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Encapsulation of Ethanol Extract Perepat Leaves (*Sonneratia alba*) with Maltodextrin Coating as an Antioxidant Functional Food Candidate

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Abstract— Perepat (*Sonneratia alba*) is a plant widely reported to have potential as a natural medicine. Encapsulation technology was developed to prevent damage to bioactive compounds in medicinal plant extracts. This study aimed to analyze the physical and chemical properties of ethanol extract of (*S. alba*) leaves and encapsulants of ethanol extract of perepat leaves with maltodextrin coating material as an antioxidant supplement and analyze the capsule bioavailability. Characterization was carried out using the Fourier Transform Infrared Spectroscopy (FT-IR) method and UV-Vis Spectrophotometer. The results showed that the highest percentage of extract and encapsulation yield was PKL 39.812% and 59.54% respectively. The highest total phenol and flavonoid content of *S. alba* leaf ethanol extract was PKL at 171.88 mgGAE/g and 25.473 mgQE/g, respectively, with the highest antioxidant activity of ethanol extract PKL IC₅₀ 3.544 µg/mL. In addition, the solubility level of encapsulated *S. alba* leaf ethanol extract in water was the highest PKL at 97.950%. The highest total phenol and flavonoid encapsulation was PKL 44.63 (mgGAE/g) and 6.357 (mgQE/g) respectively, with an antioxidant value of IC₅₀ 54.608 µg/mL. Furthermore, the IR spectrum also shows the presence of typical functional groups such as C-H Alkane, C-H Alkene functional group, C-H aromatic ring functional group, O-H functional group, hydrogen bond alcohol/phenol, C=C alkene C=O Carbonyl, single C-OH/C-OR and others confirm the formation of cross-linking in the encapsulation process. This research has shown that the encapsulation of ethanol extract alba leaves had good potential for a functional food candidate.

Keywords— Antioxidant; Bioavailability, Encapsulant, Perepat

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I. INTRODUCTION

Sonneratia alba (perepat) is a mangrove plant that grows in sandy coral reefs and mud [1]. Previous research has shown that *Sonneratia alba* (*S. alba*) leaves extract contains alkaloids, phenolics, triterpenoids, flavonoids, tannins, saponins, steroids, and glycosides [2,3]. *S. alba* belongs to Kingdom Plantae, Family Lythraceae, Genus *Sonneratia*, and Species *Sonneratia alba* [3]. *S. alba* contains flavonoid and phenolic compounds, which are bioactive compounds that can be used as cytotoxic [4], antioxidant, and antibacteri [2,5]. Previous research reported that heating could damage the structure of chemical compounds. Organic compound like, flavonoid and phenolic components are sensitive to heat and quickly oxidize. The

higher the temperature and duration of heat treatment, the lower the phenol content and antioxidant capacity [6]. Encapsulation is a technique of coating active ingredients in the form of solids, liquids and gases that aims to protect the core ingredients in the form of bioactive compounds such as phenolic compounds, tannins, flavonoids and others from various environmental influences such as light, oxygen, water and temperature [7]. Several encapsulation methods based on particle size include freeze-drying, spray-drying, cooling, fluid-bed coating, coacervation, and liposome entrapment [8]. The encapsulation technique with the freeze-drying method is one of the drying methods with low temperatures. The freeze-drying method can encapsulate a material with an encapsulation efficiency of up to 90% [9].

In the encapsulation process, there is also a coating material. This layer aims to protect active ingredients from spoilage, evaporation, active components, stability of volatile materials, and sensitivity to light. It can mask unwanted flavours or aromas of active ingredients [10]. One coating that can be used is maltodextrin because maltodextrin shows good stability against oil oxidation. Maltodextrin can also reduce viscosity and has properties to prevent oxidation so that antioxidants will be well enveloped.

As a functional product, before it can be consumed, the encapsulation needs to be tested for bioavailability using a body pH buffer simulation. Bioavailability (bioavailability) is the percentage and speed of active substances in an encapsulated product that are available in the systemic circulation in whole/active form after administration of the encapsulant product [11]. Determining the bioavailability of an encapsulant can be done by in vitro testing. In vitro test uses pH buffer to determine the amount of encapsulant absorbed in the body.

The purpose of this study was to analyze the physical and chemical properties of ethanol extract of perepat leaves and encapsulants of ethanol extract of perepat leaves from 4 different regions with maltodextrin coating material as an antioxidant supplement and analyze the encapsulation bioavailability of ethanol extract results from *S. alba* leaves.

