

The Benefits of Rosemary in Aquaculture: A Comprehensive Overview

Ruksar^{1*}, Tejpal Dahiya¹, Ravi¹, Abhimanyu¹ and Tannu Goyal²

¹ Department of Zoology, College of Basic Sciences and Humanities,
Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, 125004

² Department of Zoology, Jan Nayak Chaudhary Devi Lal Memorial College,
Chaudhary Devi Lal University, Sirsa, Haryana, 125055

*Corresponding Author: ruksar29081997@gmail.com



Aquaculture, the farming of fish, shellfish and aquatic plants, is a rapidly growing industry that plays a crucial role in global food security. As demand for seafood continues to rise, so does the need for sustainable and efficient practices to ensure the health and productivity of aquaculture systems. Among the various strategies employed to enhance aquaculture sustainability, natural plant extracts have gained significant attention. Medicinal plants have gained significant attention in aquaculture as natural, sustainable alternatives to synthetic drugs, antibiotics and growth promoters. One such plant, rosemary (*Salvia rosmarinus*), a herb traditionally known for its culinary and medicinal uses. It has emerged as a promising candidate for improving aquaculture health and performance due to its potent bioactive properties.

Introduction to Rosemary

Rosemary is an aromatic, evergreen herb native to the Mediterranean region. It has been widely used for centuries in traditional medicine and culinary applications. The plant is rich in essential oils, flavonoids and phenolic compounds, which are responsible for its various health-promoting properties. These bioactive components make rosemary a potential natural additive in aquaculture, offering a range of benefits from enhancing growth performance to improving the immune system of aquatic organisms.

Bioactive Compounds in Rosemary

The bioactive compounds can positively influence various aspects of aquaculture, from enhancing growth rates to improving disease resistance. The key to rosemary's effectiveness in aquaculture lies in its bioactive compounds, which include:

1. **Carnosic Acid and Carnosol:** These diterpenes are powerful antioxidants that protect cells from oxidative stress. They also exhibit anti-inflammatory and antimicrobial properties.
2. **Rosmarinic Acid:** A polyphenolic compound with strong antioxidant, anti-inflammatory and antimicrobial effects.
3. **Essential Oils:** Rosemary's essential oils, particularly 1,8-cineole, camphor and α -pinene, possess antimicrobial, antifungal and anti-parasitic properties.
4. **Flavonoids:** Compounds like luteolin and apigenin in rosemary contribute to its antioxidant and anti-inflammatory effects.

Enhancing Growth Performance

One of the primary goals in aquaculture is to optimize the growth rates of aquatic species. Rosemary has been shown to positively influence growth performance in fish and shrimp, leading to improved feed efficiency and weight gain.

1. **Feed Additive:** Incorporating rosemary extract into the diet of aquatic organisms has been found to enhance feed conversion ratios (FCR), meaning that the animals are able to convert feed into body mass more efficiently. This can lead to significant cost savings for aquaculture operations by reducing the amount of feed required to achieve the desired growth rates.
2. **Digestive Health:** Rosemary has been observed to improve digestive enzyme activity in fish, such as amylase and protease. This enhancement in enzyme activity aids in better digestion and nutrient absorption, contributing to faster growth.

3. **Protein Synthesis:** Some studies have suggested that rosemary extracts can stimulate protein synthesis in fish, leading to increased muscle growth and overall body mass. This is particularly beneficial in species like tilapia and salmon, where muscle growth directly correlates with market value.

Improving Immune System Function

Disease outbreaks are a significant challenge in aquaculture, often leading to substantial economic losses. The overuse of antibiotics to control diseases has led to the emergence of antibiotic-resistant pathogens, making it crucial to find alternative strategies for disease prevention. Rosemary, with its potent immune-boosting properties, offers a natural solution.

