Chapter 1

Introduction

1.1 Background

The increasing global demand for protein, together with growing concerns regarding the environmental impact of conventional livestock production, has accelerated the search for more sustainable alternative protein sources. Among the available alternatives, edible insects have received considerable attention because of their high nutritional content, effective feed conversion ratio, and reduced environmental impact as compared to traditional livestock production systems (Tang et al., 2019). Depending on the insect species, developmental stage, and processing method, edible insects generally contain 40–70% protein on a dry weight basis, making them a promising source of sustainable dietary protein (Tang et al., 2019).

Among edible insect species, crickets (*Acheta domesticus*) have attracted particular interest due to their high-quality protein, balanced essential amino acid profile, and favorable functional properties for food applications. Previous studies have demonstrated that cricket powder exhibits in vitro protein digestibility comparable to conventional protein sources such as soy protein and casein (Montowska et al., 2019). In addition to protein, cricket powder provides valuable micronutrients including iron, zinc, vitamin B12, and riboflavin, further enhancing its nutritional value (Ghosh et al., 2017). These characteristics support the potential use of cricket powder as a sustainable ingredient for developing protein-enriched functional foods.

Beyond its nutritional value, cricket powder has also been suggested to possess potential prebiotic properties because it contains chitin, a structural polysaccharide found in the insect exoskeleton. Chitin and its derivatives have been reported to promote the growth of beneficial gut microorganisms through microbial fermentation. Rather than isolated chitin alone, the combined presence of chitin,

protein, and other fermentable components within the whole cricket matrix may contribute to this potential prebiotic effect (Kipkoech, 2019). In a randomized double-blind crossover study involving healthy adults, supplementation with 25 g/day of whole cricket powder for 14 days significantly increased the abundance of *Bifidobacterium animalis* while reducing plasma tumor necrosis factor-alpha (TNF-α), suggesting beneficial modulation of gut microbiota and possible anti-inflammatory effects (Stull et al., 2018). Furthermore, insect-derived dietary fibers containing chitin have been reported to support the growth of beneficial bacterial groups, including *Lactobacillus* spp. and *Bifidobacterium* spp. (Gibson et al., 2017; Lopez-Santamarina et al., 2020). Nevertheless, evidence regarding the potential prebiotic effects of cricket powder incorporated into processed dairy products remains limited.

To improve consumer acceptance of insect-derived ingredients, cricket powder may be incorporated into familiar food products rather than consumed directly. Ice cream is one such product because it is widely accepted by consumers and possesses a complex colloidal structure consisting of proteins, fat globules, air cells, and ice crystals that can accommodate functional ingredients without substantially altering product quality (Mohammed et al., 2022). Instead of replacing dairy ingredients, cricket powder can serve as a protein fortificant that enhances both the nutritional and functional value of ice cream while preserving its familiar characteristics (Zielińska et al., 2023). Despite increasing interest in insect-fortified foods, frozen dairy products remain considerably less studied than bakery products, protein bars, or fermented dairy products.

Besides improving nutritional composition, the incorporation of cricket powder may influence important functional characteristics of dairy products. Protein digestibility is a key indicator of protein quality because it reflects the extent to which dietary proteins can be hydrolyzed into absorbable peptides and amino acids (Tang et al., 2019). In addition, the ability of cricket powder to support the growth of beneficial bacteria such as *Lactobacillus* spp. may provide further evidence of its potential functional properties within the food matrix (Campana et al., 2017). During bacterial fermentation,

microbial metabolism is commonly accompanied by a reduction in pH due to the production of organic acids; therefore, monitoring pH changes provides an additional indicator of bacterial activity and substrate utilization (Gurram et al., 2021).

Although previous studies have investigated the nutritional composition, physicochemical properties, and sensory characteristics of insect-fortified food products, limited research has simultaneously evaluated protein digestibility, *Lactobacillus* growth, and pH changes in cricket-fortified ice cream. Furthermore, frozen dairy systems remain considerably less explored than other insect-based food products. Therefore, a comprehensive evaluation of these nutritional and microbiological characteristics is necessary to determine the feasibility of cricket-fortified ice cream as a sustainable functional dairy product.

Therefore, this study aimed to evaluate the in vitro protein digestibility of cricket-fortified ice cream using a pepsin digestion model and to investigate its potential functional properties by assessing the growth response of *Lactobacillus* spp. and changes in pH during fermentation. The findings of this study are expected to contribute to the development of sustainable functional dairy products while expanding scientific knowledge regarding the application of edible insects in food systems.

1.2 Objective

- To evaluate the in vitro protein digestibility of ice cream fortified with different concentrations of cricket powder using a pepsin digestion model.
- To investigate the potential functional effect of cricket-fortified ice cream by evaluating the growth response of *Lactobacillus acidophilus*, *Lactobacillus casei*, and *Lactobacillus plantarum*.
- To determine the effect of different concentrations of cricket powder on pH changes during bacterial fermentation.

1.3 Hypothesis

Null Hypothesis (H_0)

- **H_{0_1}:** There is no significant difference in soluble protein concentration after in vitro pepsin digestion among ice cream formulations fortified with different concentrations of cricket powder.
- **H_{0_2}:** Cricket powder fortification does not significantly affect the growth of *Lactobacillus acidophilus*, *Lactobacillus casei*, and *Lactobacillus plantarum*.
- **H_{0_3}:** Different concentrations of cricket powder do not significantly affect pH changes during bacterial fermentation.

Alternative Hypothesis (H_1)

- **H_{11}:** There is a significant difference in soluble protein concentration after in vitro pepsin digestion among ice cream formulations fortified with different concentrations of cricket powder.
- **H_{12}:** Cricket powder fortification significantly affects the growth of *Lactobacillus acidophilus*, *Lactobacillus casei*, and *Lactobacillus plantarum*.
- **H_{13}:** Different concentrations of cricket powder significantly affect pH changes during bacterial fermentation.