II. MATERIAL AND METHODS

A. Material and Instrumentation

The materials used in this study were *S. alba* leaves obtained from 4 regions, Tanjung Jabung Timur Jambi Province, Pengudang, Sebong Lagoi and Dompok Riau Islands Province, ethanol, Folin-Ciocalteu reagent, Na₂CO₃ 7%, methanol P.A, gallic acid, AlCl₃, Sodium Acetate, Quarcetine, ascorbic acid, DPPH ((2,2-Diphenyl-1-picrylhydrazyl) (Sigma-Aldrich, Singapore)), aquadest, inulin, tween 80, pH buffer 1.2 and pH buffer 7.4. Instrumentation that used: UV-Vis spectrophotometric spectrophotometer (Thermo-Fisher Orion Scientific AQ-8100, Waltham, MA, USA) with wavelength 200-800 nm and FTIR Spectrophotometer (Thermo Fisher Scientific) at Wavenumbers 4000-400 cm⁻¹ and SEM (Hitachi SU-3500) magnification 500, 1000, 2500 and 5000 x.

B. Methods

Sample preparation and Extraction

The samples are shorted, washed, dried, mashed with a blender, and filtered with a 60-mesh sieve to produce *S. alba* leaf simplistic powder. Simplisia powder was extracted with ethanol (1:5) by maceration for 2x24 hours. Furthermore, the filtrate is filtered with Whatman no 1 filter paper, while the pulp is macerated again with ethanol for 24 hours. This maceration process is carried out three times. The resulting filtrate is then combined into one, after which it is evaporated using a rotary vacuum evaporator at a temperature of 50° C until concentrated, resulting in perepat leaf extract.

Encapsulation

The emulsification was carried out using maltodextrin coatings. The formulation of making a coating solution uses a ratio of 1:1 (Aquadest: Maltodextrin). The formulation of emulsion preparation uses a ratio of 1: 8 (extract: maltodextrin). The samples in this study were grouped into 4 groups, and homogenized using a magnetic stirrer at room temperature at a speed of 700 rpm. The addition of tween 80 by 20 drops (the homogeneous process is carried out for 1 hour), then dried with a freezer-dryer for 8 hours [12].

TABLE 1.
 SAMPLE CODES AND REGIONS

Sample Codes	Regions
PKL	Perepat Kampung Laut, Tanjung Jabung Timur, Jambi
PPG	Perepat Pengudang, Batam, Riau Islands
PLG	Perepat Lagoi, Batam, Riau Islands
PDP	Perepat Dompok, Batam, Riau Islands

Encapsule Percent Yield

The percent yield of the product is calculated to determine how much encapsulation is produced from the encapsulation process by referring to, by calculating the weight of the overall result of the encapsulation product and the total weight of the encapsulant material (coating and emulsifying material), then calculated in percent with the formula 1.

$$\% R = \frac{W_0}{WT} \times 100 \% \dots \dots \dots (1)$$

Where, %R: Product Yield; W0: Microencapsulated weight (g); WT: total weight of microencapsulated material (g).

Water Content of Encapsule

Measurement of the capsule water content of *S. alba* leaf extract using the Thermogravimetric method which is by evaporating water contained in food using heating which then the material is weighed until the weight becomes constant, so that the water content contained in the food has been lost or evaporated. Empty weighing bottles that have been coded for each sample are incubated at 105°C for 2 hours with the bottle cap half open. After 2 hours, an empty weighing bottle is taken from the oven and put into a desiccator for 15 minutes to remove any remaining moisture, then weighed as weight A. The encapsulated samples of crudely prepared extract are each weighed as much as 1 g and put into a weighing bottle that has previously been weighed and known as weight B. The weighing bottle along with the encapsulated sample of crude extract of perepat leaves is then put into an oven that has been set to 105°C for 4 hours. Then put in the desiccator for 15 minutes and weighed as weight C. Meanwhile, to get the percentage of water content in each sample, the following formula is used.

Encapsule Solubility

Solubility is determined referring to previous study with slight modification [12]. 0.1 g encapsulant (a) is put into 10 mL of water at a temperature of 30°C and stirred using a magnetic

stirrer. Then the solution is filtered with Whatman filter paper which has a known fixed weight. Filter paper and unfiltered parts of the sample are put in the oven for 1 hour at 105°C, then cooled in a desiccator for 15 minutes, then weighed. The weight of the unfiltered sample (b) is obtained from the difference between the weight of the final filter paper and the weight of the initial filter paper.

