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EVALUATING THE EFFICACY OF ENCAPSULATED-EGGPLANT PEEL EXTRACT AS A POTENTIAL ANTIOXIDANT SUPPLEMENT

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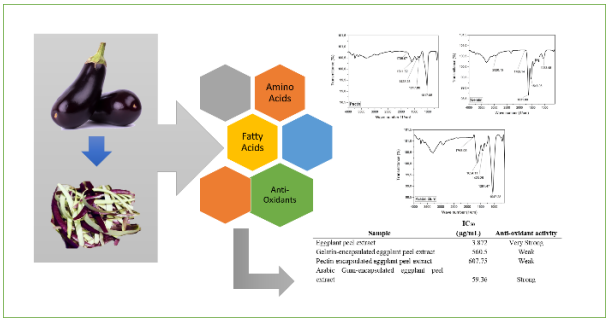
Graphical abstract



Abstract

This study aims to provide in-depth insight into the potential of encapsulated-eggplant peel as an anti-oxidant supplement, which could be a basis for the development of new therapies or products in the fields of health and nutrition. To overcome the shortcomings of eggplant peel extract, in this research, an encapsulation of eggplant peel extract was carried out using pectin, gelatin, and gum arabic to increase the absorption capacity of antioxidants, the shelf life, bioavailability of anti-oxidant compounds, and their effectiveness as a supplement. The results from morphological and functional group observation showed that encapsulation was done successfully. Eggplant peel extract had the highest antioxidant activity as indicated by the need for only 3.872 g of extract to reduce the number of radicals by 50% (IC50), followed by encapsulated eggplant peel extract using gum arabic, gelatin, and lastly pectin. The results obtained indicate that the encapsulation process of eggplant peel extract has been carried out well and this product has the potential to be used as an anti-oxidant supplement.

Keywords: Eggplant peel, encapsulation, anti-oxidant, supplement, extraction

1.0 INTRODUCTION

Living in a modern era filled with environmental pollution and unhealthy lifestyles, the increased risk of developing chronic diseases such as cancer, diabetes, and heart disease has triggered researchers to look for natural solutions to improve health and prevent the body from contracting disease. Anti-oxidants are known as an important natural solution to improve health and prevent the body from disease. They work by fighting free radicals, molecules that can cause cellular damage and lead to various degenerative diseases [1]. By introducing more anti-oxidants into the daily diet, either through natural foods or supplements derived from natural sources, the body's resistance to disease will increase and this is an effort to promote overall good health. The use of antioxidant compounds is a highly appreciated approach in the world of health and nutrition, as it helps people maintain their health naturally and effectively [2].

Anti-oxidant compounds can be divided into synthetic and natural anti-oxidants. Synthetic anti-oxidants are compounds produced from chemical processes, while natural anti-oxidants are obtained entirely from natural sources (e.g. plants, fruit, algae) and have been used in the food, cosmetics and

pharmaceutical industries for some time. Even though they are known to have many advantages such as having high solubility and being more stable at high temperatures, which means they better support the food production process, natural anti-oxidants are still less frequently used for commercial products due to their high price and complicated production. Synthetic anti-oxidants are easier to obtain and can be mass produced, thereby reducing production costs [3], [4].

Synthetic anti-oxidants are chemical compounds created in laboratories to mimic or enhance the effects of natural anti-oxidants found in food and the human body. Although they are cheaper, easier to produce, and can provide benefits in inhibiting cell damage caused by free radicals, the use of synthetic anti-oxidants can also cause some side effects. Some synthetic anti-oxidants in high doses can produce pro-oxidative effects, meaning they can increase oxidative damage to cells. In addition, several studies show that long-term use of certain synthetic anti-oxidants can disrupt the hormonal system in the body, damage the kidneys, disrupt the digestive system, and increase carcinogenic risks [5], [6], [7]. Currently there is an urgent need to look for alternative natural anti-oxidants which are certainly safer and more effective [3], [8].

