The effect of coating agents on the microencapsulated quality of red ginger essential oil (zingiber officinale var. rubrum) local north Sulawesi

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Abstract. Microencapsulation is a technology used to produce microscopic particles containing active ingredients. Essential oils can be used as active ingredients in microencapsulations for applications such as aroma control, food, and beverage industry raw materials. This study aimed to determine the effect of coating materials on the encapsulation quality of red ginger essential oil (*Zingiber Officinale Var. Rubrum)* in local North Sulawesi by spray drying method. The microemulsion was carried out using CMC, pectin, and gum arabic using 100 g of coating agent dissolved in 100 ml of aquadest (1: 1) then added red ginger essential oil homogenized using a homogenizer for 2 minutes at a speed of 11500 rpm. The ratio of nutmeg essential oil to encapsulant ingredients is 1: 5. The results showed that CMC, pectin, and gum arabic were able to protect ginger essential oil, where the trapped essential oil ranged from 25.56 – 30.90%, essential oil on the surface around 1.20-1.82% with an average moisture content of 6.02 – 7.20%. The best treatment is the use of CMC with the lowest moisture content (6.02%) and essential oils on the lowest surface (1.20%) and the highest trapped essential oils at 30.90%.

1 Introduction

Ginger (*Zingiber officinale Roscoe*) is a spice plant that is widely used as a spice and as an ingredient in natural antioxidant-producing medicines. The part of the ginger plant of high economic value is its rhizome (rhizome). Based on the shape, size, and color of the rhizome, ginger is divided into 3 groups, namely large white ginger (rhinoceros ginger, elephant ginger), small white ginger, and red ginger (*Zingiber officinale Roscoe*). In general, the three types of ginger contain starch, essential oils, fiber, small amounts of protein, vitamins, minerals, and a proteolytic enzyme called Zingibain [3]. As the name implies, red ginger is red or light orange, the fiber structure is larger, small in size, very spicy taste, and sharp

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aroma. Ginger rhizomes contain several chemical components including water, starch, essential oils, oleoresins, crude fiber, and ash. According to Hernani and Hayani (2001), red ginger contains starch content (52.9%), essential oils (3.9%), and alcohol-soluble extracts (9.93%) higher than empirrit ginger where the content of starch (41.48%), essential oils (3.5%) and alcohol-soluble extracts (7.29) and elephant ginger starch (44.25), essential oils (2.5%) and alcohol soluble extracts (5.81). Table 1, the nutritional value of 100 grams of dried ginger and a moisture content of 15%.

Table 1. Nutritional value of 100 grams of dried red ginger from North Sulawesi [8]

Component	Nilai nutrisi
Fat	5.5- g
Protein	7.2 g
Ash	4.53 g
Iron	9.41 mg
Calsium	100.02 mg
Phosphorus	214.75 mg
Essential oil yield	2.3%

After harvesting ginger rhizomes will undergo physiological, physical, chemical, and microbiological changes. Therefore it needs proper handling to maintain its quality. The action that can be done is to process it into durable processed products such as essential oils. Besides being able to extend shelf life, processing also aims to diversify products and increase economic value. The content of aromatic active substances in red ginger is separated by extract, both with certain solvents (eg ethanol) and distillation (distillation), the results are known as oleoresins and essential oils Essential oils are complex mixtures of volatile compounds that are widely applied in the food, pharmaceutical, cosmetic, and agricultural industries. However, its use is limited by low stability, high reactivity, and high volatility [17-18]

Microencapsulation is an effective technique to protect essential oils from degradation and improve their stability, while also providing controlled release and ease of delivery. And microencapsulation can maintain the active components present in the oil [12]. Microencapsulation is a method generally used to handle oil in liquid form, so that changes in the liquid form of oil into powder will be easier to handle in handling [13]. Microencapsulation can be performed using various techniques, such as spray drying, conservation, emulsification, and solvent evaporation. Several types of encapsulation materials, including natural and synthetic polymers, lipids, and proteins, have been used to microencapsulate essential oils. This technique protects the core material that was originally a liquid into a solid form so that it is easy to handle and can protect the core material from loss of flavor [14, 6, 9]

The spray drying method is the most commonly used method in the encapsulation process in the food industry. The process contained in spray drying has three stages: first the preparation of the ingredients to be dispersed and the emulsion to be processed, the second homogenizing of the ingredients, and third spraying the liquids with hot air [17]. Types of natural coatings that are often used are CMC, pectin, gum arabic or maltodextrin. [8].

CMC is a cellulose derivative polymer that has good compactibility and compressibility while gum arabic and pectin are often used because of their ability to form emulsions and high viscosity [7]. In addition, gum arabic and pectin are widely used because they are easy to find and handle processes, have high solubility, and are stable in oil and water emulsions [10 and 4].

