ABSTRACT

Tea, derived from the leaves of *Camellia sinensis* (L.) Kuntze, is one of the most widely consumed beverages worldwide, revered not only for its rich flavors but also for its potential health benefits. Over the past few decades, the global demand for tea has surged, with substantial production increases, particularly in northern West Bengal, India—a key tea-producing region. This area has witnessed an annual output reaching millions of tons, catering to both domestic and international markets. However, this impressive rise in tea production has led to an equally significant challenge: the management of tea waste. During the Crush, Tear, Curl (CTC) manufacturing process, vast quantities of waste, particularly Factory Tea Waste (CTC-FTW), are generated. This waste includes discarded tea leaves, buds, and stems, amounting to an estimated 8 to 15 million kilograms annually in northern West Bengal alone. In addition to the waste produced in tea factories, a significant amount of waste is generated from tea shops and domestic tea consumption, commonly referred to as Domestic Tea Waste (CTC-DTW).

The mismanagement of tea waste poses serious environmental challenges, including soil, water, and air pollution. Improper disposal and lack of recycling options can lead to significant ecological damage, contributing to local and regional environmental degradation. Despite the scale of the issue, few companies are actively engaged in effective waste management practices, underscoring a critical gap in the current operational framework within the tea industry. This study seeks to fill this gap by investigating the management strategies surrounding tea waste and exploring its potential as a valuable resource.

The primary focus of this research is to assess the chemical composition of tea waste and identify its potential applications in agriculture and aquaculture. Through rigorous

chemical analysis, distinct compositions between CTC-FTW and Domestic Tea Waste (CTC-DTW) are established, revealing insights into their implications for enhancing agricultural productivity and promoting aquaculture health. Notably, beneficial phytochemicals identified in CTC-FTW, including 3,5-Dihydroxybenzoic acid, 4-Oxoproline, and caffeine, are shown to have potential growth-promoting effects on fish. In contrast, compounds found in CTC-DTW, such as Triethanolamine, could enhance feed texture and palatability for aquatic species.

The research underscores the urgent need for standardized guidelines for tea waste management to mitigate environmental hazards. Establishing comprehensive waste management systems can not only address pollution concerns but also harness tea waste's potential for sustainable applications. This study is significant as it represents the first comprehensive examination of tea waste chemical composition in the region, showcasing its potential contributions to sustainable practices.

In addition to evaluating tea waste's applications in aquaculture, this research explores the co-composting of tea waste with cow dung. This combination results in nutrient-rich organic manure, which significantly supports plant growth and enhances soil properties. Experimental growth promotion studies conducted on crops such as lady's finger (*Abelmoschus esculentus*) and brinjal (*Solanum melongena*) reveal notable improvements in biochemical parameters, yield, and overall plant health. The synergistic effects of tea waste and cow dung not only reduce the reliance on synthetic fertilizers but also improve soil fertility and sustainability. The optimal mix of 50-75% tea waste and 25-50% cow dung improves the carbon-to-nitrogen ratio and enriches the compost with beneficial nutrients like nitrogen and phosphorus. This organic amendment not only supports plant growth but also mitigates disposal issues associated with tea waste.

Furthermore, both CTC-FTW and CTC-DTW are evaluated as supplementary feeds for freshwater carp species, including Rohu (*Labeo rohita*), Catla (*Catla catla*), and Mrigal (*Cirrhinus mrigala*). The study finds that a balanced 50:50 ratio of factory tea waste to oil cake (OC) leads to improved growth performance across these species. However, it also highlights the risks associated with excessive inclusion of tea waste (75% or more), which can adversely affect fish health due to high fiber content and the presence of anti-nutritional factors. These findings emphasize the importance of optimizing feed formulations to ensure the health and growth of fish in aquaculture systems.

The inclusion of tea waste in fish diets is shown to enhance critical hematological parameters, which are vital for promoting better oxygen transport and immune function in fish. By analyzing these physiological indicators, the study demonstrates the potential of tea waste to serve as a sustainable alternative or supplementary food source in aquaculture. This integration not only provides a cost-effective feed option but also contributes to effective waste management by recycling tea waste into a valuable resource.

Overall, this thesis represents a significant step forward in understanding the multifaceted benefits of tea waste utilization in agriculture and aquaculture. By elucidating the synergistic benefits of combining tea waste with cow dung for organic manure and with oil cake for fish feed, this research proposes a holistic approach to addressing the challenges of waste management and food production in the tea industry. The findings provide a foundational framework for future research aimed at optimizing feed formulations and manure compositions to enhance growth and health in crops and fish.

The utilization of tea waste in organic farming and aquaculture presents a promising pathway towards sustainable agricultural systems that benefit both the environment and local economies. By transforming a waste product into a valuable resource, this research

highlights the necessity of addressing waste management challenges in the tea industry. The innovative solutions proposed herein contribute to a more sustainable and resilient food system, emphasizing the dual benefits of environmental sustainability and economic viability. Further research is warranted to explore additional applications of tea waste and to refine management strategies, ensuring that the full potential of this resource is realized in the context of sustainable development.