Chapter 1

Introduction

1.1 Background

Cereal bars have gained increasing attention as convenient and nutritious snack products due to the rising demand for plant-based and health-oriented foods (Ketkaew et al., 2024). Their portability, extended shelf life, and ease of consumption make them suitable for modern lifestyles (Kosicka-Gębska et al., 2024). These characteristics make cereal bars a practical option for consumers who need snacks that are easy to carry, quick to eat, and still able to provide nutritional benefits. As consumers become more health-conscious and environmentally aware, plant-based cereal bars are increasingly perceived as nutritious and sustainable alternatives to conventional snack products. Consequently, there is growing interest in developing cereal bars with enhanced nutritional value, particularly those enriched with plant-based protein sources (Tjahyo et al., 2024).

The incorporation of plant-based protein ingredients into cereal bars has become increasingly popular as manufacturers aim to enhance their nutritional profile, particularly protein content. However, the addition of protein-rich ingredients can significantly influence the physicochemical properties of cereal bars, including texture, moisture retention, structural integrity, and overall product stability (Ardakani & Pourfarzad, 2026). In many cases, excessive protein incorporation may lead to undesirable characteristics such as increased hardness, poor cohesiveness, reduced binding efficiency, and compromised sensory acceptance (Małecki et al., 2020). Therefore, cereal bar formulation should consider not only the total amount of protein added, but also the specific plant-based protein source used, such as soy, pea, oat, or other plant-based protein such as edamame. This is important because plant proteins differ in functional properties such as water-holding capacity, solubility, emulsification, gelation, and color or flavor contribution, which can affect texture, binding, moisture retention, product appearance, and consumer acceptance (Ma et al.,

2022; Jakobson et al., 2023). In protein-enriched bar systems, different protein sources have been shown to influence hardness, cohesiveness, adhesiveness, water activity, color, amino acid profile, and microstructure, showing that protein type can strongly affect both physical quality and nutritional value (Małecki et al., 2020). Therefore, careful ingredient selection and optimization of formulation ratios are needed to improve protein content while maintaining acceptable texture, structural stability, and consumer acceptability.

Edamame, the immature form of soybean, has emerged as a promising plant-based protein source due to its high protein content and favorable nutritional profile, including essential amino acids, dietary fiber, vitamins, and minerals (Widiyawati & Susindra, 2018). Compared to mature soybeans, edamame possesses a milder flavor and lighter color, which may enhance sensory acceptance in food products (Kurniawati et al., 2026). Its growing perception as a natural and sustainable ingredient further supports its application in the development of plant-based cereal bars (Takano et al., 2025). Nevertheless, the amount of edamame added to the cereal bar formulation should be carefully controlled because different formulation ratios can affect specific quality attributes, such as hardness, cohesiveness, stickiness, moisture content, water activity, color, aroma, taste, and overall acceptability. This is because the balance between dry ingredients and the binder system can influence how well the bar holds together, while edamame-based ingredients may also contribute to changes in flavor, texture, and physical stability (Samakradhamrongthai et al., 2021; Klinmalai et al., 2025; Aimanulhaq et al., 2025).

Formulation ratios play a critical role in determining the quality attributes of cereal bar products. Variations in the proportion of key ingredients, such as protein sources, binders, and cereal components, can significantly influence physicochemical properties, including moisture content, texture, color, and structural integrity. For instance, an increase in protein-rich ingredients may enhance nutritional value but can also result in increased hardness or reduced cohesiveness if not

properly balanced (Małecki et al., 2020). Similarly, the amount of binder affects moisture retention and product stability, while cereal components contribute to texture and overall mouthfeel (Herz et al., 2023). These interactions between ingredients highlight the importance of systematically evaluating formulation variations to achieve a desirable balance between nutritional quality and sensory acceptance. Therefore, optimization of formulation ratios is essential to develop cereal bar products with improved physicochemical characteristics and consumer acceptability. Despite the increasing interest in plant-based cereal bars, limited studies have focused on optimizing formulation ratios of edamame-based cereal bars following the selection of an appropriate processing method. Therefore, this study aims to develop and optimize an edamame-based cereal bar by evaluating formulation ratios and their effects on physicochemical properties and sensory acceptance.

1.2 Objective

The objective of this study is to develop and optimize edamame-based cereal bars by evaluating the effect of formulation ratios on physicochemical properties and sensory acceptance.

1.3 Hypothesis

The hypotheses of this research are

1. Null hypothesis (H_0): Variations in formulation ratios have no significant effect on the physicochemical properties and sensory acceptance of edamame-based cereal bars.
2. Alternative hypothesis (H_1): Variations in formulation ratios have a significant effect on the physicochemical properties and sensory acceptance of edamame-based cereal bars.