Eggplant peel waste is known to contain relatively high levels of anti-oxidant compounds. Research results from previous research show that eggplant peel contains anti-oxidant compounds from the phenol, tannin, anthocyanin, and flavonoid groups [9]. By using an extraction process using 70% methanol solvent, high levels of phenolic compounds will be obtained, while using acetone solvent, the extract obtained will contain higher levels of tannin and anthocyanin. In this research, extracts from eggplant peel waste will be used as a source of natural anti-oxidants. Apart from the selected extract process using a method that is easy to carry out, the main ingredient in the form of eggplant peel can be easily obtained in large quantities. However, like other natural antioxidant compounds, the compounds contained in eggplant skin extract also have high sensitivity to processing and storage conditions. In addition, these antioxidant compounds also have low bioavailability, which causes limited applications in the food and health sectors. These various problems must be resolved to maximize the potential of eggplant skin extract [10], [11].

Previously, several studies have demonstrated the antioxidant potential of eggplant, but our study took it a step further by evaluating the anti-oxidant activity of the waste parts of eggplant, especially the peel. To overcome the shortcomings of eggplant peel extract, in this research an encapsulation method was carried out with certain ingredients to increase the absorption capacity of anti-oxidants, the shelf life of antioxidants, bioavailability, and their effectiveness as a supplement. In the food and pharmaceutical industries, encapsulation techniques have become a common strategy to increase anti-oxidant effectiveness and ensure product stability. Anti-oxidant encapsulation is the process of encapsulating antioxidant substances in a material or capsule to protect it from factors that can reduce its stability or effectiveness. Encapsulated anti-oxidants are better protected from exposure to oxygen, light, or temperature which can cause degradation or loss of antioxidant activity [12], [13]. In addition, encapsulation can increase the stability of anti-oxidants during storage and processing, maintaining the quality of products containing anti-oxidants and the release of anti-oxidants can be controlled and regulated, allowing for slower and more sustained delivery within the body or desired system. Several studies also reveal that encapsulation can increase the absorption and bioavailability of anti-oxidants [14].

This study aims to provide in-depth insight into the potential of coated eggplant peel as an anti-oxidant supplement, which could be a basis for the development of new therapies or products in the fields of health and nutrition. The findings from this research have the potential to make a significant contribution to the development of natural supplements that can help people maintain their health in a safe and effective manner. If proven effective, encapsulated eggplant peel-based antioxidant supplements could be an interesting alternative for improving health and quality of life.

2.0 METHODOLOG

2.1 Preparation of Raw Materials

The collected eggplant peels were washed to remove dirt and then dried in the sun for a period of 3 (three) days. The dried eggplant peel was then ground so that the particle size becomes smaller (powder size) and uniform. The eggplant peel powder was then stored in an airtight container to maintain its durability.

2.2 Extraction of Anti-Oxidant Compounds from Eggplant Peel

The extraction process was carried out using the maceration method. The solvent used is 96% v/v ethanol. Dry powder of eggplant peel waste (2.5 g) was extracted with 50 mL of 96% v/v ethanol. Extraction was carried out by soaking eggplant peel powder in 96% v/v ethanol solvent in an airtight container for 3 (three) days at room temperature. After the soaking process, the solution was stored in a refrigerator until used/characterized.

2.3 Encapsulation of Anti-Oxidant Compounds from Eggplant Peel

The encapsulation process was carried out by simple mixing and drying. The obtained eggplant peel extract was mixed with a coating in the form of a 5% w/w gum arabic/pectin/gelatin solution. Mixing at a ratio of 1:1 eggplant peel extract and coating solution was carried out using an overhead stirrer for 15 minutes at a speed of 2000 rpm. Then the drying process was carried out using an oven for 4 hours at a temperature of 40^{o}C.

2.4 Analysis and Characterization

The eggplant peel extracts and eggplant peel anti-oxidant supplements that were obtained were tested for their properties, especially their main components and anti-oxidant activity. Apart from that, the surface-section of the encapsulated by gelatin, pectin and gum arabic were also observed using Scanning Electron Microscope (SEM), functional groups using Fourier Transform Infrared Spectroscopy (FTIR). The release profile of eggplant peel extract which had been encapsulated by gelatin, pectin and gum arabic were also observed by immersing the encapsulated extracts in buffer solution pH 6. The number of extracts released in the solution were measured using UV-Vis spectroscopy at 520 nm [15].

