CHAPTER I

INTRODUCTION

1.1 Background

Indonesia possesses one of the world's largest fisheries sectors, with an estimated sustainable production potential of approximately 67 million tons annually (Marjusni and Idris, 2023), and stands as the leading global tuna producer, contributing over 19.1% of the total world supply. In 2023, the tuna export value exceeded USD 927.2 million and demonstrated ongoing growth and increasing global demand (Ministry of Marine and Fisheries of Indonesia, 2024). As the demand for tuna continues to rise, so does the growth of the tuna processing industry. However, approximately 40-70% of the total fish biomass, such as fins, gills, bones, belly flaps, heads, livers, skins, roe, and viscera, are discarded as waste throughout the processing (Estiasih *et al.*, 2021; Garofalo *et al.*, 2023). This presents both an environmental and economic challenge, as improper disposal can be harmful, while underutilization misses opportunities for value-added applications (Nawaz *et al.*, 2020).

Several research highlighted fish waste as potential sources of high-quality proteins and other functional bioactive compounds. These compounds can be recovered and further developed for use in food or industrial products with enhanced value (Nawaz *et al.*, 2020; Estiasih *et al.*, 2021; Vázquez *et al.*, 2024). Protein extraction from fish waste typically involves hydrolysis, which can be carried out through enzymatic or microbial methods. Unfortunately, extended hydrolysis may lead to an increase in TVBN and TMA levels which reduces product quality.

Tropea *et al.* (2021) reported that fish waste fermentation using *Saccharomyces cerevisiae*, *Lactobacillus reuteri*, and lemon peel led to a significant increase in protein content, indicating an overall improvement in the quality of the fermented product. In addition, Park *et al*. (2019) found that *Saccharomyces cerevisiae* produce flavin-containing monooxygenase (FMO), an enzyme capable of oxidizing TMA back into TMAO. Additionally, as found by Park *et al.* (2020), lactic acid bacteria (LAB), like *Lactobacillus plantarum*, is able to decrease TMA concentration in spoiled fish by up to 52%, mainly due to pH reduction and bacteriocin production (Xu *et al.*, 2022). This dual functionality of protein enrichment while improving sensory and nutritional properties positions microbial fermentation as a promising approach for sustainable utilization of fish waste.

Furthermore, ingredients like pineapple peel and molasses can be added as additional substrates to enhance fermentation. Pineapple peel contains bromelain, a proteolytic enzyme that aids in breaking down proteins and accelerates fermentation, while also serving as a prebiotic source (Tropea *et al.*, 2021; de Castro Leite Júnior *et al*., 2022). Meanwhile, molasses provides an energy-rich substrate for microbial activity, with approximately 50% fermentable sugar content, along with essential vitamins, minerals, and organic acids (Mangwanda *et al.,* 2023). Despite these promising elements, there is still a lack of comprehensive studies evaluating the synergistic effect of *S. cerevisiae* and *L. plantarum* fermentation of tuna wastes with pineapple peel and molasses supplementation, particularly in terms of total nitrogen enrichment and quality assessment based on the TVBN and TMA levels.

1.2 Research Problem

Tuna processing industries generate significant quantities of waste, which are often underutilized despite their high nutritional and functional potential, particularly in terms of protein content. Hydrolysis allows protein enrichment of tuna waste, however prolonged hydrolysis leads to the accumulation of undesirable compounds, such as total volatile base nitrogen (TVBN) compounds mainly trimethylamine (TMA), which are indicators of poor product quality. A previous study done by Tropea *et al.* (2021) demonstrated that fermenting fish waste with *Saccharomyces cerevisiae* and *Lactobacillus reuteri,* supplemented with lemon peel increased the protein content of the waste and helped address the shortage of protein sources in aquaculture. Additionally, a study by Park *et al.* (2019) on *Saccharomyces cerevisiae* and Park *et al.* (2020) on *Lactobacillus plantarum* showed that these microbes were effective in reducing TMA levels in fish and fish products. Altogether, these findings highlight microbial fermentation as a promising strategy for protein hydrolysis while potentially mitigating the formation of TVBN and TMA in fish. Utilization of pineapple peel and molasses as additional substrates may further enhance microbial activity and fermentation efficiency. Therefore, this research would apply different fermenting microbes and additional substrates across varying fermentation periods to ferment tuna waste. It is hoped that the fermentation process would support total nitrogen enrichment of tuna waste and resulted in good quality product based on the TVBN and TMA levels.

1.3 Objectives

1.3.1 General Objectives

The general objective of this research was to optimize tuna waste fermentation by utilizing different fermenting microbes and additional substrates over different fermentation periods for total nitrogen enrichment and quality assessment based on its total volatile base nitrogen (TVBN) and trimethylamine (TMA) content.

1.3.2 Specific Objectives

The specific objectives of this research were to determine effect of fermenting microbes, additional substrates, and fermentation period on total nitrogen content, total volatile base nitrogen (TVBN) content, and trimethylamine (TMA) content of fermented tuna waste; then to select the best treatment for total nitrogen enrichment of fermented tuna waste with acceptable TVBN and TMA levels.