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ENCAPSULATION OF AGARWOOD ESSENTIAL OIL WITH MALTODEXTRIN AND GUM ARABIC

Muhamad Sahlan[1,2*], Adam Muhammad Fadhan[1], Diah Kartika Pratami[3], Anondho Wijanarko[1], Kenny Lischer[1], Heri Hermansyah[1], Kaysa Faradis Mahira[1]

[1]*Department of Chemical Engineering, Faculty of Engineering, Universitas Indonesia, Kampus UI Depok, Depok 16424, Indonesia*
[2]*Research Centre for Biomedical Engineering, Faculty of Engineering, Universitas Indonesia, Kampus UI Depok, Depok 16424, Indonesia*
[3]*Department of Pharmacognosy and Phytochemistry, Faculty of Pharmacy, Pancasila University, South Jakarta, DKI Jakarta 12640, Indonesia*

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ABSTRACT

Agarwood is the commodity that has the highest economic value in the world, especially its oil. However, agarwood essential oils have a volatile compound component of almost 90%. To overcome this volatility, the agarwood oil can be changed into a solid dosage by encapsulation using maltodextrin and gum arabic through the freeze-drying method. Encapsulation is one solution that increases the efficiency of the packaging process and of the distribution of agarwood oil. Four different formulations of agarwood oil encapsulation were obtained that differed in the ratio of the active ingredient, agarwood oil, to the encapsulating materials, maltodextrin and gum arabic (MD-GA): F1 (2:10), F2 (5:10), F3 (10:10) and F4 (12:10). The highest loading capacity was 68.6%, obtained in the F2 sample. The surface oil content value of the four formulations ranged from 3% to 21%. The value of the encapsulation efficiency in the four formulations was between 82% and 96%. In the morphological test, all four formulations had pores on part of their surface. Overall, all samples showed good results for loading capacity, surface oil content percentage and encapsulation efficiency.

Keywords: Agarwood oil; Encapsulation; Freeze-drying; Gum arabic; Maltodextrin

1. INTRODUCTION

Agarwood is recognized as one of the most valuable natural products in international trade due to its endless uses, ranging from being an ingredient in most foods to finished products, such as incense and perfume (Boon et al., 2016). The agarwood wood is distilled to produce the essential oil of agarwood. Most of these oil products are exported abroad from is country. Agarwood essential oil has many aromatic compounds, that almost 90% of these compounds have volatile properties (Chen et al., 2011). To overcome this volatility, agarwood oil can be made into solid doses by encapsulating it in maltodextrin and gum arabic through the freeze-drying method. Encapsulation is one solution that serves the efficiency of the packaging process and of the distribution of agarwood oil.

Encapsulation was performed with a maltodextrin coating and gum arabic. The advantage of maltodextrin is that the material can easily dissolve in cold water. Maltodextrins have various

*Corresponding author's email: sahlan@che.ui.ac.id, Tel. +62-21-7863504, Fax. +62-21-7270050
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functional features, including enlargement and film-forming properties, fat-binding capabilities, and the reduction of oxygen permeability in the wall matrix (Akdeniz et al., 2017; Mangiring et al., 2018). Other coatings are made from gum arabic. Gum arabic can be used to bind flavors and as thickening agents, thin film formers and emulsifiers (Stounbjerg et al., 2018). Gum arabic is unique because of its high solubility and low viscosity (Pratami et al., 2019).

Drying the encapsulation products was carried out using the freeze-drying method. Freeze-drying is suitable for encapsulating essential oils (Prakash et al., 2018). Another advantage of the freeze-drying method over other methods is the maintenance of the quality of the drying product, so that the resulting product is much better than that produced by other drying methods (Bando et al., 2016).

2. METHODS

2.1. Encapsulation of Agarwood Oil

We varied the composition of the product, using the raw material agarwood oil as the active ingredient to be encapsulated, and maltodextrin and gum arabic (MD-GA) as the materials of the capsule walls, that is, as the encapsulating material. The ratio between the encapsulate material (MD-GA) and agarwood oil was set in four formulations, F1, F2, F3 and F4, as shown in Table 1. The encapsulate materials were prepared from maltodextrin (MD) and gum arabic (GA), as described by Marquiafável et al. (2015) with modifications.

