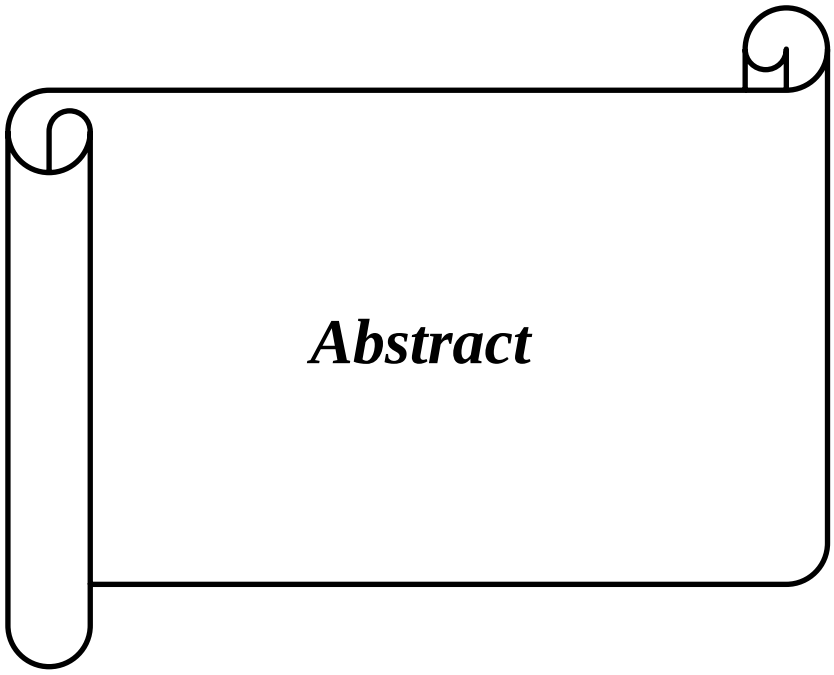
Abstract

Utilization of ripe papaya peels for extraction of valuable components and their applications in food processing

Abstract

Tropical fruits offer significant medicinal and nutritional benefits, but their processing generates by-products like skin, seeds, and inedible pulp, posing waste management and environmental challenges. However, utilizing these by-products for functional products and nutraceutical supplements can address these issues. Rich in bioactive substances such as vitamin C, phenolic compounds, flavonoids, and carotenoids, tropical fruit by-products exhibit antioxidant properties with various health benefits. Papaya, a prominent tropical fruit, contains antioxidants like carotenoids, vitamins B and C, and the digestive enzyme papain, offering cardiovascular health improvements, protection against heart attacks and strokes, prevention of colon cancer, and cholesterol reduction. Often discarded, papaya peel is abundant in soluble solids, fiber, vitamin C, phenolic compounds, papain enzyme, and minerals, exhibiting antioxidant potential. Novel extraction techniques like ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE), and enzyme-assisted extraction (EAE) have been explored to extract bioactive components efficiently and cost-effectively. The aqueous two-phase system (ATPS) offers a rapid and mild purification method for protein products. However, limited research exists on the phenolic content, protein properties, and kinetics of extraction from papaya peel. A comprehensive research strategy is needed to optimize the extraction process considering various factors. The utilization of tropical fruit by-products, like papaya peel, presents opportunities for functional products in various industries. Developing a comprehensive understanding of the extraction process and compound properties will contribute to sustainable utilization and value addition to these by-products.

The research work presents a systematic approach to extract bioactive compounds and papain enzyme from papaya peel, considering various processing factors. The extracted bioactive compounds are incorporated into a new product, while the papain enzyme is intended for use in food processing. The study contributes to the development of sustainable strategies for utilizing papaya by-products, addressing waste management, environmental concerns, and the potential for producing value-added products with health benefits.

To accomplish the goal, the thesis is divided into 7 chapters are as follows:

Chapter 1 presents a brief introduction of the papaya fruit and various parts along with its various bioactive compounds present in whole papaya fruit.. Also, it further details the various traditional and novel extraction procedures of the bioactive compounds. Further, the chapter various previously studied bioactive compounds from papaya peel related to their extraction, characterization, the encapsulation technique of bioactive compounds for food application. At last, the chapters brief the different functional foods employed for various physiological attributes along with the research gap and objectives to conduct the study.

