Chapter 1

Introduction

1.1 Background

The *Brassica* genus comprises a heterogeneous group of the *Brassicaceae* (mustard family) and is known as an essential horticultural and agricultural crop, including cabbage, broccoli, kale, cauliflower, mustards, and other cruciferous vegetables (Sun *et al.,* 2021). The *Brassicaceae* family contains around 375 genera and over 3200 species (Shahzad *et al.*, 2019). *Brassica* plants are located in Southern Europe, the Middle East, and Asia Minor and spread to the Americas, Oceania, East Asia, and other parts of the region (Hong *et al.*, 2024). These plants are characterized by mild, wet winters and hot, dry summers, although recently, they have evolved and adapted to grow in other environments, including colder and temperate zones (Card *et al.*, 2015). *Brassicas* proved to be versatile plants in agriculture and nutrition through their edible parts such as leaves, roots, buds, seeds, flowers, stems, and tubers, which have kept them relevant in food systems, traditional medicine, and horticulture all over Southeast Asia (Card *et al.*, 2015).

Brassica vegetables are essential food sources for humans and ruminants, traditionally prepared as soups, teas, and staple dishes due to their rich bioactive compounds and essential nutrients. Although *Brassica* species are consumed widely, certain parts, particularly the leaves, are underutilized and often discarded despite being rich in several health-promoting phytochemicals, polyphenols, glucosinolates, and essential vitamins. The realization of the nutritional potential of these underutilized parts creates an opportunity for their incorporation into sustainable food product development, functional foods, and health-promoting formulations (Khalid *et al.*, 2023).

As the modern consumer society is turning towards natural and functional ingredients, *Brassica* plants have gained importance due to their bioactive compounds and prospective applications in food, agriculture, nutraceuticals, and plant-based health products. With the rising trend of functional foods, there is an urgent need to look at these plants beyond conventional consumption. From a nutritional perspective, *Brassica* vegetables are rich in antioxidants, including polyphenols, vitamins K and C, soluble fibre, manganese, and glucosinolates (GLSs). These bioactive compounds promote health with antioxidative and anti-inflammatory effects; moreover, some studies link these plants with preventing degenerative diseases and cardiovascular conditions. Thus, polyphenols become worthy of further studies among such bioactive phytochemicals due to being high in concentrations, especially in *Brassica* leaves or young sprouts, and having strong antioxidant properties (Francisco *et al.*, 2016; Sun *et al.*, 2021).

It has been reported that broccoli sprouts have a higher concentration of polyphenols by 4 to 40 times compared with the mature leaves of *Brassica* vegetables. Mostly, the broccoli sprouts present a novel opportunity to understand and improve polyphenol extraction compared to mature broccoli. While most studies focus on the health benefits, antioxidant properties, and general profiling of *Brassica* plants, there is a gap in the systematic optimization of the extraction process. Various methods have been tried to recover bioactive compounds, but they usually end up being incomplete or cause degradation of the sensitive compounds, mainly due to non-optimized parameters. Therefore, there is a significant research gap regarding the efficient and targeted extraction of polyphenols from broccoli sprouts (Moya *et al.*, 2020; Mungwari *et al.*, 2025; Sun *et al.*, 2021).

The extraction of bioactive compounds, particularly polyphenols, from *Brassica* leaves has gained attention for their roles in food preservation and functional food development. As powerful antioxidants, polyphenols help reduce oxidative stress and the risk of chronic diseases, including cancer (Zhang & Tsao, 2016). Among extraction methods, ultrasonic-assisted extraction (UAE) is a promising method that improves cell disruption, mass transfer, and the yield of bioactive compounds while preserving their functionality. The efficiency of the UAE depends on parameters such as ethanol concentration, ultrasound power, and extraction time, while the temperature is kept constant. Longer extraction times can reduce yield, ethanol concentration can determine solubility, and ultrasound power enhances cell disruption. Controlling these parameters is essential to maximize yield, total phenolic content, and antioxidant activity as evaluated by FRAP, ABTS, and DPPH (Moya *et al.*, 2020; Mungwari *et al.*, 2025; Sun *et al.*, 2021). Optimizing these conditions can improve the bioavailability and functionality of *Brassica* polyphenols for food and health applications.

1.2 Objective

This study aims to optimize the extraction of polyphenols from broccoli sprouts (*Brassica oleracea* var. *italica*) using ultrasonic-assisted extraction by evaluating key parameters such as ultrasonic power, extraction time, and ethanol concentration. It also seeks to determine the optimal conditions for maximizing broccoli sprout extracts' polyphenol yield and antioxidant activity. The study will assess extraction yield, total phenolic content, and antioxidant activity. The results will then be analyzed using response surface methodology (RSM).

1.3 Hypothesis

1. <u>Effect on total phenolic content (TPC):</u>

   H0: The ultrasonic-assisted extraction parameters have no significant effect on the total phenolic content of the broccoli sprouts extract.

   H1: The ultrasonic-assisted extraction parameters significantly affect the total phenolic content of the broccoli sprout extract.

2. <u>Effect on antioxidant activity:</u>

   H0: The ultrasonic-assisted extraction parameters have no significant effect on the antioxidant activity of the broccoli sprout extract.

   H1: The ultrasonic-assisted extraction parameters significantly affect the antioxidant activity of the broccoli sprout extract.