

CHAPTER I

INTRODUCTION

1.1 Background

Plastic continues to dominate modern life due to its lightweight nature, mechanical strength, affordability, and practical versatility. However, most petrochemical based synthetic plastics demonstrate a remarkably low capacity for natural decomposition a limitation that persists even on the microplastic scale. This resistance arises from complex polymer configurations, chemical additives, and unfavorable environmental conditions, ultimately driving the escalating accumulation of plastic waste that poses significant threats to both ecosystem stability and human health [1]. In response to these environmental challenges, bioplastics have emerged as a promising solution, derived from renewable biological sources and capable of undergoing natural microbial degradation, thereby offering a more sustainable alternative to conventional petroleum based plastics [2].

Among the natural polymers commonly employed in bioplastic production, Carboxymethyl Cellulose (CMC) stands out as a widely used option. Its appeal lies in its broad availability, economical cost, and film forming capability. However, CMC still presents notable limitations, particularly in mechanical performance and resistance to moisture [3]. Chitosan has equally gained considerable attention as a bioplastic constituent, recognized for its biocompatibility, biodegradability, and inherent antimicrobial properties [4]. Recent literature further indicates that the mechanical strength and durability of chitosan based composite films can be substantially enhanced through the incorporation of plasticizers, polysaccharides, or protein based compounds [5]. Consequently, the blending of CMC and chitosan into composite films has attracted growing research interest, where in CMC contributes to structural integrity while chitosan imparts antimicrobial functionality and improved hydrophobic resistance [6]. However, despite the improved properties compared to single films, CMC and chitosan blend films still have the disadvantage of relatively low mechanical strength compared to conventional synthetic plastics.

To address the inherent limitations of CMC and chitosan blend films, researchers have explored the addition of *Uncaria gambir* (UG) extract, a naturally derived additive abundant in catechins that exhibit potent antioxidant and antimicrobial characteristics [7]. UG extract is particularly advantageous in West Sumatra, where it is readily accessible, cost effective, and environmentally benign [8]. Chromatographic analysis has revealed that catechins account for

approximately 76% of its total polyphenolic composition, reinforcing its efficacy as an antioxidant, antimicrobial, and mechanical reinforcing agent [9]. This multifunctional synergy presents a compelling opportunity for advancing CMC and chitosan bioplastics with superior properties suitable for active and sustainable packaging applications.

Abral et al. [10], demonstrated that the incorporation of *Uncaria gambir* extract into carboxymethyl cellulose and chitosan polymer matrices significantly enhanced film performance, elevating both antioxidant and antimicrobial activities while simultaneously improving tensile strength and toughness, thereby rendering the resulting biocomposite films highly suitable for active and sustainable packaging applications.

Prior research has established that the integration of chitosan into CMC films substantially enhances mechanical performance, with tensile strength increasing from 13.57 MPa to 42.41 MPa, attributed to strong electrostatic and hydrogen bonding interactions between the two polymers [11]. Building on this foundation, the present study seeks to evaluate the influence of varying gambir leaf extract concentrations on the tensile strength of CMC and chitosan bioplastic films, with the broader aim of developing an environmentally sustainable alternative to conventional plastics.

1.2 Problem Formulation

How does the addition of gambir leaf extract affect the tensile strength, tensile modulus, and elongation at break of bioplastic films derived from CMC and chitosan blends?

1.3 Research Objectives

The purpose of this study was to determine the effect of adding gambir leaf extract on the tensile strength, tensile modulus and elongation of bioplastics based on CMC and chitosan blend films.

1.4 Research Significance

This research is expected to investigate the effect of gambir leaf extract incorporation on the tensile strength, tensile modulus, and elongation of CMC and chitosan blend films, which can be developed as an environmentally friendly alternative to conventional plastics.

1.5 Research Scope

To ensure a focused study, the research scope includes:

- a. Raw Materials

- b. Fresh gambir leaves are obtained from Halaban, Lima Puluh Kota Regency, West Sumatra.
- c. Gambir extract sourced from Biota Sumatra Laboratory, Universitas Andalas, Padang.
- d. Sodium carboxymethyl cellulose is sourced from Sigma Aldrich with an average molecular weight of ~90,000.
- e. Chitosan is sourced from Sigma Aldrich with low molecular weight grade.
- f. Tensile tests performed based on ASTM D638-14 Type V standards.

1.6 Thesis Structure

This study is structured into five chapters. Chapter I presents the introduction, encompassing the research background, objectives, benefits, scope, and the rationale for topic selection along with its anticipated contributions. Chapter II constitutes the literature review, elaborating on the theoretical framework and relevant preceding studies underpinning the research. Chapter III delineates the research methodology, detailing the approaches and procedures employed. Chapter IV discusses the findings, accompanied by their analysis and interpretation. Finally, Chapter V draws conclusions by synthesizing the principal results and formulating recommendations derived from the study.