3.0 RESULTS AND DISCUSSION

3.1 Analysis of Eggplant Peel Extract Preparation

The content of eggplant skin that has gone through the extraction process was analyzed using Gas Chromatography-Mass Spectrophotometry (GC-MS), the results of which can be seen in Figure 1. The graph of the characterization results shows that the content of eggplant skin extract is mostly 1,2,3,5-cyclohexanetetrol, (1a,2ß,3a ,5ß)-, tetradecanoic acid, n-hexadecanoic acid, dihydroxyacetone, octadecanoic acid, desulphosinigrin, D-Alanine, 2-Hydroxy-5-methylbenzaldehyde, cis-Vaccenic acid, 2-Deoxy-D-galactose, Methyl 9-cis. These compounds are known to belong to a group of fatty acids, amino acids, and anti-oxidants.

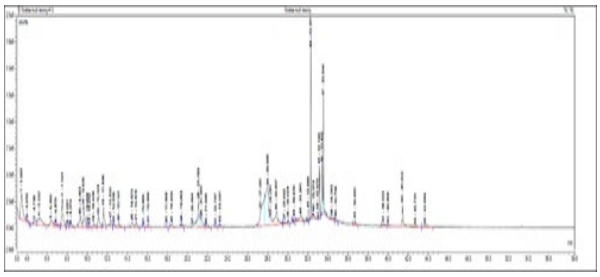


Figure 1 GC-MS analysis on Eggplant Peel Extract

Previous studies have stated that groups of fatty acids, amino acids, and anti-oxidants are often found in extracts from parts of plants and fruit. Previous research also revealed that extracts from eggplant peel using acetic acid solvent can produce extracts with high anti-oxidant content in the form of glycosides and phenolic compounds [16]. Meanwhile, there is other research that tried to analyze the content of other parts of eggplant, namely roots, leaves, stems and fruit parts. In this research, it was discovered that the extract obtained contained anti-oxidant compounds in the form of phenolic compounds, flavonoids, anthocyanins, tannins, saponins and alkaloids [17].

3.2 Observation of Surface-Sections and Functional Groups in Encapsulated Eggplant Peel Extract

The surface of the encapsulation on eggplant peel extract was observed using Scanning Electron Microscopy (SEM) characterization. Observations were carried out on each coating material, namely pectin, gelatin and gum arabic with 3500x and 10000x magnification. The observation results which have been attached as Figure 2 show that the surface of the layers is increasingly rough in the order of pectin, gelatin and gum arabic. Furthermore, the three layers show a less homogeneous surface. This could be caused by the viscosity of the coating solution based on pectin, gelatin and gum arabic itself. Even though all three can dissolve well in pure water, gum arabic and gelatin produce a thicker solution than pectin at the same concentration.

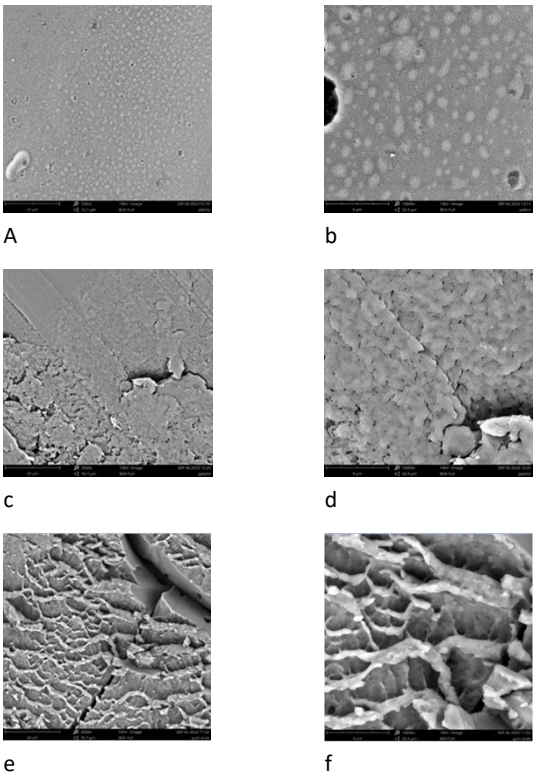
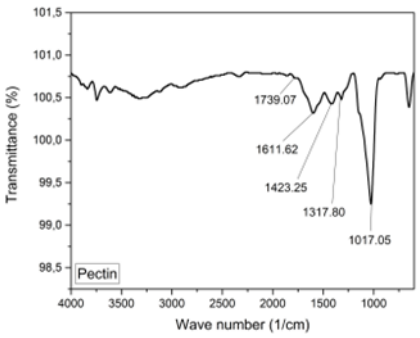


