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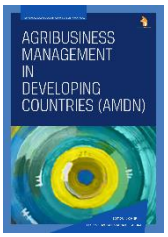

RESEARCH ARTICLE

INDIAN ALMOND LEAVES (*Terminalia Catappa* Linn.): TOWARDS SUSTAINABLE WATER QUALITY MANAGEMENT IN AQUACULTURE PRACTICES

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ABSTRACT

Aquaculture has expanded substantially in recent years due to massive growth in culture conditions. However, these extended circumstances led to increased stress, disease occurrence, new infections, and the use of synthetic chemicals to address these challenging issues. To combat disease outbreaks, farmers are utilizing chemicals like hormones, antibiotics, and vitamins. Unfortunately, these chemical substances are often introduced into culture systems without understanding the appropriate dose, application methods, mode of action, and degradation capability. This can have adverse consequences on animals, accumulate in edible tissue, and lead to drug resistance in pathogens. Throughout history, herbs have been utilized to alleviate ailments and revitalize the body systems during almost all ancient civilizations. Herbal medicine has recently become popular in aquaculture operations due to its benefits over synthetic chemicals and cost-effective. Generally, the herbal plants are known for their anti-microbial, antifungal, anti-parasitic, growth promotion, hunger stimulation, immunostimulant, and stress-reduction capabilities. Indian almond trees (*Terminalia catappa* Linn.) are one of them. Tannin is the main chemical component of *T. catappa* that has antibacterial properties. This article reviews several scientific statements on the use of Indian almond leaves as herbal biomedicine towards water quality management and aquaculture purposes as well. A basic tea bag filled with dried almond leaves could fulfill these purposes which are designed to appeal to ecologically conscious consumers. Interesting fact, that this sustainable technique can be focused on Sustainable Development Goals (SDG 3 - Good Health and Well-Being) and (SDG 14 – Life Below Water), that foster healthy aquatic ecosystems during small-scale aquaculture business activities.

KEYWORDS

Indian Almond leaves, Water Quality Management, Aquaculture, Sustainability, Herbal Biomedicine

1. INTRODUCTION

1.1 Indian almond Leaves

The Indian almond tree (*Terminalia catappa* Linn.) is a huge tree that can grow up to 30 m tall and has a wide, broad trunk. The leaves cluster at the ends of the branches (Figures 1- 4.) The leaves and bark of the Indian almond tree are commonly used as traditional medicine to treat hepatitis, dermatosis, mouth infections, and digestive problems in both children and adults. The decoction of the leaves is used to treat indigestion, furred tongue, pneumonia, and tuberculosis (TB) (Whistler, 1993).

Figure 1: Almond Tree (*Terminalia catappa*)

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Figure 2: Different Types of Almond Leaves

Figure 3: Almond Leaves

Figure 4: Almond Green Leaves

The preparation of herbal extracts is the most significant aspect in illness control because active ingredients such as antioxidants, antimicrobials, antistress, growth promotion, hunger stimulation, tonic and immune stimulation, and aphrodisiac characteristics should not be lost**.** Plants' herbal qualities are generally related to the availability and activity of compounds such as alkaloids, flavonoids, pigments, phenolics, terpenoids, steroids, and essential oils (Chanu et. al., 2012). Extracts of leaves and barks have been shown to have anti-cancer, anti-oxidation, anti-inflammatory, antifungal, and antibacterial properties against *Pythium ultimum*, *Rhizoctonia solani*, *Sclerotium rolfsii*, *Aspergillus fumigates*, *Staphylococcus epidermidis*, *S. aureus*, *Bacillus cereus, B. subtilis*, and *Pseudomonas aeruginosa* (Chansue and Assawawongkasem, 2008).

1.2 Natural Chemical Constituents of the Indian almond leaves

This plant contains tannins (punicalagin, punicalin, terflavin A and B, tergallagin, tercatain, chebulagic acid, geranin, granatin B, corilagin), flavanoids, isovitexin, vitexin, isoorientin, rutin, and triterpenoids (ursolic acid, 2α, 3β, 23-trihydroxyurs-12-en-28 oic acid). Tannin is a polyphenolic compound consisting of antibacterial properties (Ahmed et al., 2005; Chung et. al., 1998).

