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Exploring the Effect of Banana and Pomegranate Peel Extract on the Growth Performance, Antioxidant Status and Immunological Profile of Raho Fish (*Labeo rohita*)

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All authors equally contributed to the study and approved the final manuscript

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ABSTRACT

Background: Now a days natural feed additives like plant- extracts, have gained greater potential for improving overall health of aquaculture. Pomegranate (*Punica granatum*) and Banana (*Musa spp.*) peels contain greater number of bioactive compounds such as antioxidants and polyphenols that have greater potential to enhance growth performance, antioxidant defense as well as immune function in different species of fish. These natural supplements exert potential health benefits to Raho fish (*Labeo rohita*) in terms of immunological and physiological aspects. **Purpose:** The main purpose of the present review is to examine the effects of pomegranate and banana peel extracts on the growth performance, antioxidant status, as well as immunological profile of *Labeo rohita*. **Materials and Methods:** A comprehensive literature was reviewed using authentic database Google Scholar, ScienceDirect and PubMed for identifying studies on the effects of pomegranate and banana peel extracts on *Labeo rohita*. Different keywords were used like "Raho fish," "Labeo rohita," "pomegranate peel extract," "banana peel extract," and "natural feed additives." Different studies focusing on growth performance, antioxidant status and immune response in fish were selected for this review. **Results:** Present review found that the incorporation of pomegranate and banana peel extracts in the diet of fish positively influenced the antioxidant enzyme activity, growth performance, as well as immune responses in *Labeo rohita*. These natural bioactive compounds in the peels contributed to increase the feed efficiency as well as provided resistance to infections and oxidative stress, thereby improved the overall health of fish. **Conclusion:** Pomegranate and Banana peel extracts have greater potential as cost-effective and eco-friendly feed additives in aquaculture. Their inclusion in the diets of *Labeo rohita* not only enhance the growth performance but also improves immune system as well as antioxidant status, thereby promoting overall health of fish.

INTRODUCTION

Raho fish (*Labeo rohita*), commonly called as rohu is an important species in the fresh water aquaculture, especially in Southeast and South Asia (1). It is the major source of lean protein, it potentially contributes to the dietary needs of the people in these regions. It is considered as a best food source, due to its high nutritional value, as raho fish is rich in vitamins, essential amino acids, and minerals (2). Its tender flesh and mild flavor make it a best choice for a variety of cooking dishes and it is also considered as an alternative source of other animal proteins due to its low fat contents (3). In the recent years, due to the increasing global demand for efficient and sustainable aquaculture practices focused on improving the health and growth of fish through better nutrition (4). In Raho fish that holds an important significance, the nutrition not only ensures immunity, but also boosts optimal growth rates (5). Fish nutrition usually depends on synthetic additives and fishmeal, but there is also a greater interest in discovering the plant-based alternatives to naturally stimulate the health of fish. This move is focused by the need to provide more sustainable and safer feed options that do not depend on synthetic chemicals (6).The plant-derived feed additives that are used in aquaculture are expanding in use because of their natural bioactive compounds that can provide numerous health benefits. Out of these, pomegranate (Punica granatum) and banana (Musa spp.) peels have gained attention for their medicinal and nutritional properties. Such plant materials that are usually thrown away as waste, are a great source of beneficial compounds like flavonoids, tannins, antioxidants and polyphenols. These

compounds promote a greater range of physiological benefits such as improved immune function, increased resistance to oxidative stress and enhanced growth (7). The peels of banana are a rich source of bioactive compounds, chiefly antioxidants such as flavonoids, vitamin C and tannins (8). These antioxidants reduce the oxidative stress in fish by neutralizing harmful free radicals. Furthermore, banana peels are great source of essential minerals such as potassium and magnesium, dietary fiber, and phytochemicals that may impact the metabolic processes in fish (9). Likewise, pomegranate peels are rich in bioactive compounds like ellagitannins, flavonoids and polyphenols (10). Pomegranate is renowned for its strong antioxidant properties that are beneficial for protecting fish from oxidative damage which can occur due to infections, environmental pollutants or stress (11). Other than its antioxidant effects, pomegranate peel extract possesses anti-inflammatory and antimicrobial properties that helps in providing potential role in improving immunity in fish (12). Such properties make pomegranate peel a valued feed additive for enhancing the health of raho fish. The integration of such natural plant extracts into fish diets can have numerous encouraging effects. They help the fish combat oxidative stress by promoting the antioxidant status. Furthermore, the properties of pomegranate and banana peels that boosts the immunity can improve the resistance of fish to infections and in turn make the fish less vulnerable to common pathogens of aquaculture. Thereby this can lead to reduced dependence on antibiotics and improved survival rates, in turn promoting a more sustainable and healthier system of aquaculture (13).