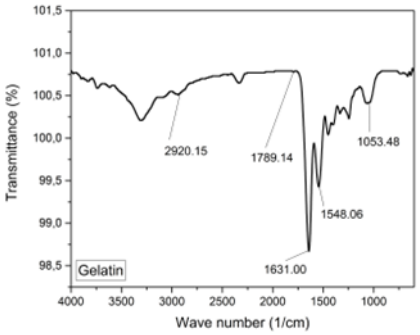
Figure 2 Surface sectional image of encapsulated eggplant peel extract: a. Pectin (3500x); b. Pectin (10000x); c. Gelatin (3500x); d. Gelatin (10000x); e. Gum arabic (3500x); f. Gum arabic (10000x).

The uniformity of the encapsulation surface is one of the things that needs to be considered when encapsulate the extract solution. A homogeneous solution will provide an even distribution of the active ingredient throughout the encapsulation process. This can result in more uniform and consistent microcapsule formation [18]. Part from that, the homogeneity of the solution can also affect the stability of the resulting microcapsules. Even distribution of ingredients in a solution can help prevent undesirable physical or chemical changes during storage or use. If encapsulation aims to increase the bioavailability of the active substance (i.e. the body's ability to absorb and use the active substance) and its effectiveness, homogeneity of the solution is a key. With a homogeneous solution, the active substances tend to be distributed more evenly in the microcapsules, which can optimize the process of releasing and absorbing the active substances by the body [19].
The success of encapsulating eggplant peel extract using 3 different materials is also proven by the results of observing functional groups using Fourier Transform-Infra Red (FT-IR) which can be seen in Figure 3. The characteristic band spectrum of the eggplant skin surface is in the form of peaks at 1737 and 1631 cm^{-1} corresponding to carboxylic acids and carboxylate functional groups indicate the presence of C=O groups seen in all three samples [20], [21]. In Figure 3a, the presence of pectin can also be seen which is marked by the appearance of peaks at wave numbers 1423.25, 1317.80, and 1017.05 cm^{-1} which indicate the presence of $–CH_2$ scissoring, –OH bending vibration peak, and –CH–O–CH– stretching, sequentially [22], [23]. Meanwhile, Figure 3b. shows the presence of C=O stretching which is marked by the presence of a peak at 1548.06 cm^{-1}, C–H stretching which is marked by peaks at 1053.48 cm^{-1} and 2920.15

cm^{-1} which is characteristic of the presence of gelatin [24], [25]. In Figure 3c, it could be seen that there is presence of gum arabic with a characteristic peak in the area of 1600 cm^{-1} and at wave number 1423.25 cm^{-1} due to asymmetric and symmetric stretching vibration of the carboxylic acid salt -COO-. Apart from that, the bands at 1291.47 cm^{-1} and 1047.28 cm^{-1} due to the stretching of the C-O bond are also visible [26].



A



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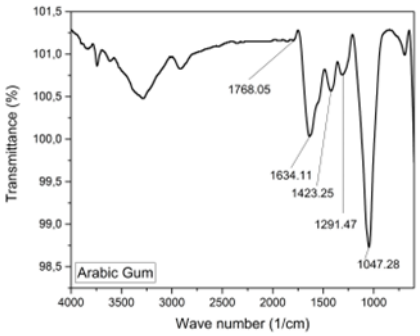

C

Figure 3 Functional group of encapsulated eggplant peel extract using: a. Pectin; b. Gelatin; c. Arabic Gum

3.3 Antioxidant Activity of Encapsulated Eggplant Peel Extract

The antioxidant activity of the extract obtained was measured using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. DPPH antioxidant activity is one method commonly used to measure the antioxidant capacity of certain compounds or materials. DPPH is a radical-free organic compound that is purple in color, and can react with antioxidants present in the test sample. The results of the DPPH test at a wavelength spectrum of 517 nm can be seen in Table 1.

