

I. INTRODUCTION

1.1. Introduction

Meatballs, known as *bakso* in Indonesia, are a widely consumed food product appreciated for their versatility, affordability, and unique texture. The quality of meatballs is largely determined by their physicochemical properties, such as texture, moisture content, and water activity, which directly influence consumer acceptability (Meng et al., 2022). However, achieving the ideal balance of these properties remains a challenge in meatball production, particularly when using mixed meat formulations such as beef and chicken. This has prompted the exploration of innovative ingredients and processing techniques to enhance the quality of meatballs. Among these innovations, the use of enzymes has shown promising potential in improving the physicochemical characteristics of various food products. Enzymes such as proteases, amylases, and transglutaminases are widely applied in food processing to modify protein structures, enhance textural properties, and improve water retention (Zhang et al., 2023). Their ability to catalyze specific biochemical reactions makes them valuable tools for optimizing product quality across different food categories.

Transglutaminase, an enzyme commonly used in the food industry, has gained attention for its ability to improve the texture and binding properties of meat products (Zhang et al., 2023). This enzyme catalyzes the formation of covalent bonds between proteins, specifically between the γ -carboxamide group of glutamine residues and the ϵ -amino group of lysine residues, resulting in a stronger and more cohesive protein network (Kolotylo et al., 2024). This cross-linking action enhances the structural integrity of meat products, leading to improved texture, increased water-holding capacity, and reduced water absorption during cooking (Zimoch-Korzycka et al., 2024). In meatballs, transglutaminase can create a firmer and more elastic texture, which is highly desirable for consumer satisfaction. Additionally, the enzyme's ability to bind proteins from different sources,

such as beef and chicken, makes it particularly useful in mixed-meat formulations, where achieving uniformity and consistency can be challenging (Erdem et al., 2020). Despite its proven effectiveness in various meat products, such as sausages, ham, and surimi, the application of transglutaminase in beef-chicken meatballs, especially for meatball applications, has not been extensively studied. This research seeks to address this gap by investigating the impact of transglutaminase on the physicochemical properties of meatballs, with the goal of developing an optimized formulation that meets the consumers expectations.

This research is conducted as part of a collaborative effort to support a small local business in developing an improved meatball formulation using the transglutaminase enzyme. By assisting this business, the project aims to evaluate the effects of transglutaminase on key physicochemical characteristics of beef-chicken meatballs, including texture (measured through force analysis), moisture content, moisture absorption, and color. The outcomes of this study are expected to provide practical insights into how transglutaminase can enhance product quality and consistency in small-scale meatball production.

1.2. Scope of project

This research aimed to optimize beef-chicken meatballs by incorporating transglutaminase to enhance texture, moisture retention, and yield. The formulation was adjusted with varying enzyme concentrations, and samples were prepared under controlled conditions to ensure consistency. Key parameters—texture (hardness, springiness, cohesiveness), moisture content, water activity, color and moisture absorption—were measured using appropriate instruments. Statistical analysis compared treated samples against controls, identifying the optimal enzyme level. The study offers valuable insights for the food industry to consistently enhance product quality and economic yield, boosting competitiveness.

1.3. Objective

The primary objective of this research is to optimize the formulation of beef-chicken meatballs by incorporating transglutaminase enzymes, with the aim of enhancing their physicochemical properties and overall quality.

1.4. Hypothesis

- *H0: There is no significant difference in moisture content, texture, water absorption, or color parameters between the control, 0.3% TG, and 0.5% TG treatments.*
- *H1: There is a significant difference in at least one of these parameters between treatments.*