The Total Phenolic and Flavonoid Content

The total phenolic content in both extract and encapsule was measured with the modified Folin-Ciocalteu method. 1 mL samples was added into 0.5 mL Folin-Ciocalteu, shaken, and incubated for 8 min. Furthermore, the samples add 4 mL of Na₂CO₃ (7% v/v) solution and homogenous with aquades (up to 10 mL), then incubate for 2 hr at room temperature. The absorbance was then measured by UV-Vis spectrophotometer at 744.8 nm wavelength. The percentage of total phenolic content was calculated by following the formula 2.

$$TPC = (C \cdot V \cdot DF) / g \times 100\% \dots\dots\dots (2)$$

Information:

- TPC = Total Phenol content
- C = Sample concentration
- V = Volume of extract used
- DF = Dilution factor
- g = Sample weight

The total flavonoid content in extract and encapsulants was measured by following previous studies with slight modifications. Briefly, 80 µL of sample extract was mixed with 80 µL of 2% aluminum chloride and 120 µL of sodium acetate solution (50 g/L) and incubated for 30 min at room temperature. Afterward, the absorbance was measured at 431 nm using a calibration curve of quercetin in an alcohol solution with concentrations ranging from 0 to 50 µg/mL. The results were obtained by subtracting it from the blank and expressed as milligrams of quercetin equivalents (QE) per gram of coffee (mg QE/g) ± the standard deviation (SD) [12].

$$TFC(mgQE/g) = C \times \frac{V}{m} \times DF \dots\dots\dots (3)$$

Notes

- TFC: Total Flavonoids Content
- C : Quercetin concentration (mg/mL).
- DF : Dilution factor.
- m : Extract weight (g).
- V : Volume of extract (L)

Antioxidant Activities

Analysis of antioxidant activity was conducted using the DPPH method (1.1-diphenyl-2-picrylhydrazyl). Antioxidant was carried out triple using ethanol as a blank with four concentration variations of extract and encapsulants. Preparation of the sample solution was weighed as much as 0.02 g of encapsulated ginger dissolved in 200 mL of ethanol. Samples were taken in 0.2 ml, 3.8 ml of 0.1 M DPPH solution was added, and homogenized using a vortex for approximately 60 seconds. They were then incubated for 30 min. After

incubation, absorbance readings were carried out with a spectrophotometer by adjusting the wavelength to 517 nm. A color change will indicate the presence of radicals from purple to yellow.

The control treatment was used as a controller and treated the same as the sample. Blank (control) used ethanol as a sample substitute. Free radical scavenging activity was assessed as reduced DPPH colour. Free radical scavenging power is expressed in per cent (%) RSA (% Radical Scavenging Activity) is % DPPH bleaching. The results of the antioxidant activity was calculated by formula 3.

$$RSA (\%) = \frac{\text{Control absorbance} - \text{Sample absorbance}}{\text{Control absorbance}} \times 100\% \dots\dots (4)$$

IR Spectrum and Morphology Analysis

Maltodextrin, Tween, and encapsulants had their infrared spectra recorded using Fourier-Transform infrared spectroscopy (Alpha II-Brucker) at wave numbers ranging from 500 to 4000 cm⁻¹. Using a SEM-EDX JEOL JSM-6510LA, the morphology form of the microencapsule produced by the microencapsulation method were examined [12].

Bioavailability of Encapsulate

The Dissolution Test was performed by inserting 500 mg of encapsulant microcapsules into a container containing 10 mL of phosphate buffer pH 1.2 and 7.4 at room temperature. Snapshots of pH 1.2 phosphate buffers were taken at time intervals of 30, 60 and 120 minutes, snapshots of pH 7.4 phosphate buffers were taken at time intervals of 30, 60, 120 and 240 minutes. The filtrate measured absorbance at maximum wavelength with a UV-Vis spectrophotometer. The standard curve is made by measuring the absorption of encapsulant solutions in phosphating buffer medium pH 1.2 with concentrations of 10, 20, 30, 40 and 50 µg/mL and in phosphating buffer solution medium pH 7.4 with concentrations of 10, 20, 30, 40 and 50 µg/mL.

