Several studies have shown that certain alternative feed ingredients, such as soybean meal and poultry by-product meal, can provide sufficient protein and energy for the growth of farmed fish. Insect meal has also been found to be a promising alternative, with high protein and fat content, as well as the presence of valuable micronutrients [33].

Sustainability

The sustainability of alternative feed ingredients must be assessed in terms of their environmental impact, resource use, and economic feasibility. Several studies have highlighted the potential for alternative feed ingredients to reduce the pressure on wild fish stocks and the impact of aquaculture on the environment. In addition, the sustainable sourcing of alternative feed ingredients, such as using waste streams or locally grown crops, can reduce the industry's carbon footprint and contribute to the circular economy [34].

Economic Feasibility

The economic feasibility of alternative feed ingredients depends on their availability, cost, and market demand. Several studies have shown that alternative feed ingredients, such as soybean meal and insect meal, can be cost-competitive with fishmeal and fish oil, particularly when considering the environmental benefits and potential for local sourcing.

Conclusion

Aquaculture has become an important source of food production that has helped address the challenges of food security, economic development, and job creation. Despite its potential benefits, the industry faces significant challenges such as disease outbreaks, environmental degradation, and access to resources. Innovative approaches such as improved management practices, using alternative feeds, and eco-friendly systems can help address these challenges, allowing for the development of sustainable aquaculture.

References

1. Doris S, Jiansan J (2009) Global aquaculture and its role in sustainable development. Reviews in aquaculture 1(1): 2-9.

2. Simon FS, John M (2003) The role of aquaculture in rural development. Economics 47-58.

3. Alex W (1995) Prawns, profit and protein: aquaculture and food production. The Ecologist 25(2-3): 120.

4. Mylene HL, Ahmed M (2002) Improving developing country food security through aquaculture development-lessons from Asia. Food Policy 27(2): 125-141.

5. Béné C, Barange M, Subasinghe R, Merino G, Williams M, et al. (2015) Feeding 9 billion by 2050-Putting fish back on the menu. Food Security 7: 261-274.

6. Allison EH (2011) Aquaculture fisheries poverty and food security.

7. Michael CR, Knapp G (2016) The Political Economics of Marine Aquaculture in the United States. Reviews in Fisheries Science & Aquaculture 24(3): 213-229.

8. Stefanie MH (2014) Fish Nutrition and Current Issues in Aquaculture: The Balance in Providing Safe and Nutritious Seafood, in an Environmentally Sustainable Manner. J Aquac Res Development 5 (3): 1-10.

9. Choremi C, Markos K, Kosmas V, Cosmas N (2020) Environmental issues of Aquaculture development. Egyptian Journal of Aquatic Biology and Fisheries 24(2): 441-450.

10. Roel HB, Marc CJV (2011) Sustainable aquaculture in ponds: Principles, practices and limits. Livestock Science 139(1-2): 58-68.

11. Edwards P (2015) Aquaculture Environment Interactions Past Present and Likely Future Trends. Aquaculture 447(1): 2-14.

12. Sindermann CJ (1984) Disease in marine aquaculture. Disease in Marine Aquaculture 37: 505-530.

13. Godfray HC, Beddington JR, Crute IR, Haddad L, Lawrence D, et al. (2010) Food Security: The Challenge of Feeding 9 Billion People. Science 327(5967): 812-818.

14. Melba GBR, Rohana PS, Helga J, Junning C, Xiaowei Z, et al. (2012) The role of crustacean fisheries and aquaculture in global food security: Past, present and future. Journal of Invertebrate Pathology 110(2): 158-165.

15. Robert SP, John EP, Cristina MB (2006) Farming the reef: is aquaculture a solution for reducing fishing pressure on coral reefs. Marine Policy 30(2): 111-130.

16. Young N, Brattland C, Digiovanni C, Hersoug B, Olofsson E, et al. (2019) Limitations to growth Socialecological challenges to aquaculture development in five wealthy nations. Marine Policy 104: 216-224.

17. Melba GBR, Rohana PS, Kazuo O, Supranee C, Robert A, et al. (2005) Disease and health management in Asian aquaculture. Veterinary Parasitology 132(3-4): 249-272.

18. Chellam B, Moon-Soo H, Harikrishnan R (2011) Impact of plant products on innate and adaptive immune system of cultured finfish and shellfish. Aquaculture 317(1-4): 1-15.

19. Nur AH, Sze YW, Ahmad ZA (2017) Multiclass of Endocrine Disrupting Compounds in Aquaculture Ecosystems and Health Impacts in Exposed Biota. Chemosphere 188: 375-388.

20. Brenda MS, José LB (2018) Biological Approaches for Disease Control in Aquaculture: Advantages, Limitations and Challenges. Trends in Microbiology 26(11): 896-903.

21. Halley EF, Sand NJ, Timothy EE, Tyler C, Benjamin SH, et al. (2018) Avoiding the ecological limits of forage fish for fed aquaculture. Nature Sustainability 1: 298-303.

22. Hans VB, Liu Y (2014) Estimating costs of sea lice control strategy in Norway. Preventive Veterinary Medicine 117(3-4): 469-477.

23. Ljungqvist A (2007) IPO underpricing. Handbook in Finance 1: 375-422.

24. Martin VKI, Rudy R (1997) Concepts in production ecology for analysis and quantification of agricultural input-output combinations. Field Crops Research 52(3): 197-208.

25. Claude E, Louis RD, Brent DG, David CH, Lorenzo MJ, et al. (2020) Achieving sustainable aquaculture: Historical and current perspectives and future needs and challenges. Journal of the World Aquaculture Society 51(3): 578-633.

26. Juhani P, Malcolm J, Juha K, Nikki J (2004) Compensatory growth in juvenile rainbow trout, *Oncorhynchus mykiss* (Walbaum), held individually. Aquaculture 235(1-4): 285-296.

27. Rosamond N, Ronald WH, Alejandro HB, Simon RB, Ling C, et al. (2021) A 20-year retrospective review of global aquaculture. Nature 591(7851): 551-563.

28. Shahidul I (2005) Nitrogen and phosphorus budget in coastal and marine cage aquaculture and impacts of effluent loading on ecosystem: review and analysis towards model development. Marine Pollution Bulletin 50(1): 48-61.

29. Albert GJT, Marc M (2008) Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. Aquaculture 285(1-4): 146-158.

30. Hua K, Cobcroft JM, Cole A, Zeng C, Kyall Z, et al. (2019) The Future of Aquatic Protein: Implications for Protein Sources in Aquaculture Diets. One Earth 1(3): 316-329.

31. Santosh PL, André D (2022) 3 - Nutritional requirements of cultured fish: formulating nutritionally adequate feeds. Feed and Feeding Practices in Aquaculture pp: 65-132.

32. Ana RS, Jan D, Kleopatra S, Elina Z, Antonella C, et al. (2021) The BioBased Industries Joint Undertaking as a catalyst for a green transition in Europe under the European Green Deal. EFB Bioeconomy Journal 1: 1-8.

33. Harinder PSM, Gilles T, Valérie H, Philippe A (2014) State of the art on use of insects as animal feed. Animal Feed Science and Technology 197: 1-33.

34. Harikrishnan R, Balasundaram C, Moon-Soo H (2011) Impact of plant products on innate and adaptive immune system of cultured finfish and shellfish. Aquaculture 317(1-4): 1-15.