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# Evaluation of Microencapsulation Formulation of Breadfruit (*Artocarpus Altilis L*) Ethanol Extract

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**ABSTRACT**

Microencapsulation is one of the pharmaceutical technologies used to enhance the stability and effectiveness of herbal active compounds. This study aims to evaluate the formulation of microencapsulated preparations of ethanol extract from breadfruit leaves (Artocarpus altilis L.) using a chitosan–alginate polymer system. The research was conducted experimentally in vitro by preparing microcapsules with extract concentrations of 0.25%, 0.5%, and 0.75%, followed by evaluations including stability testing, moisture content, and floating tests in the rat stomach. The results showed that all formulations were physically stable without any changes in color, shape, odor, or texture over six temperature cycles. The moisture content of the microcapsules ranged from 0.63% to 12.34%, with the lowest value observed at the 0.75% concentration. Floating tests indicated that all formulations had a floating lag time of less than 2 minutes, with the longest floating duration of up to 8 hours at the 0.75% concentration. Based on these results, microencapsulation of breadfruit leaf ethanol extract at a concentration of 0.75% is considered the best formulation and has the potential to be developed as a gastroretentive pharmaceutical preparation.

## INTRODUCTION

As a country with abundant natural resources, Indonesia has the opportunity to become a leader in herbal medicine innovation, while maintaining public health in a more natural and affordable way . This presents Indonesia with the opportunity to develop herbal medicines, which are a prospective and promising industrial product in both local and global markets (Nasri, Kaban, et al. 2023). Pharmaceutical technology is currently developing rapidly, making it easier for the pharmaceutical industry to produce high-quality drugs, particularly in terms of drug stability. Drug stability is crucial because it impacts drug effectiveness, safety, and quality. One technology used in the pharmaceutical industry is microencapsulation. Microencapsulation is defined as spherical particles with sizes varying between 2-5000 µm containing a core substance. Microencapsulation continues to be of great interest in controlled release due to its relative ease of delivery. Not only that, microencapsulation can also protect and maintain active components from environmental influences and is also used to protect the digestive tract, especially the stomach, from irritation caused by active drug ingredients (Mardikasari, 2020).

The application of microencapsulation consists of active ingredients, protective polymers, and solvents. However, this process has its own challenges because it is quite complicated and requires quite high costs. This technology offers a number of advantages, such as hiding undesirable tastes or odors, maintaining the stability of volatile compounds, and increasing the bioavailability of active ingredients. This method is also able to reduce irritation to the digestive tract and ensure effective release of active ingredients (Wati et al., 2022). Differences in production techniques, types of base materials, and coatings can affect the final size of the resulting particles (SK Sari, 2020).

Microcapsule evaluation, such as moisture testing, is important to ensure quality and stability, as high water content can reduce stability and trigger microbial contamination (Wahyuningsih et al., 2020). The floating test assesses the dosage form's ability to adhere to the stomach due to its low density, allowing for gradual and regular drug release (Andini et al., 2022). The temperature cycle stability test was conducted by storing the sample alternately at ±4 $^{\circ}$C and ±40 $^{\circ}$C for 24 hours each, in six cycles (Indriaty et al., 2022). The purpose of microencapsulation is to increase the stability of the active ingredient in the dosage form during storage, create a sustained-release dosage form, protect the active ingredient from decomposition in gastric fluids, and can be used to protect the digestive tract, especially the stomach, from irritation caused by the active ingredient in the drug.

The use of herbal plants as an alternative therapy is known to not only provide physical benefits but also contribute to improving an individual's quality of life. (Harahap Harnis and Rezeky 2022) reported that the use of natural ingredients can help reduce stress and anxiety, thereby supporting psychological well-being. One herbal plant with potential for development is breadfruit leaves (Artocarpus altilis L.), which have various pharmacological activities.

One of the plants that is believed to be able to be used as medicine is breadfruit (Artocarpus altilis), which is a herbal plant that has many benefits. This plant is able to grow in various places due to its high adaptability. Anti-inflammatory: Breadfruit leaf extract Phytochemical Screening of Breadfruit leaves (Artocarpus Altilis) has significant anti-inflammatory activity, so it can be used as a natural anti-inflammatory drug (Rohman et al., 2020). Breadfruit leaves have strong antibacterial activity against *Escherichia coli* and

*Staphylococcus aureus bacteria*, so it can be used as a natural antibacterial drug (Widowati et al., 2020). Breadfruit leaf extract has significant antioxidant activity, so it can be used as a natural antioxidant drug (Sulistiyani et al., 2020). Breadfruit leaves have significant antidiabetic activity, so they can be used as a natural antidiabetic drug (Kumar et al., 2022). Breadfruit leaf extract has significant anticancer activity, so it can be used as a natural anticancer drug (Rahman et al., 2023). Therefore, one of the plants that can be used as medicine is the breadfruit plant (*Artocarpus altilis*) (Fiana et al., 2020).