Eggplant skin extract without encapsulation process showed the highest anti-oxidant activity as indicated by the need for only 3.872 µg of extract to reduce the number of radicals by 50% (IC_{50}). Meanwhile, for extracts that had been encapsulated with pectin, gelatin, and gum arabic, the amount needed to reduce the number of radicals by 50% increased by 560.5, 607.75, and 59.36 µg. The results of the anti-oxidant activity test on eggplant peel extract without encapsulation are in line with research conducted by Diatta, et al (2020) which reported that the average IC_{50} value for eggplant was 3.37 µg/mL [27].

Table 1 Anti-oxidant activity on eggplant peel extract and encapsulated eggplant peel extract

Sample	IC_{50} (µg/mL)	Anti-oxidant activity
Eggplant peel extract	3.872	Very Strong
Gelatin-encapsulated eggplant peel extract	560.5	Weak
Pectin-encapsulated eggplant peel extract	607.75	Weak
Arabic Gum-encapsulated eggplant peel extract	59.36	Strong

A decrease in the activity of encapsulated anti-oxidants can be caused by the method, temperature or length of time the encapsulation process was carried out. Meanwhile, for coating materials, encapsulation with arabic gum showed the best performance which may be due to the higher viscosity and roughness on the coating surface compared to the other two coating materials. This will make the eggplant peel extract contained in it slower to release from the coating and it will be better protected from compounds that might react with anti-oxidant compounds and reduce their activity.

3.4 Release of Eggplant Peel Extrac

The ability to release eggplant peel extract from the encapsulation was tested in a buffer solution with pH 6. The results obtained can be seen in Figure 4. The graph in Figure 4 shows that there was a burst release at the beginning of time using both pectin, gelatin and gum arabic encapsulation. After that, the extract was released gradually and in the sixth hour, the pectin encapsulation was able to release 92% of the extract, the gelatin encapsulation released 83%, and the gum arabic encapsulation released 65% of the eggplant skin extract. This can happen because the longer the time, the more degraded the coating used is and more of the eggplant peel extract can be released into the buffer solution [28].

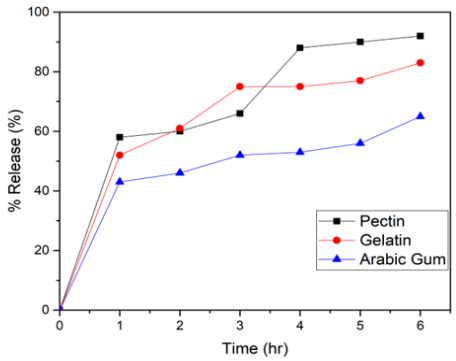

Figure 4 Release profile of eggplant peel extract

Gum arabic encapsulation can withstand shedding longer than the other two materials. This is in line with the results of observing surface morphology using SEM and also the results of anti-oxidant activity where the encapsulation wall formed looks rougher and thicker than the others. This causes more resistance on the encapsulation walls which makes it take longer to degrade and makes the eggplant peel extract slower to diffuse, so coatings with this material can protect anti-oxidant compounds better [28].

4.0 CONCLUSION

The encapsulation process of eggplant skin extract using three different ingredients, pectin, gelatin and gum arabic has been successfully carried out. Gum arabic showed the best performance of the three materials used, as indicated by the best anti-oxidant activity (IC50 of 59.36 μg/mL). Release test showed gum arabic encapsulation has a slower release extract solution compared to encapsulation using pectin and gelatin, where at a release time of 6 hours, gum arabic releases 65% of the extract, while encapsulation with pectin and gelatin has released 92 and 83% of the extract respectively. The results of this study indicate that there is good potential for the development of encapsulated-eggplant peel extract as a natural anti-oxidant supplement.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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