Aquadest was used to dissolve the maltodextrin and gum arabic. The initial stage of the preparation was to create an encapsulation solution from a mixture of maltodextrin and gum arabic with a 1:1 ratio by dissolving 5 grams of maltodextrin and 5 grams of gum arabic in 20 mL of aquadest. Then the solution of the encapsulation mixture was stirred with a rotation density of 5,000 rpm for five minutes. The encapsulation process used the method described by Akdeniz et al. (2017). The encapsulate solution was mixed with agarwood oil as using an Ultra-Turrax T18 homogenizer (IKA, Königswinter, Germany) at 10,000 rpm for five minutes. The suspension formed was dried by means of a freeze-dryer. The drying process was carried out at -40°C and vacuumed for 19 hours following a freeze-drying method (Afriani et al., 2015).

Table 1 The ratio of agarwood oil and encapsulate material in microencapsulation

Formula	Ratio of Agarwood oil: MD-GA
F1	02:10
F2	05:10
F3	10:10
F4	12:10

2.2. Loading Capacity Analysis

The loading capacity was calculated by measuring the dry weight of the encapsulate material and the dry weight of the solids produced from the encapsulation of agarwood oil. The loading capacity was calculated by the following Equation:

$$\text{Loading Capacity} = \frac{W_{solid} - W_{coating}}{W_{solid}} \times 100\%. \tag{1}$$

2.3. Surface Oil Content

The surface oil content was determined using the method described by Zungur et al. (2014) with some modification. First, we weighed 1 gram of solids to prepare each sample of F1, F2, F3, and F4. After weighing, we dissolved the samples into 20 mL of petroleum ether. Then we shook the sample for two minutes and then let it stand for 15 minutes at room temperature in dark conditions for the extraction process. The residuals of the solids of the F1, F2, F3, and F4 samples that had been extracted in the petroleum ether solution were filtered using Whatman paper. The resulting residue was dried in the oven for four hours at 105°C. The value of the surface oil content was calculated as the mass of the solid preparation at the start of the test minus the dry residual mass of the solids of the samples. Then the value of the surface oil content was divided by the amount of oil at the beginning of the experiment. This test was done three times on the first, fifth, and tenth days.

2.4. Efficiency of Encapsulation

The efficiency of the encapsulation was calculated using the methods described by Carneiro et al. (2013), with slight modifications. The total oil content was assumed to be the amount of agarwood oil before encapsulation (Carneiro et al., 2013; Putri et al., 2019). The efficiency of the encapsulation is calculated based on this equation:

$$(\mathrm{EE}) = \frac{\text{Total oil content} - \text{surface oil content}}{\text{total oil content}} \times 100\% \quad (2)$$

2.5. Morphology Analysis

A morphological analysis of the agarwood oil solids was done at the Fire and Safety Engineering Laboratory, Faculty of Engineering, State Jakarta University, using a scanning electron microscope ((SEM) JSM6400; JEOL, Tokyo, Japan). The samples examined via the SEM were the four formulation F1, F2, F3, and F4 of agarwood oil encapsulation. A morphological analysis was performed to see the surfaces of the encapsulation in samples produced by freeze-drying.

3. RESULTS AND DISCUSSION

3.1. Loading Capacity

From the mass of the resulting the encapsulation, we calculated the loading capacity for each sample. The graph of the calculated loading capacity is given in Figure 1. The loading capacity of the F1 sample is very different from the loading capacities for the other three samples. This is possibly because the solids encapsulation mass obtained in the F1 sample was smaller than the initial coating masses, due to the large number of encapsulations performed by the solvent during the freeze-drying process (Đorđević et al., 2014).

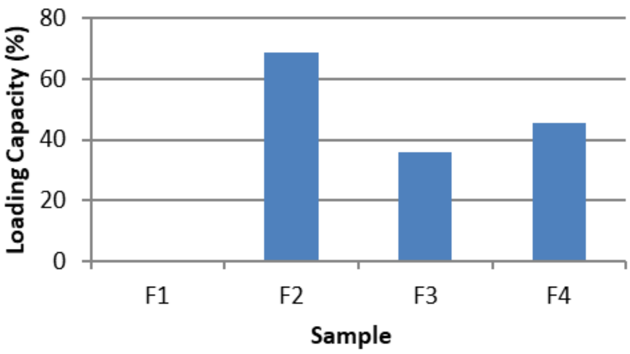


Figure 1 Loading Capacity

The F2 sample had the highest loading capacity value, 68.6%. This shows that in the F2 sample, the MD-GA encapsulated the agarwood oil better than did in the F1, F3, and F4 samples. The F3 and F4 samples had a smaller loading capacity than the F2 sample because there was some oil or encapsulation that coexisted with the solvent during the freeze-drying process, such that the mass of the solids of the F3 and F4 samples became less.