1. **Antioxidant Defense:** The antioxidant compounds in rosemary, such as carnosic acid and rosmarinic acid, help in neutralizing free radicals, which are harmful by-products of cellular metabolism. By reducing oxidative stress, rosemary helps in maintaining the overall health of aquatic organisms, making them less susceptible to diseases.
2. **Anti-Inflammatory Effects:** Inflammation is a natural response to infection, but chronic inflammation can weaken the immune system. Rosemary's anti-inflammatory properties help in modulating the immune response, preventing excessive inflammation and supporting a healthy immune system.
3. **Antimicrobial Activity:** Rosemary's essential oils possess strong antimicrobial properties against a wide range of pathogens, including bacteria, fungi and parasites. This antimicrobial activity helps in reducing the incidence of infections in aquaculture systems, thereby lowering the need for chemical treatments.
4. **Enhancement of Non-Specific Immunity:** Rosemary has been found to enhance non-specific immune responses in fish, such as the activity of macrophages and the production of lysozymes. These immune components play a crucial role in the initial defense against pathogens, providing a stronger and faster immune response.

Improving Water Quality

Maintaining optimal water quality is critical in aquaculture, as poor water conditions can lead to stress, disease and reduced growth rates in aquatic species. Rosemary can indirectly contribute to better

water quality through its effects on the aquatic environment.

1. **Reduction of Ammonia Levels:** Ammonia is a toxic by-product of protein metabolism in fish. High levels of ammonia can lead to stress and even mortality. Rosemary has been shown to improve nitrogen metabolism, leading to lower ammonia excretion in fish. This contributes to better water quality and a healthier environment for aquatic organisms.
2. **Algal Control:** Excessive algal growth, particularly harmful algal blooms, can deteriorate water quality by depleting oxygen levels and releasing toxins. The antimicrobial properties of rosemary essential oils can help in controlling algal growth, thus maintaining a balanced ecosystem in aquaculture systems.
3. **Biofilter Efficiency:** Rosemary has the potential to enhance the efficiency of biofilters used in recirculating aquaculture systems (RAS). Biofilters rely on beneficial bacteria to break down waste products like ammonia and nitrite. The antimicrobial properties of rosemary can selectively inhibit harmful bacteria while promoting the growth of beneficial ones, thus improving the overall efficiency of biofilters.

Reducing Stress in Aquatic Organisms

Stress is a major concern in aquaculture, as it can lead to a weakened immune system, slower growth and increased susceptibility to diseases. Stress in aquatic organisms can be caused by various factors, including poor water quality, handling, overcrowding and transportation. Rosemary has been found to have stress-reducing effects, making it a valuable addition to aquaculture practices.

1. **Cortisol Reduction:** Cortisol is a stress hormone that is elevated during stressful conditions. High levels of cortisol can suppress the immune system and impair growth. Studies have shown that rosemary can reduce cortisol levels in fish, thereby mitigating the negative effects of stress.
2. **Behavioural Modulation:** Rosemary has been observed to have calming effects on fish, reducing aggressive behaviours and improving social interactions. This is particularly beneficial in species that are prone to stress-induced aggression, such as tilapia and trout.
3. **Enhanced Recovery:** Rosemary can also aid in the recovery of fish from stressful events, such

as transportation or handling. By reducing oxidative stress and inflammation, rosemary helps in faster recovery, minimizing the impact of stress on overall health and productivity.

Potential Applications in Disease Management

1. **Bacterial Infections:** Rosemary's antimicrobial properties make it effective against common bacterial pathogens in aquaculture, such as *Aeromonas hydrophila* and *Vibrio spp.*. Using rosemary as a dietary supplement or as a bath treatment can help in reducing the incidence and severity of bacterial infections.
2. **Parasitic Infections:** Parasites are a significant problem in aquaculture, leading to substantial losses. Rosemary essential oils have shown efficacy against various parasites, including *Ichthyophthirius multifiliis* (commonly known as "Ich"). Regular use of rosemary-based treatments can help in controlling parasitic infections without the need for harsh chemicals.
3. **Fungal Infections:** Fungal infections, particularly those caused by *Saprolegnia spp.*, are common in freshwater aquaculture. Rosemary's antifungal properties can help in preventing and treating such infections, reducing the reliance on synthetic fungicides.