Physicochemical Composition of Pomegranate and Banana Peels

The physicochemical composition of fruit peels like BPW and PPW mainly depends on the harvest time, cultivation method of the fruit, the ripeness stage and the different methods that are used for the extraction of juice (14). Pomegranate Peel Waste contains various chemical compounds like Gallic acid and ellagic acid, hydroxycinnamic acids, hydroxybenzoic acids, yellow coloring molecules, flavone derivatives, and anthocyanin that is main source of the red color for the fruit (15). Pomegranate Peel Waste is a rich source of essential oil (16), ellagitannins like, granatine A and granatine B and punicalagins (17). The waste of pomegranate peel also contains pelletierine (18). Banana Peel Waste comprises hemicellulose, cellulose, pectin, lignin, polysaccharides, proteins, chlorophyll, and low molecular weight compounds (19). The Banana Peel Waste is a source of beneficial bioactive compounds such as catecholamine, phenolics, dopamine and anthocyanin (20). The waste of banana feel is rich in gallocatechins that makes it a beneficial dietary source for diseases like cancer and heart disease(21) and flavonoids and various other compounds such as trans-β-carotene, trans-α-carotene, pro-vitamin A compounds, sterols, cryptoxanthin, polyunsaturated fatty acids, cycloartan-type triterpenes and linolenic acid (22). Banana Peel Waste contains tannins, phenols, lipids and essential oil that show improved antimicrobial activity (23). Moreover, the proximate composition of pomegranate and banana peel wastes are given in the Figure 1. (24)

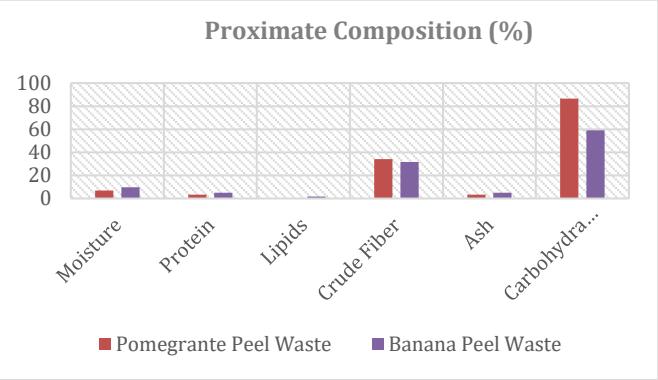
Table 1

Physicochemical Composition of Pomegranate and Banana Peel Waste (%) (24)

	Banana Peel Waste	Pomegranate Peel Waste
Pectin	3.5	8.1
Essential oil	0.106	0.20
Porosity	56.41	30.88
Bulk density	0.39	0.60
Fat	13.1	3.31
pH	6.23	4.83

Figure 1

Proximate composition of pomegranate and banana peel waste (%) (24)



Growth Performance in Labeo rohita

The growth performance is a critical factor in aquaculture that defines sustainability and profitability. The growth efficiency is assessed by parameters such as specific growth rate (SGR), feed conversion ratio (FCR), weight gain (25). Banana peel extract boosts growth by improving nutrient assimilation and digestion because of its high mineral and fiber content (26). Tannins and Flavonoids excite enzymatic activity in the gut, permitting better breakdown of carbohydrates and proteins (27). Study has revealed that diets supplemented with banana peel extract or powder can decrease FCR and knowingly increase body weight (28). Pomegranate peel extract also provisions growth by decreasing infections and maintaining gut health (29). The antioxidant compounds decrease metabolic stress, permitting more energy to be directed to growth while the antimicrobial compounds in the peel avoid harmful bacteria from inhabiting the digestive tract (30). Studies explains that supplementation with pomegranate peel extract results in increased weight gain, improved survival rates, and greater energy efficiency in Labeo rohita (31). Both these extracts offer a safe, natural, and efficient solution for stimulating growth performance without depending on antibiotics or synthetic chemicals (32).

Table 2

Effects of Pomegranate and Banana Peel Extracts on Growth Factors of Labeo rohita

Parameter	Pomegranate Peel Extract Impact	Banana Peel Extract Impact
Weight Gain	Increased body weight	Increased body weight
Feed Conversion Ratio (FCR)	Reduced FCR through improved assimilation	Reduced FCR due to better digestion
Specific Growth Rate (SGR)	Improved	Improved

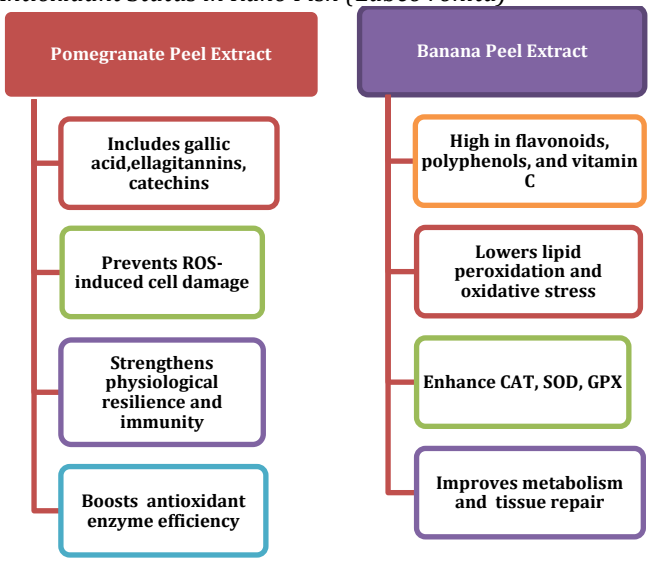
Survival Rate	High improvement due to antimicrobial effect	Moderate improvement