3.2. Surface Oil Content

The surface oil content was the percentage of active substances that moved to the surface of the encapsulation. The value of the surface oil content was used to calculate the encapsulation efficiency of the solids in the F1, F2, F3, and F4 samples. Figure 2 shows that the percentage of surface oil content changed on the first, fifth, and tenth days.

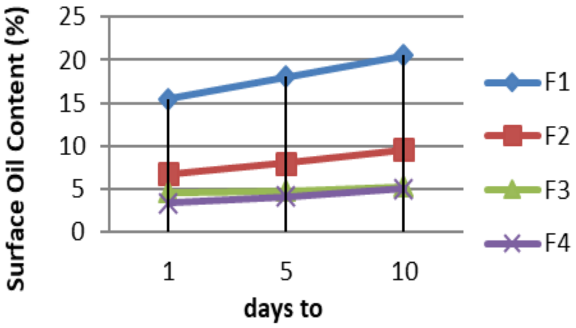


Figure 2 Percentage of surface oil content on the first, fifth, and tenth days

In Figure 2, every sample shows an increase in the percentage of surface oil content from day one to day ten. Agarwood oil encapsulation that have a high surface oil content are more sensitive to oxidation because the capsule does not completely cover the oil. During storage, the surface oil content of agarwood oil solids always increases. This indicates that the encapsulation of the agarwood oils has been damaged or has eroded, causing the oil in the capsule move to the surface (Rao et al., 2016).

The F1 sample had the highest percentage of surface oil content. This is because the MD-GA in F1 sample only coated a little oil; so the oil contained in the encapsulation of the F1 sample faded faster as the oil moved to the encapsulation surface. This means that F1 sample contained a small amount of agarwood essential oil. There are relationships between the oil content in the capsules and the speed of encapsulation. Therefore, the oil in the F1 sample faded faster than the F2, F3, and F4 samples.

The F4 sample had the smallest percentage of surface oil content. This indicates that not much is lost from the encapsulated oil in the F4 solids sample. Because the MD-GA in F4 sample coated the oil better than did the other three samples, on the tenth day, the F4 sample had lost only 5% of the encapsulated oil.

3.3. Efficiency of Encapsulation

The encapsulation efficiency is the percentage of agarwood oil substances that can be encapsulated from the total agarwood oil supplied to a system. Figure 3 shows changes in the efficiency of the encapsulation for each sample on the first, the fifth, and the tenth days.