1.3 Indian almond leaves as Pharmaceutical and Medicinal Agent

Indian almond leaves have been locally claimed to be a wound healing substance for Siamese fighting fish when wounded (Liu et al., 1996). A group researcher conferred that the leaves have a potential to use as an alternative treatment for chemical substances and antibiotics (Chansue et al., 2004). The antibacterial active principles of herbals may lyse the cell

wall, hinder protein and DNA synthesis, inhibit enzyme secretions, and disrupt the quorum sensing route signaling mechanism. The ethanol extract from Indian almond leaves was found to be effective against Staphylococcus aureus, with a minimum inhibitory concentration of 512 µg/ml (Citarasu, 2010; Burapadaja, 1997).

Indian almond, *Terminalia catappa*, extract is an alternative antibacterial remedy against tilapia bacterial pathogen *A. hydrophila*. The growth of two strains of *A. hydrophila* was inhibited at a concentration of 0.5 mg ml/L. Indian almond (*Terminalia catappa*) has been reported to treat tilapia fish ectoparasites viz., *Trichodina* sp. The infected fish become lethargic generate excessive mucus and become off feed eventually which results in considerable deaths. It was observed that the crude extracts of Indian almond at 800 mg/L significantly ($P<0.05$) eliminated the *Trichodina* sp. infections in tilapia (average weight 3.62±0.06 g each) (Chitmanat et al., 2005).

According to these investigators Indian almond at 800 ppm was effective in eradication of *Trichodina* sp. from tilapia after 2-day treatment. The leaf extracts can eliminate *Zoothamnium* spp. infection of black tiger post larva shrimp within 24 hours after exposure and has potential to decrease the number of *Gyrodactylus* and *Dactylogyrus* infection of goldfish (Watchariya et al., 2004; Chansue and Tangtrongpiros, 2005).

The herbal extracts cause fungal cell wall rupture, altering permeability, disrupting metabolism, and RNA and protein synthesis, resulting in death found that extracting Indian almond leaves (*Terminalia catappa*) decreased fungal infection in tilapia eggs. *T. catappa* crude extracts exhibited antifungal activity in vitro against *Pythium ultimum*, *Rhizoctonia solani*, *Sclerotium rolfsii*, and *Aspergillus fumigatus* (Citarasu, 2010; Chitmanat et al., 2005).

The use of herbal leave has the potential to reduce the use of synthetic chemical substances while also overcoming its limitations such as side effects, residual difficulties, and drug resistance. Indian almond leaves offer herbal biomedicine capabilities; nonetheless, substantial study is required to optimize the dose and duration of treatment against the most frequent infections (Goun, et al., 2003).

2. Aquaculture Practices and Challenges in Asia

Aquaculture has increased significantly in recent years, but there are various restrictions to this intensification, such as crowding, which causes stress and leads to disease outbreaks and crop failures. Besides, white spot syndrome virus (WSSV) is an economically significant shrimp illness that causes high mortality rates and serious damage to shrimp farms. The infected shrimp's main clinical symptom will be white patches in the exoskeleton and epidermis. Within 3-10 days following the commencement of the symptoms listed above, this infection might result in 100% mortality. The WSSV has a broad host range and has been found in shrimps, crabs, copepods, insects, and pest prawns (Fauci, 1993).

To combat disease outbreaks, farmers are increasingly relying on chemical components such as hormones, antibiotics and vitamins. Generally, these chemical compounds are introduced into culture systems without regard for dose, application methods, mode of action, or degradation capability. This may result in negative effects for the cultured animal, residual buildup in edible tissue, and medication resistance in pathogens (Citrasu, 2006).

The adverse effects of antibiotics stimulated consumer interest in natural products. Plants are storehouses and abundant sources of safer and less expensive chemical substances. These natural plant chemicals have been shown to have a variety of functions, including antistress, growth promoter, appetizer, tonic, immunostimulants, and antimicrobials. Furthermore, the substances are obtained from natural sources, and possess additional fascinating properties such as non-toxic, biodegradable, and biocompatible (Aftab and Sial, 1999).