Antioxidant Status

The main threat in aquaculture is oxidative stress that is triggered by the overproduction of free radicals (ROS). It harms lipids, proteins, and DNA, that leads to higher disease susceptibility, immune suppression, and reduced growth (33). To combat oxidative stress, fish naturally rely on antioxidant enzymes such as catalase (CAT), glutathione peroxidase (GPX) and superoxide dismutase (SOD) (34). Pomegranate peel extract is effective because of its high content of polyphenols and ellagitannins. These compounds boosts GPX and SOD activity, guard cellular membranes from oxidative damage, and considerably lower oxidative stress markers (35). Pomegranate supplementation has been related with enhanced survival rates under stressful conditions as well as improved tolerance to environmental stress (36). Banana peel extract provides flavonoids, vitamin C, and phenolic compounds that improve endogenous antioxidant defenses and scavenge ROS. Regular supplementation increases CAT and SOD activity in Labeo rohita and decreases lipid peroxidation in muscle and liver tissues (37). Therefore, both extracts offers a dual mechanism: pomegranate peels offer solid ROS scavenging activity and banana peels improve baseline antioxidant defenses (38).

Figure 2

Antioxidant Status in Raho Fish (Labeo rohita)

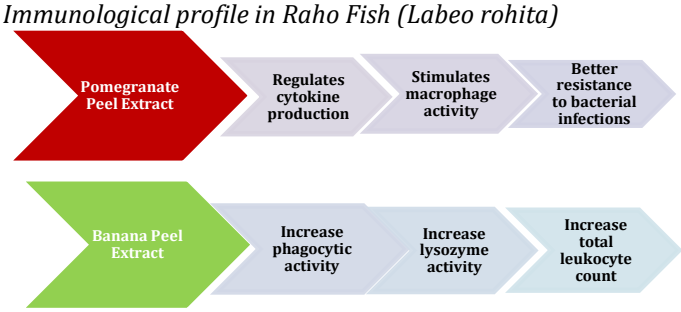


Immunological Profile

The immunity of fish can be divided into adaptive immunity and innate immunity. The strengthening of innate immunity is predominantly important to decrease mortality from fungal and bacterial diseases in aquaculture (39). Pomegranate peel extract shows a more important role in anti-inflammatory and adaptive immunity. It regulates cytokine production, stimulates macrophage activity and enhances the production of immunoglobulins. These effects result in higher survival and better disease resistance (40). Studies state that raho fish nourished with pomegranate peel extract display better resistance to bacterial infections such as *Aeromonas hydrophila* that is common in freshwater aquaculture (41). Banana peel extract has shown the capability to increase phagocytic activity, lysozyme activity, and total leukocyte count in raho fish. These improvements show a greater innate defense that enables raho fish to battle common pathogens. The antimicrobial phytochemicals also act openly on destructive microbes in the gut thus reduce infection risks (42). By the combination of both extracts, the farmers of aquaculture can deliver raho fish with a stronger immune system which is both protective and proactive (43).

Figure 3

Immunological profile in Raho Fish (Labeo rohita)



Comparative Analysis of Pomegranate and Banana Peel Extracts

While both pomegranate and banana peel extracts offer several health benefits to Labeo rohita, their effects vary to some extent in emphasis. Pomegranate peel extract excels as an immune and antioxidant booster, because of its great concentration of ellagitannins, flavonoids and polyphenols. It is particularly beneficial in improving immune responses and combating oxidative stress, leading to improved survival and disease resistance (44). Banana peel extract is mainly effective in supporting growth because of its ironic fiber content, nutrient composition, and capability to increase feed utilization effectiveness. It make sure nutrient absorption, better digestion, and weight gain, creating it more appropriate as a growth enhancer (45). Thus, banana peel extract may be more constructive for improving growth and feed efficiency, while pomegranate peel extract plays a greater role in improving antioxidant and immunity status (46). If they are used together or in rotation, they supplement each other, providing a complete improvement in physiological health, growth performance, and disease resistance of raho fish (47).

CONCLUSION

Pomegranate and Banana peel extracts signify eco-friendly and highly valuable feed additives with the ability to modify aquaculture nutrition. Their bioactive compounds not only support the antioxidant defense system and lift the immunological profile but also improve growth performance by improving feed utilization of raho fish (*Labeo rohita*). These natural supplements upturn resistance to diseases, decrease oxidative stress, and improve survival rates, making them appropriate alternatives to antibiotics and synthetic growth promoters. Moreover, by the utilization of these agricultural by-products, they promotes sustainable aquaculture practices and waste reduction. In general, the integration of pomegranate and banana peel extracts into fish feed formulations embraces important ability for promoting cost-effective, healthy, and environmentally supportable aquaculture.

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