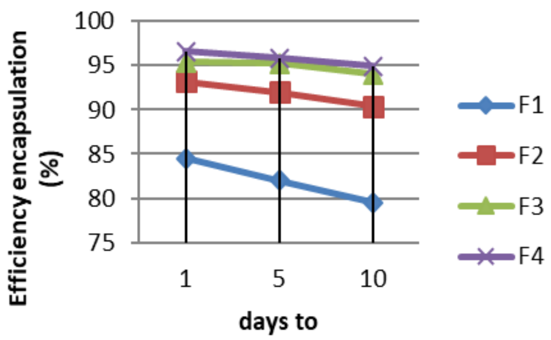


Figure 3 The efficiency of encapsulation on the first, fifth, and tenth days

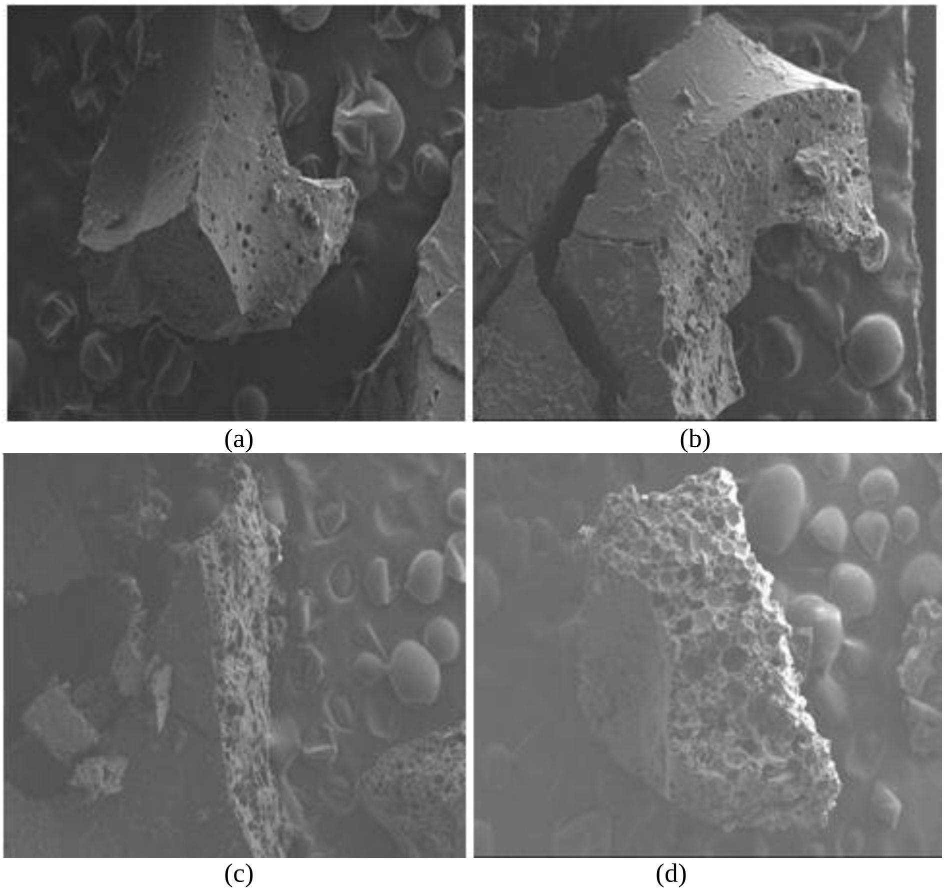
In Figure 3, every sample showed a decrease in the efficiency of encapsulation from day one to day ten. A decrease in encapsulation efficiency is caused by an increase in surface oil content in each formulation. When the amount of agarwood oil that begins to move to the surface of encapsulation increases, the strength of the encapsulation to hold the liquid in it decreases (Edris et al., 2016).

The F4 sample had the highest encapsulation efficiency. This is because the MD-GA in F4 sample encapsulated the highest amount of agarwood oil, such that encapsulation could cover more agarwood oil. The F4 sample had the smallest percentage of surface oil content, indicating that not much oil contained in the sample went missing. Overall, all samples showed good encapsulation efficiency results. The efficiency measured in this study ranges from 80% to 97%.

The applications of the encapsulation technique are of great interest nowadays because of the technique's easy handling properties, its ease of particle formation, and its high resistance to chemical and physical modifications (Kamaruddin et al., 2014). This encapsulation preparation method must offer an economical approach that employs a cheap and abundant material and a well-understood drying technique. Furthermore, the method must be suitable for economical and large-scale production in industry (Qomariyah et al., 2019).

3.4. Morphology Analysis

The encapsulation particles have a smoother surface and more folds if gum arabic is used (Barros Fernandes et al., 2014). The indentations are formed due to the properties of the encapsulated material used, such as polysaccharides like maltodextrin (Barbosa et al., 2005). Indentation occurs due to the process of shrinking or to shrinking particles that occur during the process of drying and cooling. In the morphological test, the surfaces of the four samples had a porous solid part. In Figure 4, we see that the F1 sample had the fewest pores.



(a) (b) (c) (d)

Figure 4 Morphological test result: (a) F1; (b) F2; (c) F3; and (d) F4

The F2 sample had more pores on its surface than did F1, but fewer than did the F3 and F4 samples. The F4 sample had the most pores on its surface.

The F1 and F2 samples show few pores on their surface because the ability of the encapsulate material to encapsulate the agarwood oil is still good; the encapsulate material only coats a little oil. The larger number of pores in the F3 and F4 samples is due to the insufficient encapsulation, that is, the inability to encapsulate large quantities of oil. The porous encapsulation surface is caused by the amount of liquid present within the encapsulation surface layer; the encapsulating surface forms a cavity. The more liquids contained in the layer of encapsulation, the more pores that occur on the surface of the encapsulation resulted.

In previous SEM research, the average pore size of dried agarwood essential oil was very small, 9.09 µm (Fazila, 2012). The cell walls were not deformed, so it was difficult for the chemical components to escape. The pore size of dried agarwood oil expanded to 18 µm when agarwood was soaked in lactic acid because of the microbial activities in the lactic acid, significantly degrading wood components (Fazila & Halim, 2012).

4. CONCLUSION

The encapsulation of agarwood oil in our samples showed good results for loading capacity, surface oil content percentage and encapsulation efficiency. The efficiency decreased on the first, fifth, and tenth days in four samples F1, F2, F3, and F4. The surface oil content increased on the first, fifth, and tenth days. The largest loading capacity, 68.8%, was produced by F2. The more oil is coated, the more pores on the surface of the encapsulation agarwood oil. This method is suggested suitable for economical and large-scale production in industry.

5. ACKNOWLEDGEMENT

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