Chapter 1

Introduction

1.1 Background

In recent years, global dietary patterns have shifted toward healthier lifestyles, driven by increased awareness of the link between nutrition, physical activity, and chronic disease prevention. This phenomenon has led to growing demand for nutrient-dense foods that support physical performance and recovery. Protein-rich products, in particular, have gained significant attention due to their role in muscle maintenance and overall health (Ajomiwe et al., 2024). As a result, the market for high-protein foods continues to expand alongside the global health and fitness industry.

However, many commercial protein products are highly processed and commonly formulated using isolated protein fractions, along with additives, artificial flavorings, and stabilizers. In response, consumers are increasingly seeking clean-label, minimally processed, and plant-based alternatives that are perceived as more natural and sustainable (Liu et al., 2025). Plant-based foods are also associated with various health benefits, including reduced risks of cardiovascular disease, obesity, and type II diabetes (Wang et al., 2023). Therefore, developing a plant-based, high-protein snack bar using whole ingredients represents a practical approach to meet current consumer demands.

Plant-based raw materials such as sacha inchi (*Plukenetia volubilis*), black beans (*Phaseolus vulgaris*), and lupine beans (*Lupinus albus*) offer strong potential for high-protein snack bar formulation due to their high protein content and functional properties. Sacha inchi contains approximately 25–30% protein, while lupine beans can reach up to 35–40%, making them suitable as primary protein sources (Lemus-Conejo et al., 2024; Chukwuejim et al., 2025). Black beans contribute additional nutritional value and are widely recognized for their fiber content and health benefits (King et al., 2024). Beyond protein content, these ingredients also provide important macronutrients such as dietary fiber and

lipids, which influence both the nutritional quality and physicochemical characteristics of the final product.

Snack bars are popular due to their convenience, portability, and long shelf life. They can incorporate whole-food ingredients, providing a balanced nutritional profile of protein, fat, carbohydrates, fiber, and moisture, which are important determinants of product quality, texture, stability, and consumer acceptability (Duda-Seiman et al., 2025).

Previous studies on plant-based snack bars have mainly focused on enhancing protein content and sensory properties using ingredients such as soy, pea, and rice proteins (Baek et al., 2024; Villarreal et al., 2025). However, these formulations often rely on processed ingredients and provide limited evaluation of overall nutritional composition. Research has shown that increasing the proportion of sacha inchi can significantly enhance snack bar protein content, reaching 26.77% at a 45% inclusion level (Yasmin, 2025). Similarly, the incorporation of lupin flour has been reported to improve protein, dietary fiber, and overall nutritional quality while maintaining consumer acceptance (Oğuz et al., 2025). Nevertheless, a comprehensive assessment of macronutrients, including protein, fat, carbohydrates, fiber, and moisture, remains essential, as variations in the proportions of sacha inchi, black bean, and lupine bean can substantially influence the nutritional composition and functional properties of the final product (Momanyi et al., 2020).

The nutritional composition of snack bars is strongly influenced by the proportions of sacha inchi, black bean, and lupine bean used in the formulation. Because each ingredient possesses a distinct nutrient profile, variations in their ratios alter the levels of protein, fat, carbohydrates, dietary fiber, and moisture in the final product, resulting in significant differences in proximate composition among formulations (Momanyi et al., 2020). These macronutrients also contribute to the functional and physicochemical properties of the snack bars, where protein supports structural formation and

texture development, carbohydrates influence sweetness, binding, and energy density, fat affects mouthfeel, flavor retention, and softness, while fiber and moisture impact water absorption, shelf life, microbiological stability, and product safety (Costa-Pinto & Gantner, 2020). Furthermore, texture and color are critical quality attributes that determine consumer acceptance and perceived product quality. Textural properties such as hardness, chewiness, cohesiveness, and adhesiveness influence the eating experience and overall preference (Ishak et al., 2022), whereas color serves as an important visual indicator of freshness, quality, and expected flavor, often shaping consumers' initial purchasing decisions (Boruczkowska et al., 2025).

1.2 Objective

This study aims to develop and characterize high-protein snack bars formulated from sacha inchi (*Plukenetia volubilis*), black bean (*Phaseolus vulgaris*), and lupine bean (*Lupinus albus*). Specifically, it evaluates the effects of different ingredient ratios on macronutrient composition (protein, fat, carbohydrate, crude fiber, and moisture) and physicochemical properties, including texture (hardness and chewiness) and color (L*, a*, b* values), to identify the most suitable formulation.

1.3 Hypothesis

Null Hypothesis: There is no significant difference in the proximate analysis and physical properties (texture and color) among snack bars formulated with different ratios of sacha inchi, black bean, and lupine bean.

Alternative Hypothesis: There is a significant difference in proximate analysis and physical properties (texture and color) among snack bars formulated with different ratios of sacha inchi, black bean, and lupine bean.