2.1 Diseases in the Aquarium Fishes: Challenges of Chemical Treatments

The ornamental fish industry is an aquaculture-based business that is a popular hobby around the world, generating hundreds of millions of dollars and supporting rural communities in underdeveloped nations. Veterinarians are increasingly involved in illness care of related species, whether for individual home clients, retail and wholesale enterprises, or in larger display settings. Diseases in fish develop through many of the same pathways of influencing primary and perpetuating causes as in other animals. Often leads in the practical technique of euthanizing one or more badly afflicted fish with various tools (Chapman et al., 1997).

The skin shows early clinical indications of numerous viral and non-infectious fish disorders. Aquarium fish frequently live in suboptimal settings with limited amounts of water in aquarium systems with a limited capacity to maintain enough water quantity; unlike natural fish, they cannot escape a potentially harmful environment. Even the most equipped aquarium, paired with diligent attention to water quality standards, will never really replicate natural circumstances in the wild. Thus, maintaining fish in aquariums is a compromise that usually has a negative impact on the fish's health (Magnadottir, 2006).

Progress in recent years has highlighted the ornamental fish's significant strength as an alternative model for the environmental sideline in aquaculture, both in freshwater and marine areas. These include lower upbringing costs and an earlier life stage. Aquarium fish are one of the world's largest pet populations. There is an increasing demand for veterinary services linked to ornamental fish. The skin shows early clinical indications of several infectious and noninfectious fish diseases. Many factors influence ornamental fish culture and aquarium systems, including water availability, water temperature, energy required to use the water, and product pricing. Recent rules on illness and quarantine, medication use especially chemical treatments are great concern (Schmale et al., 2002).

Thus, effluent discharge from chemical treatments has made it evident that the economics of traditional ornamental fish are shifting. Prompt diagnosis and treatment are critical for success after an outbreak occurs. Routine observation of mortality and altered swimming or feeding behavior can aid in the early discovery of a medical condition. Addressing health concerns through both proactive and reactive programming has become a critical prerequisite for sustaining aquaculture output and product trade. The present ornamental fish management plan stresses appropriate health management to reduce the possibility of disease incursions. The decorative fish sector will continue to grow, as will commerce in live organisms, which is necessary for ornamental fish development at both the subsistence and commercial levels. The risk of major disease incursions and newly emerging diseases will continue to threaten the sector, and unless appropriate health management measures are maintained and effectively implemented, the government and private sectors will bear additional costs in terms of production losses and the efforts required to contain and eradicate diseases, funds that would have been better spent preventing their entry into the system (Rao et al., 2013).

Concentrating efforts on preventive through herbal treatment could be better management techniques. Chemical treatments in aquariums, when used improperly or at incorrect dosages, can have a variety of negative effects on fish, including toxicity, stress, gill damage, behavioral changes, disruption of the nitrogen cycle, and even death, depending on the specific chemical used and its concentration always follow instructions carefully when treating aquarium water with any chemicals (Table 1).

Table 1: Various illnesses and chemical treatments for aquarium and finfish culture (Rao, et. al., 2013).

Symptoms	Possible Causes	Chemical Treatments
Small white spots on fins/ skin, clamped fins	Ich	For freshwater species (Sea water Bath) and for Sea water species (Fresh water Bath), Formalin and Malachite green is preferably used for this type of cause.
Peppery coating, yellowish, clamped fins	Velvet	Copper sulphate bath for 1-2 minutes.
Gray or white fluffy patches	Fungus	Methyl Blue, Antibiotics for secondary infections.
Gray or white fluffy patches around mouth	Mouth Fungus	Erythromycin, Kanacyn, Fish Pen (penicillin), Maracyn. Antibiotics for secondary infections. (Use Maracyn simultaneously with Maracyn II).

Table 1 (cont): Various illnesses and chemical treatments for aquarium and finfish culture (Rao, et. al., 2013).		
Unusual racing around tank. Black to red nodules beneath skin.	Flukes	Paragon, Clout, Proxipro, Fluke-Tabs.
Milky cloudiness on Skin	Costia, Chilodonella	Copper sulphate, Acriflavine.
Destruction of fins or tail	Tail or fin rot	Maracyn, Methylblue, Antibiotics, Tetracycline, Chloromycetin.
Crustaceans on skin	Argulus, Ergasilus	Trifon, Anti-Fluke treatment