Data Analysis

The measurements were repeated at least three times and data were expressed as mean ± SD. Data were analyzed using one-way analysis of variance (ANOVA), and value of P < 0.05 was considered as statistically significant.

III. RESULT AND DISCUSSION

A. Extract Yield

Ethanol perepat extract for PKL was obtained as much as 20.088 g with a yield of 39.971%, PPG 12.254 g with a yield of 24.438%, Sebong Lagoi 6.805 g with a yield of 13.591% and Dompak 6.234 g with a yield of 12.432% (**Figure 1**). The percentage yield of perepat extract obtained from each growing location has different values, this is due to differences in growing locations that affect the amount of secondary metabolite compounds contained in the perepat leaf sample. The composition of chemical components varies from region to region in the same plant [13].

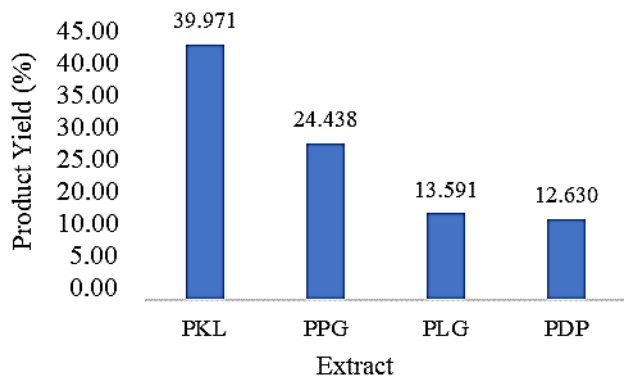


Fig. 1. Extract Yield (%)

Factors affecting the production of secondary metabolites are environmental conditions. One of the factors that affect the production of secondary metabolites is temperature and CO₂, the higher the temperature and CO₂ levels, the higher the production of secondary metabolites [14]. The content of secondary metabolites in an organism is influenced by environmental factors such as light, and available nutrients added that the growth of biota is influenced by external and internal factors [15,16]. External factors such as habitat, season, water temperature, and type of food available. While internal factors such as age, size, and other biological factors. The content of chemical compounds in a plant is greatly influenced by its geographical location, temperature, climate, and soil fertility [16].

B. Total Phenolic and Flavonoids Content

The highest total phenol content was PKL which was 171.88 (mgGAE/g), PPG 41.70 (mgGAE/g), PLG 38.29 (mgGAE/g) and the lowest total phenol content was PDP which was 37.04 (mgGAE/g). The highest total flavonoid levels were PKL of 25,473 (mgQE/g), PPG of 8,376 (mgQE/g), PLG of 8,269 (mgQE/g) and PDP of 4,613 (mgQE/g). Total levels of phenols and flavonoids in a plant have different levels (Table 2). This difference is influenced by several factors both internal and external. Internal factors such as genes and external factors include temperature, light, humidity, and nutrient content in the soil [17]. Moreover, phenol and flavonoid levels are closely related to environmental factors such as where plants grow [17,18].

The most considerable total encapsulate phenol content was PKL, which was 44.63 (mgGAE/g), PPG 31.71 (mgGAE/g), PLG 29.21 (mgGAE/g), and the lowest total encapsulant phenol content was PDP which was 24.25 (mgGAE/g). The total phenol content of the capsule is directly proportional to the total flavonoids content of ethanol extract of *S. alba* leaves for the highest PKL and the lowest PDP. Qualitatively capsule form samples contain phenol compounds with less content than the extract form [19]. This is in line with several previous studies, which also show the same thing [12-13].

TABLE 2.
 TOTAL PHENOL AND FLAVONOIDS OF BOTH
 EXTRACT AND ENCAPSULE

Samples	Extract		Encapsules	
	TPC (mgGAE/g)	TFC (mgQE/g)	TPC (mgGAE/g)	TFC (mgQE/g)
PKL	171.88 ^a	25.473 ^b	44.63 ^a	6.357 ^b
PPG	41.70	8.376	31.71	5.669
PLG	38.29	8.269	29.21	5.067
PDP	37.04	4.613	24.25	3.518

Note: Superscripts with different lowercase letters on the same line showed significant differences (Sig < 0.05)

Based on the total phenol yield, the most significant flavonoids were found in the extract form compared to the encapsulated form because flavonoid compounds are one of the most abundant classes of phenol compounds found in plants. In addition, in this study, the samples used in the total phenol and flavonoid tests were the same, resulting in a similar total value [20]. Phenol and flavonoids are compounds that function as antioxidants for the body. The ratio of total flavonoids in encapsulants is lower than in extracts, and in addition to being influenced by encapsulation, it can also be affected by the surfactants used [21]. Surfactants increase the solubility of a substance by lowering the surface tension between the solute and the medium [22]. The total phenols and flavonoids contained in the encapsulant significantly differed from the extract.

