CHAPTER I
INTRODUCTION

1.1 Significance of study

Sugarcane production plays a vital role in the global sugar industry, reaching approximately 1.9 billion metric tons in 2022 for sugar extraction (Food and Agriculture Organization of the United Nations, 2023). However, processing generates a significant by-product, sugarcane bagasse, which accounts for roughly 30% of the sugarcane stalk's dry weight (Molina-Cortés, A., Quimbaya, M., Toro-Gomez, A., & Tobar-Tosse, F., 2023). Traditionally, bagasse has been used for on-site electricity generation within sugar factories. However, exploring alternative applications is crucial for efficient waste management and resource utilization.

Nanocellulose, a high-value material derived from renewable resources, offers a promising solution for sugarcane bagasse valorization. Nanocellulose production from bagasse can not only reduce waste generation within the sugar industry but also unlock new avenues for material development. Nanocellulose possesses remarkable properties, including biodegradability, lightweight structure, and cost-effectiveness, making it highly desirable in various fields. Notably, the nanocellulose market has witnessed significant growth, reaching nearly USD 146.7 million in 2019, with a projected industry trend of 21.4% growth from 2020 to 2026 (Kiran, 2020). The versatility of nanocellulose extends to diverse applications, including electronics (generators, solar cells, touch sensors), consumer goods (computers, mobile phones), and the healthcare sector (biomedical engineering, tissue engineering) (Kiran, 2020)

This study investigates the utilization of sugarcane bagasse as a raw material for nanocellulose production using a combined approach of high-pressure homogenization pretreatment and enzymatic processing. The extracted nanocellulose will then be blended with PLA/PBS to develop biopolymer scaffolds for tissue engineering applications.

1.2 Research objective

1.2.1 To investigate the effect of co-operated high-pressure homogenization with enzymatic hydrolysis on the size reduction of nanocellulose derived from sugarcane bagasse.

1.2.2 To optimize the ratio of PLA, PBS, and nanocellulose for the production of biocompatible scaffolds with desired mechanical properties suitable for tissue engineering applications.

1.2.3 To develop a bio-scaffold incorporating optimized PLA/PBS and nanocellulose composite for artificial liver bioreactor application.

1.3 Research hypothesis

1.3.1 Sugarcane bagasse, due to its high cellulose content, is a suitable raw material for producing nanocellulose with desired properties for tissue engineering applications.

1.3.2 Co-operated high-pressure homogenization combined with enzymatic hydrolysis will significantly reduce the size of nanocellulose particles derived from sugarcane bagasse compared to using these techniques individually.

1.3.3 Incorporation of nanocellulose into biopolymer scaffolds will increase their hydrophilicity compared to scaffolds without nanocellulose.

1.3.4 Biopolymer scaffolds containing optimized ratios of PLA, PBS, and nanocellulose will exhibit superior mechanical properties, and hydrophilicity compared to scaffolds with non-optimized ratios, making them more suitable for tissue engineering applications.

1.4 Scope and limitation of study

This study investigates the potential of sugarcane bagasse as a raw material for nanocellulose production for tissue engineering applications. Nanocellulose will be isolated from pretreated sugarcane bagasse using a combined approach of high-pressure homogenization and enzymatic hydrolysis. The structure and properties of the extracted nanocellulose will be characterized. Subsequently, the nanocellulose will be blended with PLA and PBS in various ratios to develop biocompatible scaffolds for tissue engineering. The optimal ratio of PLA, PBS, and nanocellulose in the scaffold will be determined based on its properties. Finally, the biocompatibility of the optimized scaffold will be evaluated using in vitro cell culture with human Wharton's jelly-derived mesenchymal stem cells (hWJ-MSCs) undergoing differentiation towards hepatocyte lineage on the scaffold.

1.5 Expected results

1.5.1 The combined application of high-pressure homogenization and enzymatic hydrolysis is expected to significantly reduce the size of nanocellulose particles derived from sugarcane bagasse compared to using these techniques individually.

1.5.2 Incorporation of nanocellulose into biopolymer scaffolds is anticipated to increase their hydrophilicity, as measured by water contact angle analysis.

1.5.3 The optimized nanocellulose-based biopolymer scaffolds are expected to exhibit minimal cytotoxicity towards hWJ-MSCs as assessed by cell viability assays like MTT assay

1.5.4 This study aims to evaluate the potential of the optimized scaffold to support the differentiation of hWJ-MSCs towards the hepatocyte lineage.