Based on previous research by Mardikasari et al., (2020) which used chitosan and alginate polymers. With this research, it is hoped that the microcapsule preparations formed are in accordance with the literature which can be seen from the results of stability tests, water content tests, and floating tests to see the ability of the microcapsule preparations to survive on the gastric mucosa for 2 hours.

## METHOD

This research was conducted at the Integrated Laboratory of Prima Indonesia University from October 2025 to December 2026 using an in vitro experimental research design. The activities carried out in this study included extract preparation, microencapsulation, and microencapsulation evaluation using stability, water content, and floating tests in the stomach.

Tools and materials

The tools consist of pH meter, rotary vacuum evaporator, magnetic stirrer, petri dish, analytical balance, stopwatch, ether, glass object, surgical scissors, tweezers, 5 cc injection syringe, tablet disintegration, and glassware commonly used in the laboratory. The materials consist of breadfruit leaves (*Artocarpus altilis L*) 96% ethanol, ether, 0.2 N NaOH, sodium alginate, chitosan, 0.15 M CaCl2, NaCl, HCl, and distilled water.

Procedure

a. Making breadfruit leaf extract (*Artocarpus Altilis L*)

   Breadfruit leaf extraction was carried out using the maceration method using 96% ethanol with a ratio of (1:10) for 3 days, then a stirring process was carried out every 24 hours at room temperature. The macerate was filtered, then the filtrate was separated, and the soaking was repeated twice in new solvent. Then the filtrate was concentrated with *a rotary evaporator* at a temperature of 60 ° C until a thick extract was obtained (Khanifah et al., 2022).

b. Making microcapsules from breadfruit leaf extract (*Artocarpus Altilis L*)

   The preparation of microcapsules begins by dissolving 2 grams of sodium alginate in a small amount of distilled water in a beaker glass while stirring using a magnetic stirrer until homogeneous. Then, add 0.75 grams of chitosan with a small amount of distilled water, stir until evenly mixed. The ethanol extract of breadfruit leaves is then mixed in three concentration variations, namely, 0.25 grams, 0.5 grams, and 0.75 grams with the addition of distilled water until it reaches 100 ml. Each formulation is then dripped into 50 ml of 0.15 M CaCl2 solution using a 5 cc syringe to produce wet microcapsule granules. The resulting granules are soaked briefly in 0.15 M CaCl2 solution, then filtered and dried at 45 ° C for 24 hours before testing (Mardikasari et al., 2020).

Evaluation of Preparations

a. Microencapsulation Stability Test of Breadfruit Leaf Ethanol Extract

   The microcapsules are placed into a previously prepared sterile container.

The microcapsules were then stored at 4 ° C for 24 hours, then transferred to 40 ° C for another 24 hours. This process was repeated six times, with observations made at each cycle to detect any changes (Aqsyal & Mardiyanti, 2023).

b. Testing the Water Content of Microencapsulated Breadfruit Leaf Ethanol Extract

The petri dish was previously dried in an oven at 110 ° C for 1 hour. Next, the petri dish was cooled in a desiccator for 30 minutes and weighed to obtain the initial weight. A total of 2 grams of microcapsules were placed into the dish and then heated in an oven at 110 ° C for 2 hours. After going through the heating process, the petri dish was cooled again in a desiccator for 30 minutes and weighed to obtain its weight. This heating and weighing process was repeated until a stable weight was obtained (D. Sari et al., 2024). Then measure the water content in the sample using the following formula (Nasria et al., 2024):

Water content (%) = (Initial weight − Final weight) / Initial weight x 100%

c. Making Gastric Fluid

Gastric fluid is made by mixing 2 grams of NaCl into 250 ml of distilled water and putting it into an Elenmeyer flask. Then, add 7 ml of concentrated HCl and stir until evenly mixed. The solution is then diluted with distilled water until it reaches a volume of 1 liter. The pH of the solution is measured to ensure it is within the range of 1.2±0.1. (Wardatun et al., 2020).

d. Preparation of Gastric Mucosal Membrane

This study used mice with an average weight of 250 grams that had been fasted for 24 hours before being treated. After being anesthetized with ether, abdominal surgery was performed to remove the stomach organs. Then the removed organs were cleaned with physiological NaCl solution (Wardatun et al., 2020).

e. Floating Microencapsulation Test of Breadfruit Leaf Ethanol Extract

Fifty microcapsules were inserted evenly into the gastric mucosa of mice. Then, the mouse's gastric mucosa tissue was placed on a glass slide and inserted into a disintegrity tester containing a medium in the form of gastric fluid. The testing tool was run with a movement frequency of 30 times per minute at a temperature of 37 ± 0.5 ° C. Observations of the microcapsules attached to the gastric mucosa were made every 30 minutes for 2 hours (Wardatun et al., 2020).