C. Antioxidant Activities

Perepat extract PKL, PPG, and PLG have very strong antioxidant activity and PDP has strong antioxidant activity, whereas PKL has a small IC₅₀ value of 3.544 µg / mL, PPG 5.482 µg / mL, PLG 46.659 µg / mL, and PDP 68.281 µg / mL. The products of PKL, warehouses and lagoi have very strong antioxidant activity because of the IC₅₀ value <50 and dompat have strong antioxidant activity because of the IC₅₀ value >50 (Table 3).

TABLE 3.
 THE ANTIOXIDANT ACTIVITY OF ETHANOL
 EXTRACT AND ENCAPSULANTS

Sample	IC ₅₀ ± SD (µg/mL)	
	Extract	Encapsulants
PKL	3.544 ± 0.00 ^a	54.608 ± 0.03 ^b
PPG	5.482 ± 0.01 ^a	237.234 ± 0.03 ^c
PLG	46.659 ± 0.01 ^b	820.435 ± 0.04 ^c
PDP	68.281 ± 0.005 ^c	1032.387 ± 0.05 ^f

Note: Superscripts with different lowercase letters on the same line showed significant differences (Sig < 0.05)

Antioxidant activity is influenced by total phenol and flavonoid levels. This is reinforced by previous studies [12-13] which states that phenol and flavonoid compounds have a linear

contribution to antioxidant activity, so the higher the levels of phenols and flavonoids, the better the antioxidants. Vice versa, the lower the total levels of phenols and flavonoids, the lower the antioxidant activity.

The antioxidant activity of capsule perepate extract from PKL has strong antioxidant activity. PPG, PLG and PDP capsules have no antioxidant activity. The antioxidant activity of PKL has IC_{50} 54.608 $\mu\text{g/mL}$, PPG 237.234 $\mu\text{g/mL}$, PLG 820.435 $\mu\text{g/mL}$, and PDP 1132.387 $\mu\text{g/mL}$. PKL results have strong antioxidant activity because IC_{50} values >50 and $IC_{50} <100$, for PPG, PLG and PDP do not have antioxidant activity because IC_{50} values >200 . This is in line with the total levels of phenols and flavonoids that have decreased after encapsulation so that the antioxidants contained in the encapsulants have also decreased when compared to antioxidant extracts. This is reinforced by previous research, which reported that the value of this encapsulated antioxidant activity is related to the total levels of phenols and encapsulated flavonoids produced [5]. High levels of total phenols and encapsulated flavonoids will produce high antioxidant activity as well, so that the ability of antioxidants to donate electrons in terms of suppressing the development of free radicals is also higher. Vice versa, if the total levels of phenols and encapsulant flavonoids are low, the antioxidant activity will be low.

D. Encapsulant Yield (%)

The encapsulant product yield value for PKL samples is 53.202%, PPG is 50.945%, PLG is 50.742% and PDP is 50.033% (Figure 2). Factors that affect the percent yield are coating and drying materials, because incomplete drying causes the encapsulant powder to have a high moisture content and stick to the inlet tube.

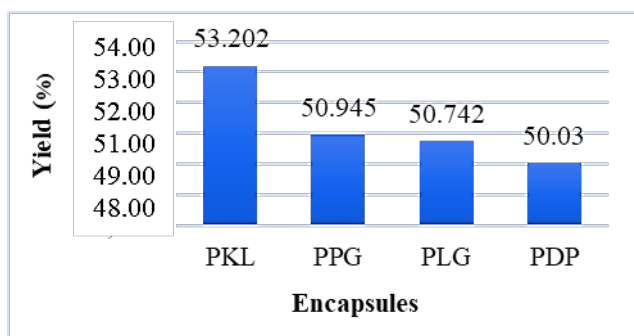


Fig. 2 Encapsulation Product Yield (%)

The microcapsule accommodated in the outlet tube becomes small and the yield decreases. The difference in yield percentage is influenced by the viscosity of the material to be dried. High viscosity will also cause the material to become stickier. This makes the amount of material left behind printed during the granulation process so that the resulting yield becomes low. Maltodextrin has a low viscosity so the greater the total solids and per cent yield obtained [23].