Chapter 2 summarizes the literature review on the whole papaya fruit and great medicinal potential along with its traditional use to cure a variety of human diseases. The major stress is given on the by-products produced from papaya processing industries which could be a potential hazard to environmental pollution. Further the chemical constituents of papaya peel have been reviewed in detail with a brief description of several biologically active molecules (phenolic compounds, flavonoids, coloring pigments, proteins, dietary fibers, and vitamins), which can be utilized for various applications in the food, pharmaceutical, cosmetic and textile industries. Additionally, an overview of different technologies used to extract bioactive compounds from various sources has been briefly discussed, along with their mechanisms, process, advantages, disadvantages, and process parameters. Moreover, this chapter provides concise details on the freeze drying process for extracted compounds, as well as the spray drying technique for fruit juice. Furthermore, it explores the practical application of extracted bioactive compounds in the development of functional food products, as well as the versatile application of papain in various domains such as food processing, pharmaceuticals, and cosmetics. It highlights the potential of bioactive compounds in enhancing the nutritional and health benefits of food products, while also showcasing the diverse uses of papain in different industries.

Chapter 3 investigated the effect of pretreatment such as microwave-assisted (900 W) and enzyme-assisted (1mL) and type of solvent on kinetics of ultrasound-assisted extraction (0, 15, 30, 45, 60, 75 and 90 min.) of bioactive compounds and antioxidant activity from papaya peels was investigated. The enzyme used was viscozyme and the solvents used were water, ethanol, and their combination (1:1). The effect of combination of pretreatments was also studied. All analyses were carried out in triplicates. Phytochemical

properties like total phenolic content, total flavonoid content, 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging activity, was performed for the samples taken out at each interval. The data from the experiments were fitted to second order kinetic model and Langmuir model. The bioactive compounds from the best extraction techniques will be freeze drying for further application in the food processing.

Chapter 4 investigates the behavior of papain enzyme (cysteine protease) in an aqueous two-phase system (ATPS) comprising polymer/salt. Considering the excluded volume effect, polyethylene glycol (PEG) with a molecular weight of 6000 g/mol was used to form the ATPS. Sulphate salts (ammonium sulphate and sodium sulphate) were chosen to form phases owing to their ability to promote the hydrophobic difference between the phases. As per the preliminary experiments, a suitable amount of PEG (6000 g/mol) with various concentrations (10%, 12%, 14%, and 16%), ammonium sulphate (10%, 12%, 14%, 16%, and 18%, w/w), sodium sulphate (10%, 12%, 14%, 16%, and 18%, w/w), and 20% (w/w) crude feedstock were chosen for this study. As per the different combinations, polymer and salts were weighed to prepare phase systems in 50 mL graduated centrifuge. The required quantity of distilled water was then added to the mixture, bringing the final volume to 50 mL. The content was thoroughly homogenized for equilibration, and phase separation was then accomplished by centrifuging at 7000 rpm for 10 min. Then, cysteine protease activity of top phase and bottom phase were assessed. Further the best condition given maximum protease activity was compared with the ethanol extraction conventional technique. In addition, the chapter also includes the SDS-PAGE (Sodium dodecyl-sulfate polyacrylamide gel electrophoresis) patterns and Gel permeation chromatography of cysteine protease partitioned from papaya peels.

Chapter 5 aimed to enrich the spray-dried watermelon juice (SWP) powder with freeze-dried phytochemical compounds extracted from papaya peel (FPP), considering the surging consumer demand for health promoting food properties. To achieve this, firstly, the watermelon juice was spray dried with different concentrations of maltodextrin (MD) (3% and 5%) at different inlet temperatures (130°C, 140°C and 150°C). Moving ahead, the best combination was selected based on moisture content, water activity, dissolution measurement, color, lycopene content, and particle density parameters, respectively. The optimized powder was enriched by the freeze-dried phytochemical extract at different concentrations (0.5%, 1%, 1.5%, 2 and 2.5%). Further, total phenolic content, antioxidant activity, and sensory analysis were carried out to confirm the enrichment.

Chapter 6 has been studied the enzymatic tenderization with papain, a tropical plant enzyme derived from papaya peel. This research has been evaluated papain influence on cut mutton and chicken meat using dipping method. Different concentration of papain (0.025%, 0.05%, 0.075%, 0.1%, 0.125%, 0.15%, 0.175% and 0.2%) was added in solution and then the cut meat was dipped in a specific concentration. Texture profile analysis, cooking profile and sensory evaluation were performed to determine the tenderness of meat, respectively. This experiment confirms that papain is a proteolytic enzyme that causes improvement of meat quality.

Chapter 7 summarizes the complete work of extraction of bioactive compounds from papaya peel using different novel extraction technique and to determine the optimum condition with minimum influence of the bioactive compounds. Effect of various solvents and pretreatments were performed to extract the bioactive compounds using UAE. Enzyme-water (E-W) gave higher values of the responses as compared to other treatments which was the aim of optimization. The extracted bioactive compounds were preserve using the freeze drying. The freeze dried powder was used for the development of functional food to increase the utility of papaya peel. Secondly, ATPS, a downstreaming process was used to extract and purify the papain enzyme from the papaya peel. The full factorial design was used to optimize the condition. The extracted enzyme was used for the meat tenderization.