## RESULTS AND DISCUSSION

Microencapsulation Stability Test Results

**Table 1.** Results of the Stability Test of Breadfruit Leaf Ethanol Extract

| Microencapsulation Concentration | Color | Form | Smell | Texture | Changes during the cycle |
|---|---|---|---|---|---|
| Blank | Cream | Round | Odorless | Solid and not brittle | No changes |
| 0.25% | Brick red | Round | Typical breadfruit leaves | Solid and not brittle | No changes |
| 0.5% | Brick red | Round | Typical breadfruit leaves | Solid and not brittle | No changes |
| 0.75% | Brick red | Round | Typical breadfruit leaves | Solid and not brittle | No changes |

Microencapsulation Water Content Test Results

**Table 2.** Results of Water Content Test of Breadfruit Leaf Ethanol Extract

| Concentration | Initial Weight (g) | Final Weight (g) | Percentage Level (%) |
|---|---|---|---|
| Blank | 46.45g | 46.31g | 0.30% |
| 0.25% | 53.55g | 49.90g | 6.81% |
| 0.5% | 56.52g | 49.54g | 12.34% |
| 0.75% | 51.88g | 51.55g | 0.63% |

Results of Floating Test on Rat Stomach

**Table 3.** Results of Floating Test on Rat Stomach

| Microencapsulation Concentration | Floating Lag Time (minutes) | Floating Lag Time (hours) |
|---|---|---|
| Blank | < 2 minutes | 4 hours |
| 0.5% | < 2 minutes | 6 hours |
| 0.25% | < 2 minutes | 4 hours |
| 0.75% | < 2 minutes | 8 hours |

Microencapsulation Stability Test of Breadfruit Leaf Ethanol Extract

The results of the stability test shown in Table 1 show that all microencapsulation formulations, both blank and extract concentration variations of 0.25%, 0.5%, and 0.75%, did not experience changes in color, shape, odor, or texture during six cycles of low temperature (4°C) and high temperature (40°C) storage. This condition indicates that the chitosan-alginate-based microencapsulation system used is able to protect the ethanol extract of breadfruit leaves from extreme environmental influences. This good physical stability is in line with the research of Al-farini et al. (2025) and Stevi et al. (2025) who reported that the combination of chitosan and alginate polymers can form a strong gel matrix, thereby maintaining the integrity of the microencapsulated particles during storage.

The absence of changes in texture and brittleness also indicates that the cross-linking between alginate and Ca2+ ions occurs optimally, forming a stable microcapsule structure. These results are consistent with the research of Mai et al. (2025) on the microencapsulation of white turmeric extract which showed good physical stability at various temperature cycles. Thus, the microencapsulation formulation of breadfruit leaf ethanol extract in this study has met the physical stability requirements of pharmaceutical preparations.

Microencapsulated Water Content Test of Breadfruit Leaf Ethanol Extract

Based on Table 2, the water content of microencapsulation showed variations influenced by the extract concentration. The formulation with a concentration of 0.5 % had the highest water content of 12.34%, while the concentrations of 0.25% and 0.75% showed water contents of 6.81% and 0.63%, respectively. The relatively low water content at a concentration of 0.75 % indicates that increasing the amount of extract can contribute to a denser matrix structure, thereby reducing the ability of the particles to absorb water.

These results are in line with the research of Kesehatan dan Prima (2025) on microencapsulation of Chinese betel leaf herb extract, which stated that differences in active ingredient concentrations can affect water content through changes in the porosity of the polymer matrix. Water content that remains within safe limits is important to maintain microencapsulation stability, because high water content can trigger degradation of active ingredients and the growth of microorganisms. Thus, the microencapsulation formulation of breadfruit leaf ethanol extract, especially at a concentration of 0.75 %, shows the most optimal water content characteristics.

Floating Microencapsulation Test in Rat Stomach

The floating test results in Table 3 show that all microencapsulated formulations had a floating lag time of less than 2 minutes, indicating rapid floating ability in gastric fluid medium. Differences were seen in the duration of floating time, where the 0.75 % formulation was able to survive up to 8 hours, longer than other concentrations. This indicates that increasing the extract concentration affects the density and structure of the microcapsules, thereby increasing adhesion and retention capabilities in the gastric mucosa.

This finding is in line with the research of Al-Farini et al. (2025) and Mai et al. (2025) who reported that floating microencapsulation preparations with chitosan-alginate matrix were able to increase the residence time of drugs in the stomach. Good floating ability is very important for gastroretentive drug delivery systems, because it can extend the contact time of the active ingredient with the gastric mucosa, thus potentially increasing the bioavailability of breadfruit leaf extract which has pharmacological activities such as anti-inflammatory and antioxidant (Rahmat et al., 2025).

## CONCLUSIONS AND RECOMMENDATIONS

Based on the research results, it can be concluded that microencapsulation of breadfruit leaf (*Artocarpus altilis L.*) ethanol extract with a chitosan-alginate system produces a physically stable preparation, has a water content that is still within safe limits, and shows good floating ability in the stomach. The formulation with an extract concentration of 0.75 % is the best formulation because it has good stability, the lowest water content, and the longest floating time. These results indicate that microencapsulation has the potential to improve the quality and effectiveness of breadfruit leaf extract as a candidate for gastroretentive pharmaceutical preparations.

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