E. Encapsulation Efficiency

The highest encapsulation efficiency is PLG which is 76.29%, PPG which is 76.04%, PDP which is 65.47% and the lowest PKL which is 25.97% (Figure 3). The efficiency of PKL capsule has a low value, this is because the total phenol of PKL extract is far compared to the total phenol encapsulated by street vendors. However, PKL encapsulants still have the highest total phenol, flavonoid and antioxidant activity compared to others. The encapsulation process protects the core ingredients from environmental influences and controls the release of coated materials. Encapsulation efficiency relates to the properties of the coating material used such as film-forming ability as well as stable emulsion-forming ability. The factors that most often affect the encapsulation efficiency are the encapsulation material and the inlet temperature [24,25].

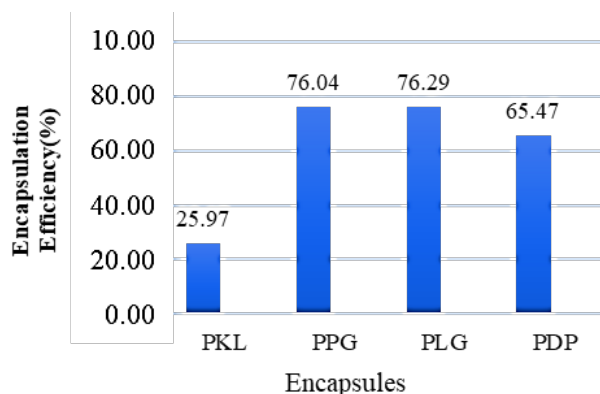


Fig. 3 Encapsulation Efficiency (%)

The factors affecting encapsulation efficiency are based on the material properties of the core and the encapsulant material. Maltodextrin as an oil encapsulant offers advantages such as low price, neutral aroma and taste, and low viscosity, but there are disadvantages one of which is low emulsification capacity [23]. Other research also revealed that maltodextrin has a neutral aroma and taste, low viscosity, and can protect antioxidant components. Still, maltodextrin has low emulsion ability and volatile retention and effect maltodextrin unable to form a layer that can protect the product from destructive change processes. Hence, it needs to be combined with other coatings [26].

F. Encapsule Water Content

The capsule water content analysis of ethanol extract of perepat leaves which has the largest average water content from this study, namely PDP with a water content value of 5.05%, PLG with a water content value of 4.95%, PPG with a water content value of 3.03% and the lowest water content of this study, namely PKL of 2.91% (Figure 4).

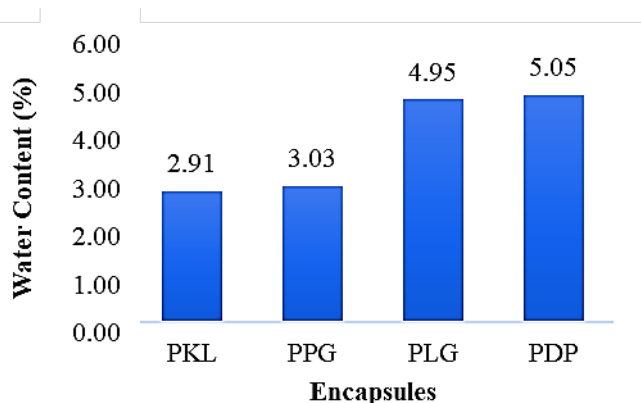


Fig. 4 Encapsule Water Content (%)

Previous research reported that the results of the study showed that the higher the concentration of maltodextrin and tween 80, the lower the water content [27]. The interaction between maltodextrin and tween-80 can cause a decrease in the moisture content of the material. This is because maltodextrin is composed of free hydroxyl groups and tween-80 has hydrophilic properties so that it will easily bind water to the material [28]. During the drying process, water bound together with maltodextrin and tween 80 will be more volatile so that it can reduce the moisture content of the resulting product. Maltodextrin has a simple molecular structure so that bound water and free water can be easily removed in the drying process [23]. Water content is a component that can affect the damage of a food because it can cause chemical changes. The higher the moisture content will also trigger the growth of bacteria and fungi that can cause damage to the dry product. The water content contained in a material is influenced by several things, namely the encapsulant material, the duration of the drying process, and the course of the drying process.