2.2 Utilization of the Tropical Almond Tree Leaves in Aquaculture Practices

In tropical areas of Asia, People used to come across the scenario of the dried tropical almond tree leaves scattered around in parks, roadways, and in walk paths. And the litters of the almond tree leaves were swept heaps by the street sweepers. Inadvertently, we neglect the hidden valuable properties of almond tree leaves in the aquaculture industry. Presently Aquaculture industry is facing many challenges and problems that are overlooking the new advancement and innovations which prospers the sector. Aquaculture in Asia has expanded significantly in recent years. Increased aquaculture production has led to a rise in disease, notably infectious diseases, causing significant economic losses. Farmers' handbooks commonly list hormones, antibiotics, and vitamins as cures for fish and shrimp diseases (Chanu et al., 2012).

Farmers are frequently uninformed of or intentionally overlook critical elements and precautions for using these chemicals, such as proper application method, dose, and adverse effects. The subsequent misuse of these chemicals has resulted in the appearance of drug-resistant bacteria and environmental degradation, both of which are harmful to humans. They contain active ingredients with antioxidants, antimicrobial, antistress, growth promotion, appetite stimulation, tonic and immunostimulation, and aphrodisiac properties. These qualities are associated with plant chemicals such as alkaloids, flavonoids, pigments, phenolics, terpenoids, steroids, and essential oils. Herbal medicine has been utilized in laboratories and published in papers, with limited field experience. Some farmers have expertise in this treatment procedure but have a long way to go before applying it on a substantial basis (Jayaprakas and Sambhu, 1996).

Generally, the chemicals have been investigated as growth promoters, antibacterials, and for other purposes, however they cannot be used in commercial mariculture due to residual accumulation in fish and prawn edible tissues. The usage of antibiotics in shrimp hatcheries has resulted in tissue biomagnification, which leads to the complete consignment being rejected at export. The Marine Product Export Development Authority of India has advised hatchery operators and farmers to avoid using antibiotics such as chloramphenicol, nitrofurans (including furazolidone, nitrofurazone, furaltadone, nitrofurantoin, furylfuramide, nifuratel, nifursoxime, nifurprazine and derivatives), neomycin, nalidixic acid, sulphamethoxazole, chlorpromazine, colchicine, dapsone, dimetridazole, metronidazole, ronidazole, and others. Many of these are still utilized in hatcheries and farms (Sanandakumar, 2002).

People around the world are becoming more aware of the dangers of antibiotics and turning to natural alternatives. Plants serve as storage and production facilities for safer and less expensive chemicals. Herbal medicine has been used since prehistoric times. Almost all ancient civilizations employed plants to cure human ailments and revitalize body systems. Most herbal plants are both safe and affordable. Generally, the usage of plant extracts does not result in drug resistance. Herbal remedies can aid in disease control by neutralizing radicals, which are unstable chemical entities that extract electrons from other molecules to stabilize themselves (Fauci, 1993).

Reactive oxygen species (ROS) generated in vivo include superoxide anion, hydroxyl radical, and hydrogen peroxide, which are extremely reactive and potentially harmful transitory chemical entities. These are constantly created in the human body because they are required for energy supply, detoxification, chemical signaling, and immunological function. ROS are controlled by endogenous superoxide dismutase, glutathione peroxidase, and catalase. Over-production of ROS, caused by exposure to external oxidizing agents or a failure of defense mechanisms, damages cell structures, DNA, lipids, and proteins, raising the risk of more than 30 diseases (Valko et al., 2006; Aruoma, 1998). Flavonoids and phenolic acids, which are abundant in higher plants, protect against the harmful effects of ROS. Some chemicals in basil (Ocimum) have high antioxidant properties. Cinnamon possesses antioxidant properties like the synthetic antioxidant butylated hydroxytoluene (Middleton and Kandaswami 1993).

2.3 Impacts of Water Quality

Water quality is an important aspect in fish aquaculture. Poor water quality can cause a variety of issues, including disease spread and fish mortality. Water is an essential component in fish farming since fish cannot survive without it, and not just any water, but high-quality water. Compromise the water quality for your fish, and you risk losing all of them. The principal causes of poor water quality in fish farming include high temperatures, excessive ammonia, low oxygen, residual feed, and others. Control these elements, and you can avoid poor water quality and its repercussions. Also, not all water sources are suitable for fish farming, therefore you must carefully choose your water source before establishing your fish farm. Lakes, dams, rivers, and subterranean water, such as wells and boreholes, are the most prevalent sources of fish farming. Such water sources need to be frequently established free of dangerous pollutants such as toxic heavy metals (Jalal et al., 2023_a).

