Chapter 1

Introduction

1.1 Background

Food waste, the by-products derived from the processing of raw materials into higher value added products is a major problem in Indonesia as it comprises a significant proportion of the national waste generation (Nirmal et al., 2023). According to *Sistem Informasi Pengelolaan Sampah Nasional* (SIPSN) in 2025, Indonesia generated approximately 16.9 million tons of waste in 2025, of which food waste accounted for 39.37% or more than 6 million tons. A large portion of this waste originates from fruit and vegetable processing industries, consisting of various by-products, including 25-30% peels, followed by rinds, seeds, and cores (Sarker et al., 2024). Moreover, fruit waste is one of the most problematic waste due to the inefficient degradation of organic materials, accounting for up to 40% of organic waste. These residues often accumulate in landfills where the slow degradation of organic materials contributes to environmental pollution and increasing landfill demand (Putri et al., 2017).

Among the various fruit wastes generated in Indonesia, banana, pineapple, and cempedak peels represent abundant and underutilized biomass resources. According to the Indonesian Bureau of Statistics (2025), the production of banana, pineapple, and cempedak in Indonesia reaches 10.39 million tonnes, 2.88 million tonnes, and 879 thousand tonnes, respectively. As the production of these fruits continues to increase, the generation of corresponding fruit waste also rises (Casabar et al., 2019). Nirmal et al. (2023) reported that a significant proportion of the fruits is discarded, with peel waste generation estimated at 40–50% for pineapples and approximately 20% for bananas. Notably, cempedak, an Indonesian local fruit, also produces a high amount of peel waste, with about 70–80% of the fruit consisting of waste and by-products (Akter & Haque, 2019). Fruit peels have demonstrated potential for valorization into value-added products, such as biopolymers, sources of bioactive compounds, and renewable energy materials (Emmanuel et al., 2025; Rapa et al., 2024). In particular, fruit peels utilization as a carbon source is a novel method to investigate alternative sources due to their high availability, low cost, and natural sugar content, which can be utilized by microorganisms for fermentation processes without requiring extensive hydrolysis or other pretreatment (Adeyemo et al., 2024; Savitri et al., 2024).

Several studies have shown that fruit peel waste, such as banana and pineapple peels, contains high levels of reducing sugars that can serve as carbon sources in microbial growth media to support the growth of microorganisms (Akter et al., 2022; Pathanibul & Hongkulsup, 2021). Tseng et al. (2023) demonstrated that fruit extracts can be utilized as substrates for biocellulose production with *Komagataeibacter europeaus* to replace glucose and fructose. Previous studies also reported that banana peel supported lactic acid production by *Lactobacillus* strains, while pineapple peel showed potential for bioethanol production using *Saccharomyces cerevisiae*, highlighting their suitability as alternative carbon sources for microbial growth (Arekemase et al., 2020; Pangaribuan et al., 2021). Fruit peel extracts also contain bioactive compounds such as phenolics and flavonoids that have been reported to exhibit dual effects, either enhancing microbial growth through antioxidant activity or inhibiting microorganisms due to antimicrobial properties (Anjum & Sundaram, 2023; Astuti et al., 2019; Hashim et al., 2024).

Despite the potential of fruit waste valorization, limited studies have evaluated the chemical properties of these fruit peel extracts in relation to their suitability as carbon sources for microbial growth media. Additionally, studies on cempedak peel extracts remain limited, and most previous research has focused on bioactive compound Therefore, characterization of these extracts is essential to determine their suitability for microbial cultivation and to increase the value of fruit peel waste as a low-cost alternative to commercial carbon sources (Pangaribuan et al., 2021).

1.2 Objective

The objectives of the study are (i) to characterize banana, pineapple, and cempedak peel extracts including its reducing sugar, phenolic and flavonoid content, antioxidant activity, and the presence of functional group (ii) to determine the effect of different fruit peel extracts on yeast growth (iii) to evaluate the suitability of fruit peel extracts as alternative carbon sources compared to conventional glucose-supplemented media for yeast growth.

1.3 Hypothesis

H_0a: Different fruit peel extracts do not have significant differences in reducing sugar content, total phenolic content, total flavonoid content, antioxidant activity, and functional group.

H1a: Different fruit peel extracts have significant differences in reducing sugar content, total phenolic content, total flavonoid content, and antioxidant activity, and functional group.

H_0b: Different fruit peel extracts with varying reducing sugar content, total phenolic content, total flavonoid content, and antioxidant activity do not significantly affect yeast growth.

H_1b: Different fruit peel extracts with varying reducing sugar content, total phenolic content, total flavonoid content, and antioxidant activity significantly affect yeast growth.

H_0c: Fruit peel extracts cannot support microbial growth as effectively as conventional glucose-supplemented media.

H_1c: Fruit peel extracts cannot support microbial growth as effectively as conventional glucose-supplemented media.