G. Encapsulated Solubility

The analysis of the encapsulated solubility of ethanol extract of perepat leaves which has the largest solubility in water, namely PKL 97.950%, PPG 96.906%, PLG 96.84% and solubility in the most minor water, namely PDP 97.787%. This study has a high solubility because it uses maltodextrin and tween 80 coating materials, where the factors that affect the solubility of an encapsulant are the materials used in making encapsulants. The higher the concentration of maltodextrin and the concentration tween-80, the higher the solubility. The interaction between maltodextrin and tween-80 can lead to an increase in total dissolved solids in the material, because maltodextrin has high solubility properties in water and is composed of a mixture of oligosaccharides and simple sugars. In contrast, tween 80 has hydrophilic properties that quickly bond with water to increase solubility. Maltodextrin increases solubility because the substance is composed of free hydroxyl groups that can bind with water so that they are easily dissolved in water [27]. Maltodextrin has a high solubility level because

it can absorb water and has a fast dispersion process. The more free hydroxyl groups in the filler, the higher the solubility level. Higher solubility means better product quality because it is easier to present [11].

H. IR Spectrum and Morphology

The IR spectral analysis of encapsulated, tween 80 and maltodextrin can be analyzed that peaks appear at wavelengths 2850-2970 and 1340-1470 cm^{-1} which may indicate the presence of C-H Alkane functional groups that usually appear at these wavelengths. At wavelengths 675-995 cm^{-1} peaks appear which may indicate the presence of C-H Alkene functional groups that usually appear at wavelengths 3010-3095 and 675-995 cm^{-1} . Then comes the peak at wavelengths 690-900 cm^{-1} which likely indicates the presence of the C-H functional group of the aromatic ring that usually appears at wavelengths 3010-3100 and 690-900 cm^{-1} . Peaks appear at wavelengths 3200-3600 cm^{-1} which may indicate the presence of functional groups O-H hydrogen/phenol bond alcohols that usually appear at these wavelengths. Peaks appear at wavelengths 1610-1680 cm^{-1} which may indicate the presence of C=C alkene functional groups that usually appear at these wavelengths. Peaks appear at wavelengths 1180-1360 cm^{-1} which may indicate the presence of C-N Amine/amide functional groups that usually appear at these wavelengths. In addition, peaks appear at wavelengths 1050-1300 cm^{-1} which may indicate the presence of C-O Alcohol/ether/carboxylic acid/ester functional groups that usually appear at these wavelengths (Figure 5).

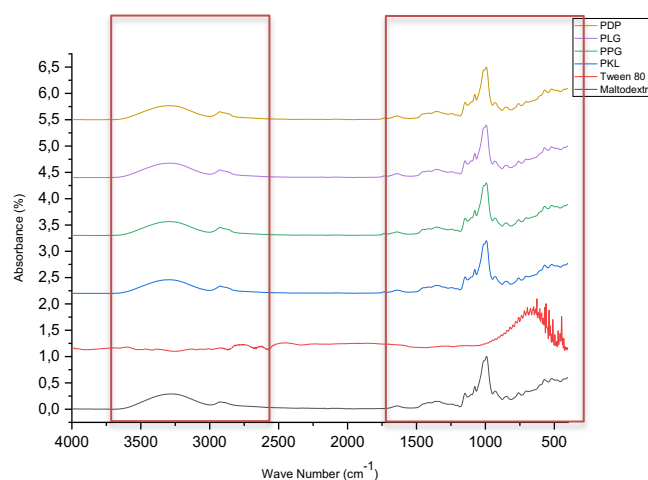


Figure 5. IR Spectrum Encapsule and Components

The IR spectrum results show the presence of C-H Alkane functional groups, C-H Alkene functional groups, C-H aromatic ring functional groups, O-H functional groups, hydrogen/phenol bond alcohols, C=C alkenes, C=O Aldehyd/ketones/carboxylic acid/esters and C-O Alkopol/ether/carboxylic acid/ester functional groups which are functional groups found in flavonoid compounds. Flavonoids have several functional groups, including C = C double bonds, C = O double bonds, C-O single bonds, C - H

single bonds, and O – H single bonds [29]. Highlights in the red section indicate that a cross-linked polymerization reaction of the extract with the coating occurred [30]. The results of the comparison of the FT-IR spectra between the coating and the encapsulation results show that an encapsulation is formed, and it can be seen that all the spectra present in the encapsulation material appear on the encapsulation.