Always avoid water sources, such as municipal water supplies, because they are excessively loaded with chemicals. Disease outbreaks present a substantial threat to fish aquaculture. Intensive crowding, stressful situations, poor water quality, and poor diet or nutritional habits can all make fish vulnerable to sickness. Furthermore, meteorological changes, such as intense sunlight, should expose fish to disease. All these challenges are frequent in fish farming. Bacterial infections and parasite infestations such as sea lice are common in captive-bred fish, resulting in high mortality rates (Oso and Adeyinka, 2023). Major problems observed in fish farms include disease outbreaks among fish populations due to overcrowding, water quality issues, the spread of parasites like sea lice to wild fish, the potential for escaped farmed fish to disrupt native ecosystems, environmental pollution from fish waste and uneaten feed, antibiotic overuse, and concerns about animal welfare; all of which can significantly impact the sustainability of fish farming (Table 2).

Table 2: Common Problems Faced by the Fish Farmers in the Aquaculture Industry. (Kaisheng et al., 2024; Jalal, et al., 2023_b).

No.	Areas	Common Problems
1.	Expenditure	Expensive Feed and fertilizer are very expensive.
2.	Disease	Disease death rates and pharmaceutical costs.
3.	Water Quality Attributes	Water quality in ponds is managed due to variable characteristics.
4.	Reproduction	Breeding in a caged environment.
5.	Culture	Problems related to the intensification of culture.

2.4 Mitigations through Almond Leaf Litters for High Cost on Feed and Fertilizers

Extracts of the Indian almond leaves (IAL) are an excellent source of nutrient that has a high degree of organic materials, tannins (punicalagin, punicalin, terflavin A and B, tergallagin, tercatain, chebulagic acid, geranin, granatin B, corilagin) several flavonoids, isovitexin, isoorientin, rutin and triterpenoids, and humic acid. The cost of fertilizers can be reduced by leaf litter by taking up carbon dioxide from the atmosphere, converting the gas into organic carbon compounds, and when trees shed their leaves, leaving them to decompose in the soil as they are eaten by microbes. Leaves litter, when decomposes houses many tiny organisms such as zooplankton, infusorians, and insect larvae to colonize, which is indirectly utilized by the fish as natural feed thus, the reduction of cost in the supplemental feed will take place. Darkening of rearing water by decomposing leaves also provided a good contrast background for the larvae to visualize and efficiently capture its prey, thus contributing to better feeding success. Unlike other types of leaves, Indian Almond leaves decompose slowly, allowing them to reap their benefits for more extended periods (Aya, 2019).

2.5 Disease Mortality Rates and Cost of Medications

In post-larvae rearing of black tiger shrimp, IAL (Indian Almond Leaf) extracts provide significant improvements in the survival of fish as well as of tiger shrimp (*Penaeus monodon*) (Ikhwanuddin et al., 2014). In conclusion, 3.0 mg mL-1 concentration of *T. catappa* leaf extract has a positive effect on the survival rate and growth performance of P. monodon PL, but higher concentrations become toxic and can cause high mortality.

IAL acts as an anticancer, antioxidant agent, antifungal, and anti-inflammatory agent against bacterial and fungal infections. It also reduces stress in fish which is the primary driver of disease and disorders. Stress reduction in fish is achieved by IAL extracts which create a blackout effect for darker environments and make the fish feel safer and in natural environments. The chelate-like siderophore is toxic to the membrane of microorganisms. When tannins form a chelate complex with ions, there will be no ions available for microbes to grow under aerobic conditions. Therefore, energy can be used more on growth than the immune system against harmful bacteria (Mahadevi et al., 2019).

