Encapsulation of Bioactive Compounds from Papaya Peels in Alginate Beads for Anti-Diabetic Applications

Anas Iqbal*, Muhammad Hamza, Muhammad Hafeez, Syeda Fatima
Biosciences Department, Mohammad Ali Jinnah University (MAJU), Karachi, Pakistan.
*E-mail: anasiqb621@gmail.com

ABSTRACT

Introduction: Papaya peel is one of the major by products produced by the use of Carica papaya for fresh fruit consumption and juice production. Generally, it is known as waste, papaya peels are rich in many bioactive phytochemical among these phenolics and flavonoids are abundant. They have gained increasing scientific interest based on their pharmacological potential. Recent progress in green biotechnology and nutraceutical studies highlights fruit wastes as less expensive, environmentally friendly, and available material for the development of therapeutic agents. Out of their most important biological activities, these phytochemicals have also antidiabetic applications by inhibiting the enzyme α-amylase which have gained attention in scientific studies. The α-amylase enzyme plays a important role in the breakdown of starch and in result glucose releases: hence, inhibition of α-amylase can be a promising strategy for managing postprandial hyperglycemia which is associated with type 2 diabetes. This research aims to observe the phytochemical profile, inhibitory action of α-amylase, encapsulation of papaya peel extract for controlled release & to find out its importance for future pharmaceutical applications.

Objectives: The primary objectives of the research are:

1. To extract and identify the major compounds like total flavonoid and phenolic content from papaya peels.
2. To determine the phenolics and flavonoids compounds using high-performance liquid chromatography (HPLC).
3. To check the α-amylase inhibitory action of papaya peels extract for its anti--diabetic applications.
4. To encapsulate the extract in sodium alginate beads for more protection, stability, and controlled release of phenolics & flavonoids.
5. To perform safety related analyses, including acid-insoluble ash determination, to check the purity and quality of the papaya peels.

Methodology: The fresh peels of Carica Papaya were washed, dried and turned into fine powder through grinder. The extraction of bioactive compounds was done using methanol to get a concentrated extract rich in phenolics and flavonoids. The total amount of flavonoid was determined by the USSR method and the amount of flavonoid was measured in mg of catechin equivalent per gram of extract. After that HPLC was conducted to determine the presence of important phytochemicals which gives a chemical profile of the extract. Then the amylase inhibitory test was performed to find the percentage of enzyme inhibition by extract under controlled conditions. The ionic gelation using sodium alginate was used to encapsulate the extract as beads to increase its delivery and stability of the active compounds. We checked the encapsulation efficiency and the bead formation to ensure that the maximum level of phytochemicals is enclosed in beads. To check the safety of the powdered of papaya peels, acid-insoluble ash contents were determined to check the level of inorganic residues, digestibility, and contamination present in the powdered product of Carica Papaya Pees. All experimental data were properly aligned to the relevant analysis to make the data accurate and reproducible.

Key Findings: Papaya peel extract has been shown to have high total flavonoid content (126 mg CE/g), which proves that this extract is rich in antioxidant and therapeutically useful compounds. The HPLC profiling showed us that there are a number of important phenolic and flavonoid molecules, which supports

the scientific principle of studying the pharmacological importance of the extract. The alpha-amylase inhibition test showed that the extract has a high level of inhibitory activity, which means that it has the potential to change the degradation of starch and, consequently, the level of postprandial glucose. Sodium alginate bead encapsulation of the extract provided an effective way to enclose bioactive compounds in the extract and allow slow and controlled release. The beads were homogenous, constant, and efficient in the preservation of the integrity of the encapsulated compounds. The tests of safety revealed a good level of acid-insoluble and soluble ash, representing high purity and low levels of contamination of the plant material.

Conclusion: It has shown that papaya peels are a rich source of bioactive compounds that have great antioxidant and antidiabetic properties and are easily available because they are agricultural waste that is easily available. This study offers a framework of the use of the fruit waste to make therapeutic products through extraction, phytochemical profiling, enzyme inhibition, and encapsulation. The exciting results of α-amylase inhibition and sustained release of the encapsulated extract has the potential to manage type 2 diabetes. Moreover, the results advance a wider trend in a circular practice of bioeconomy, in which the food processing by-products are converted into high-value functional products instead of dumped. The strategy will encourage sustainability, minimise wastage and create new avenues of creating greener drugs and health care innovation.

Keywords: Carica Papaya, α-amylase Inhibition, Bioactive Compounds, Diabetes Management, Sodium Alginate Encapsulation.

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