Based on **Figure 6**, the results of SEM encapsulated ethanol extract of PKL perepat leaves show that the surface structure is irregular and hollow. The morphology of encapsulants will affect the characteristics of the resulting encapsulant products, such as oil on the surface, release of active ingredients, retention, and others. A good microcapsule result is round without wrinkles, which means the active ingredients are very well encapsulated [31,32].

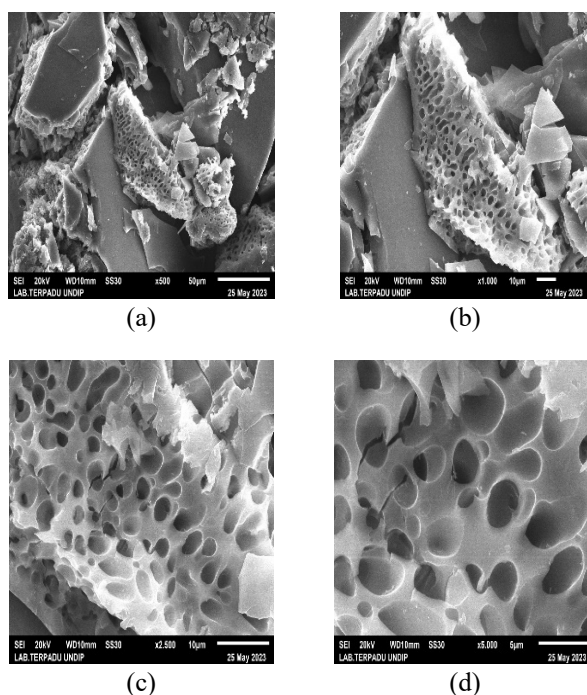


Fig. 6. The capsule surface structure of perepat leaves (a) 500x, (b) 1,000x, (c) 2,500x, (d) 5,000x

I. Encapsulant Bioavailability

In this study, an In Vitro release test was carried out using maltodextrin as a polymer matrix in the encapsulation of ethanol extract of *S. alba* at leaves by looking at the effect of maltodextrin on the release profile of *S. alba* leaf ethanol extract. It can be seen that the release of capsule weighing 500 mg which has the largest release is at pH 7.4 within 240 min of 99.62%, pH 7.4 within 120 min of 97.00% and pH 7.4 within 60 min of 71.76%. The lowest capsule release was pH 1.2 within 30 min at 46.88%. Factors that affect the dissolution process include stirring speed, test temperature, viscosity, pH, composition of the dissolution medium, and the presence or absence of wetting agents [33].

TABLE 6
 THE ENCAPSULE BIOAVAILABILITY

Time Variations (Min)	% Encapsule Releases	
	pH 1.2	pH 7.4
30	46.88	44.25
60	48.67	71.76
120	50.96	97.00
240	0.5	99.62

In the gastric simulation, which is pH 1.2, it can be seen that the capsule of ethanol extract from *S. alba* leaves released slightly. The encapsulation of ethanol extract from *S. alba* can withstand the stomach release rate (**Table 6**). At pH 7.4, it can be seen that the encapsulation of ethanol extract from *S. alba* leaves released is very large because the encapsulation of ethanol extract from *S. alba* leaves does not take place in digestion (stomach) but in the blood. Engineering through encapsulation is known to alter and control the release of bioactive compounds [34]. Free radicals are highly reactive, capable of damaging biologically relevant molecules such as DNA, proteins, carbohydrates, and lipids inside the nucleus and cell membrane [35]. Antioxidants are essential in increasing antibody protection, resistance to bacterial infections, immunity, and membrane repair in DNA. The DNA repair system carried out by antioxidants is critical to the body's defense against oxidative damage or free radicals [36].

IV. CONCLUSION

The physical properties and chemical properties of ethanol extract of perepat leaves and encapsulants of ethanol extract of perepat leaves that have high yields are PKL with the highest percent yield of extracts and encapsulants, solubility, water content, total phenol levels of extracts and encapsulants, total flavonoid levels of extracts and encapsulants, the highest antioxidant activity of extracts and encapsulants. The results of the encapsulation bioavailability test of ethanol extract of PKL perepat leaves had a high encapsulant release at pH 1.2 for 120 minutes by 50.96% and pH 7.4 for 240 minutes by 99.62%.

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CONFLICT OF INTEREST

Authors declare no conflict of interest to disclose.

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