The methanolic extracts of *T. catappa* leaf inhibited the growth of Bacillus subtilis and Staphylococcus aureus but had no inhibitory effects on *Pseudomonas aeruginosa*, Salmonella typhi, and *E. coli*. Ectoparasite *Trichodina* was eradicated from tilapia at 800 ppm concentration of ground leaves, while the growth of *Aeromonas hydrophila* was also inhibited at a concentration of 0.5 mg/ml leaves. The extracts were also observed to reduce the fungal infection in tilapia eggs (Babayi et al., 2004).

A group researcher showed that the effect of *T. catappa* crude ethanolic extracts on the survival of mangrove crabs is like that of usage of antibiotics at the zoea five and crab instar 1 stages (Aya et al., 2019). This further supports the possible replacement of antibiotics with this natural product. The leaves extract also cure the fin rot and tail rot and heal the wounds caused by ulcers (Shams et. al., 2021).

3. Management of Water Quality from Fluctuating Parameters

Maintaining the water quality in ponds daily or weekly is the biggest task for fish farmers. Analyzing the quality parameters to check that everything is in normal condition is vital for pond management and fish survival. In water quality management, IAL plays a major role in conditioning and stabilizing water quality parameters. Extracts of the plant were known to be able to reduce water pH and heavy metal toxicity. They will lower hard water to a pH of 6.0 while soft water can be reduced to a pH of 5.0. Tannins in IAL leaves are responsible for changing the colour of the water to yellowish brown colour which is preferred by the fishes to hide. Total ammonia and nitrogen are efficiently reduced by the leaves of IAL; other than this, it also removes the turbidity in water (Bryan, 2017). This plant-based coagulant could be used as a water treatment agent in culture tanks as shown in Figure 5.

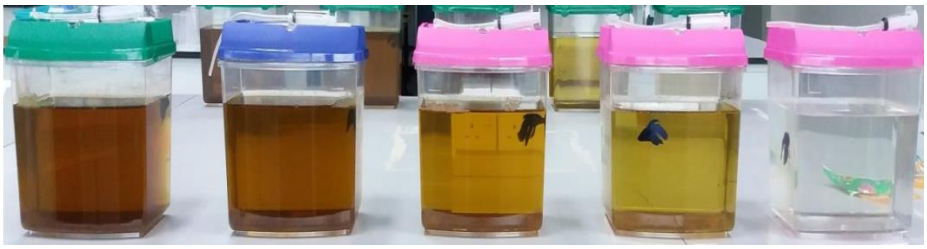

Figure 5: Different Colure of water by using Indian Almond Leaves [Shams, et. al., 2021]

3.1 Breeding in Captive Conditions

Healthy and stress-free fish is a major criterion for the selection of fish for breeding which is managed by IAL leaves extracts. IAL is utilized for the whole process from breeding to rearing. From healthy broodstock to larval survival rates are all positively influenced by IAL. Wide varieties of fish species love dark environments because they believe that darkness will help them protect their eggs and make them feel less exposed to predators; without the dark environment, they won't even attempt to reproduce. IAL leaves serve as a nest-building substrate for betta fish also protect the fry after breeding by maintaining a good amount of infusoria in the tanks. Settling leaves at the base of the tank reduces the water motion and allows larvae to conserve their energy instead of going against the flow of the current. (Mahadevi et al., 2019; Rex Dalser, 2019).

The effects of *T. catappa* leaf extract on the breeding activity of Siamese gourami (*Trichogaster pectoralis*), also known as snake gourami, were determined by controlling the water pH using the extracts from *T. catappa* leaves. The results indicated that after exposing the fish to various pH using the extracts, the best environment to breed the Siamese gourami was at pH 6.5. Such findings could help the fish farmers in breeding the fish instead of harvesting the seeds of the fish from the wild for culturing. In the aquarium industry in Thailand, betta breeders use the extracts from *T. catappa* as it helps them in creating vibrant colors in betta fish and is also used after betta fights to heal wounds. The spawning capacity is also increased by the IAL leaves extracts in betta (Lee et al., 2016).

3.2 Problems Related to Intensification of Culture

In an intensive culture of shrimp, the shrimp farmers suffer a lot from high losses due to high mortality rates and decreased growth rates. Most farmers have been using chemical hypochlorite (with 60% active substance in the pond and antibiotics to treat the shrimp pathogens to increase the growth rate. The use of antibiotics was reported not only to be ineffective, but they create more resistant bacterial strains, which worsen the situation in shrimp culture as well as environmental risks while released (Vici et al., 2000).