Environmental and Economic Benefits

1. **Reduced Use of Antibiotics and Chemicals:** By enhancing the immune system and providing natural antimicrobial effects, rosemary can reduce the need for antibiotics and chemical treatments in aquaculture. This helps in minimizing the risk of antibiotic resistance and reduces the environmental impact of chemical residues.
2. **Sustainability:** Rosemary is a natural and renewable resource. Its use in aquaculture supports sustainable practices by promoting natural health solutions and reducing dependency on synthetic additives. This aligns with the growing demand for eco-friendly and sustainable aquaculture products.
3. **Cost-Effectiveness:** While the initial cost of incorporating rosemary into aquaculture systems may be higher than traditional treatments, the long-term benefits, including improved growth rates, reduced disease outbreaks and better water quality, can lead to significant cost savings. Additionally, the potential premium for sustainably produced

seafood can further enhance the economic viability of rosemary use in aquaculture.

Application of Rosemary in Aquaculture

1. As a Feed Additive

Purpose: Rosemary extracts or essential oils are commonly added to fish feed to enhance overall health, immunity and growth.

Benefits

- **Antioxidant Protection:** The powerful antioxidants in rosemary (such as carnosic acid, carnosol and rosmarinic acid) reduce oxidative stress in fish, protecting them from cellular damage.
- **Growth Promotion:** Rosemary stimulates digestive enzymes and enhances nutrient absorption, leading to better feed conversion rates and faster growth.
- **Disease Resistance:** By boosting the immune system, rosemary reduces the incidence of infections caused by pathogens such as bacteria, fungi and parasites.

2. As an Immunostimulant

Purpose: Enhancing the immune system of aquatic species to increase resilience against diseases.

Benefits

- Rosemary's bioactive compounds activate immune responses, such as increasing the activity of macrophages and other immune cells.
- It helps aquatic organisms resist common diseases such as bacterial infections (*Vibrio*, *Aeromonas*) and parasitic invasions.

3. For Disease Prevention

Purpose: Using rosemary to control microbial populations in water or in fish feeds.

Benefits

- **Antimicrobial and Antifungal Properties:** Rosemary inhibits the growth of harmful bacteria, fungi, and parasites, preventing diseases and reducing the need for antibiotics.

4. Enhancing Fillet Quality and Shelf Life

Purpose: Post-harvest application to maintain the quality and freshness of fish products.

Benefits

- Rosemary's antioxidants help prevent lipid oxidation, which improves the

shelf life and sensory qualities (taste, texture) of fish fillets.

- Its preservative effects are valuable for aquaculture producers looking to extend the marketability of their fish products without synthetic additives.

5. Formulations and Dosage

Forms

Rosemary can be administered in various forms, including dried leaf powder, essential oils or concentrated extracts mixed into fish feed or as a water additive.

Dosage

The effective dosage depends on the species, stage of life, and purpose (e.g., growth enhancement vs. disease prevention). Typical inclusion rates range from 0.5% to 2% of the diet, with careful adjustments based on the desired outcome and species-specific tolerance.

Challenges and Future Prospects

While the benefits of rosemary in aquaculture are clear, there are still challenges that need to be addressed to fully realize its potential.

1. **Standardization of Extracts:** The effectiveness of rosemary in aquaculture depends on the concentration and composition of its bioactive compounds. There is a need for standardized extracts with consistent potency to ensure reliable results across different aquaculture systems.
2. **Dosage and Application Methods:** Determining the optimal dosage and application methods for rosemary in different

species and aquaculture systems is crucial. Overuse or incorrect application can lead to unintended side effects or reduced efficacy.

3. **Regulatory Approval:** In some regions, the use of plant extracts in aquaculture may require regulatory approval. Research and documentation of rosemary's safety and efficacy are essential to gaining acceptance and approval from regulatory bodies.
4. **Research and Development:** Continued research is needed to explore the full range of benefits that rosemary can offer in aquaculture. This includes studying its effects on different species, understanding its mechanisms of action, and developing new formulations and application methods.

Conclusion

The use of rosemary in aquaculture offers a natural and sustainable alternative to synthetic chemicals, antibiotics and growth promoters. Given the rising demand for eco-friendly and organic aquaculture products, rosemary provides a natural solution that aligns with consumer preferences and regulatory trends toward reducing chemical use in food production. Rosemary, with its multifaceted benefits like antioxidant, antimicrobial, immune-boosting and growth-promoting properties make it a promising tool for improving the health and productivity of farmed aquatic species. The use of rosemary in aquaculture is still in its early stages, but the potential is vast. As research continues to explore and validate the benefits of rosemary, it is likely to play an increasingly important role in shaping the future of sustainable aquaculture.

* * * * *