Although the use of probiotics has proved to be effective. It increases the production cost, which therefore does not interest farmers or hatchery owners. Tannic acid binds strongly to metal ions and calcium, inhibiting intestinal bacterial growth Therefore, such property of the extract will prevent the shrimp post larvae (PL) from dangerous metal ions in water (Chansue and Assawawongkasem, 2008).

3.3 Antimicrobial Actions in Fish Tanks and Aquarium

The hexane extract showed higher and broader antibacterial action than the other extracts. Indian almond *Terminalia catappa* extract is an alternate antibacterial treatment for tilapia ectoparasites and the bacterial infection *A. hydrophila*. At 0.5 mg/mL, two *A. hydrophila* strains' growth was suppressed. The antibacterial active components of herbal extracts may lyse cell walls, prevent protein and DNA synthesis, inhibit enzyme secretions, and disrupt the quorum sensing pathway's signaling mechanism. Root ethanol extracts were highly effective at inhibiting the growth of both Gram positive and Gram-negative bacteria (Adigüzel et al., 2005; Chitmanat et al., 2005).

In practice, most individual herbs or spice extracts must be used at high concentrations to have effects comparable to antibiotics. Many extracts include many active compounds. Oregano (*Origanum vulgare*) includes about 30 antimicrobial compounds. found that black tiger shrimp post-larvae (PL 1-25) grown in bacteria-inoculated water had a higher Vibrio load (3.76 x 105 CFU/g) in their tissues. *Artemia nauplii* were treated with methanol extracts of *Solanum trilobatum*, *Andrographis paniculata*, and *Psorolea corylifolia*, which reduced Vibrio load in black tiger shrimp post-larvae. Inoculation challenges with different organisms such as *Pseudomonas aeruginosa, Staphylococcus aureus, and Salmonella typhi* yielded similar outcomes (Citarasu et al., 2000; 2003 a, b).

A group researcher investigated the bacterial load in Indian white shrimp (*P. indicus*) juveniles fed with seaweed and herbal extracts and reared in water inoculated with *Vibrio parahaemolyticus* (Immanuel et al., 2004). Dried almond leaf abundance and their broad beneficial properties should be considered and utilized at the utmost level in aquaculture industries. Research and many scientific findings are to be encouraged in the coming days. As the leaves are scattered away everywhere, the research will be cost- effective. So, the IAL leaves scattered in the land will shift from ground to lab. Tropical almond tree (*Terminalia catappa*), also known in the Philippines as "talisay" is a large tropical tree in the Combretaceae (leadwood tree) family that grows mainly in tropical areas of Asia.

Some researchers revealed from their research findings that the presence of "talisay" leaf litter allowed tiny animals like zooplankton and insect larvae to colonize the leaf surfaces. These critters quickly became food for ayungin larvae. It's also likely that the buildup of leaves at the tank bottom inhibits water motion, allowing the larvae to preserve energy rather than

going against the current. The darkening of the rearing water induced by the decomposing leaves may have also provided a nice background or contrast for the larvae to efficiently acquire their prey, contributing to higher feeding success and, as a result, dramatically increasing larval survival. Previous research has also revealed that the simple presence of he "talisay" leaf litter in culture tanks presents some advantages to improve fish survival from fingerlings to commercial sizes (Aya, 2019; Aya et al., 2019).

A group researcher postulated that the ectoparasite *Trichodina* was eradicated from tilapia while the growth of *Aeromonas hydrophila* was also inhibited at a concentration of 0.5 mg/ml leaves (Chitmanat et al., 2005). The extracts were also shown to prevent fungal infections in tilapia eggs. A group researchers investigated the effects of *T. catappa* leaf extract on breeding activity of Siamese gourami (*Trichogaster pectoralis*), commonly known as snakeskin gourami, by regulating the pH of the water with *T. catappa* leaf extracts (Lee et al., 2016). The results showed that after exposing the fish to several pH levels with the extracts, pH 6.5 was the optimal environment for breeding Siamese gourami. Such findings could assist fish farmers in growing fish rather than harvesting fish seeds from the wild for cultural purposes.

Furthermore, other research that used simply extracts of the "talisay" leaf found significant improvements in the survival of fish and tiger shrimp. determined the effectiveness of different concentrations of *Terminalia catappa* leaves extract on the survival and growth of the post-larvae of black tiger (Ikhwanuddin et al., 2014). Tannin present in the aqueous extract of the leaves of the tropical almond tree could also enhance water quality in culture tanks by reducing the pH and total ammonia nitrogen (TAN) levels, as well as removing the turbidity in water, proving that this plant-based coagulant could be used as water treatment agents in culture tanks. Some studies have also shown that the beneficial organic compounds in *T. catappa* leaves extracts have antimicrobial and antifungal properties. It was observed that *T. catappa* leaf extract had no observable anti-bacterial effect on the water (Bryan, 2017).

A group researchers however have shown that the methanolic extracts of the *T. catappa* leaf inhabited the growth of *Bacillus subtilis* and *Staphylococcus aureus* but had no inhibitory effects on *Pseudomonas aeruginosa*, *Salmonella typhi* and *Escherichia coli*. found that the extracts of *T. catappa* leaves possessed potent antioxidative and scavenging activities that increase as the leaf matures (Babayi et al., 2004; KO et al., 2002). *T. catappa* leaf extracts have also been shown to be beneficial in the breeding of ornamental fish, particularly in the elimination of external parasites such as *Gyrodactylus* sp. and *Dactylogyrus* sp. from goldfish (*Carassius auratus*). This might benefit the aquarium sector, given that goldfish, a popular decorative fish, are frequently impacted by these ectoparasites. In the case of *Aeromonas hydrophila* infection in ornamental fishes it was discovered that plant extracts known for their antimicrobial properties could be used as alternative therapeutics to treat bacterial septicemia caused by *A. hydrophila* in fish, rather than antibiotics (Jacob et al., 2018).

T. catappa is a miracle tree for betta fish and Siamese fighting fish (*Betta splendens*), which are popular decorative fish in the aquarium trade. This is due to its involvement in curing fungal infections, decreasing the pH, and lowering the hardness of the culture water for this ornamental fish. In Thailand's aquarium business, extracts from *T. catappa* are widely used by betta breeders because they aid in the creation of brilliant colors in betta fish as well as the increase of spawning capability. The researchers from Khon Khaen University's Faculty of Veterinary Medicine undertook a study to validate the claims of Thai betta breeders about *T. catappa's* antibacterial qualities (Chansue et. al., 2008). Besides, they exposed three popular ornamental fish species: guppy fish (*Poecilia reticulate*), fancy carp (*Cyprinus carpio*), and Siamese fighting fish (*Betta splendens*) to water extracts from dried leaves of *T. catappa* for more than 14 days findings that the extracts exhibit antibacterial capabilities, which address concerns about chemical residues and antibiotic resistance in ornamental fish rearing (Chansue and Assawawongkasem, 2008).

4. Conclusion

New diseases are arising in animals and humans because of the overuse of antibiotics and antimicrobial growth promoters. Herbal biomedicines offer a possible alternative to synthetic pharmaceuticals in aquaculture. There is a need to conduct more extensive research on medicinal plants to benefit human health. Authorities should evaluate the current legislation on the use of herbal and natural treatments in aquaculture and allow for more autonomy in their use. Based on the observations presented above, enhancing dried *Terminalia catappa* leaves in culture aquarium and fish tanks may give the physical benefit of a leaf litter substrate while also leaching valuable organic compounds into the rearing water. While the process appears easy, additional research is needed, particularly on new applications of *T. catappa*. Meanwhile, extracts from *T. catappa's* dried leaves have demonstrated antibacterial and antifungal activity. Nonetheless, more research on this topic is needed, particularly to determine the degrees of toxicity of the extracts on cultured organisms.

5. Way Forward

A simple teabag format of Indian almond leaves cold be a potential to be a unique and environmentally beneficial solution for the aquarium and aquaculture markets. It appeals to amateurs and small-scale aquaculture farmers looking for sustainable options because it is simple and mess-free to improve water quality. It is positioned to appeal to environmentally concerned consumers by aligning Sustainable Development Goals 3 and 14 (Organism Under Water; Good Health and Well-being), which advocates for sustainable methods that promote healthy aquatic habitats.

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