Several research results reported on microencapsulation research on essential oils [20], evaluating the influence of several parameters in the basil essential oil microencapsulation process. The results showed that particle size, surfactant concentration, and stirring speed had a significant effect on the physicochemical characteristics of the microcapsules. In addition, there is also a study [22] that evaluates the effect of pH and emulsifying agent concentration in making lime essential oil microcapsules. The results showed that the pH and concentration of the emulsifying agent had a significant effect on the physical characteristics and stability of the microcapsules. From several research results that are used as reference sources, this study will evaluate the use and ability of several coating materials for the microencapsulation of North Sulawesi-specific red ginger essential oil.

2 Materials and methods

2.1 Materials and tools

The ingredients used are Red Ginger obtained from ginger farmers in Bitung City, Carboxymethyl cellulose (CMC), gum arabic, pectin (Brataco), and aquades obtained from chemical stores in Manado. The equipment used is measuring cups, glass beakers, Erlenmeyer, blower ovens, Aldrich Sigma, and other glassware for analysis.

2.2 Distillation of red ginger essential oil

The production of essential oils uses the method of distillation with water and steam, using a Balitro type distillation device with a capacity of 5 kg. The distillation stage is the preparation of fresh red ginger raw materials by reducing the size by cutting into pieces with a size of 1 x 1 cm and then drying for 12 hours. The distillation device is filled with distilled water just below the goose, the material to be distilled is put into the distillation tank and arranged flat on the surface. The distillation tank cap is immediately installed so that no steam escapes. Then the cooling device is connected to the steam dispensing funnel. After all the sets of distillation devices are ready, the stove is turned on. The condensate comes out of the cooler in the container using a glass container so that a mixture of oil and water is obtained. Oil is present in the top layer of the mixture. The oil is separated by means of a separator funnel. Oil distillation is carried out for 6-7 hours or until distillate is produced in the form of water only. Red ginger oil that has been obtained from the distillation process is then analyzed in the Manado Health Polytechnic laboratory with parameters (color, density, refractive index and acid number)

2.3 The procedure microencapsulate.

The process of making microemulsions is carried out using CMC coating agents, gum Arabic, and pectin with aquades (1: 1) then added red ginger essential oil in a ratio (1: 5), homogenized using a homogenizer for 2 minutes at a speed of 1500 rpm. Furthermore, drying is carried out with a spray dryer (*spray dryer*) at a temperature of 50-550C. [1]

2.4 Product analysis

Ginger essential oil is analyzed according to Standar Nasional Indonesia (SNI) for essential oils, including determination of oil refractive index (refractometer), specific gravity (Pycnometer), oil yield (clevenger method), moisture content (Immicible Solvent Distillation Method), oil solubility in alcohol and Oil Optical rotation. The resulting encapsulation products are analyzed for moisture content, [15], essential oils on the surface, and trapped essential oils [16]. The resulting data were analyzed using the SPSS 2007 program.

2.5 Essential oil in surface microencapsulate

A total of 0.5 g (a) microcapsules in Erlenmeyer were extracted with 6.7 ml of hexane, then shaken and filtered using Whatman no 1 filter paper. The extract is put into an evaporator flask that has a known weight (b). Washing is repeated with 3.3 ml of hexane 3 times. The combination of extracts is evaporated solvent using a rotary vacuum evaporator at 400C. The residue is weighed as essential oil on the surface of the microcapsule (c**)** [16].

$$\%\ Oil\ in\ surface = \frac{c-b}{a} x\ 100\% \quad (1)$$

2.6 Essential oils trapped

A total of 10 mg of microcapsules were dissolved in 0.5 ml of ethanol and then filtered using Whatman no 1 filter paper. The residue left on the filter paper is then dissolved in chloroform. The addition of chloroform is carried out until it reaches 10 ml. The solution was sonicated for 5 min and filtered again until the filtrate was obtained. The filtrate obtained is put in a cup that has been known to weigh and heated in a 1050C oven for 30 minutes. The weight of the trapped essential oil is obtained from the scales after heating [16].

3 Results and discussion

The quality of red ginger essential oil produced is as shown in Table 1.

Table 1. Analysis results of essential oil quality Parameters

Parameter	Red ginger oil	Indonesian National Standards (SNI)
Color	clear yellow	Light yellow - yellow
Density	0.875	0.8720-0.8890
Refractive index	1.480	1.4850 -1.4920
Acid number	3.0	3.2
solubility in alcohol70%	clear soluble 1:3– 1:4	1: 3 – 1: 7
Moisture content	7.20%	

Source : [8]

3.1 Color

Color is one of the parameters in seeing the quality of oil in a visual way. The color of ginger oil determined by SNI is clear while the results obtained by red ginger oil are classified as pale yellow. The difference in color is caused by red ginger raw materials where the outside is red and the inside is yellowish-cream and is also directed by temperature and pressure, where temperatures that are too high with too low pressure can cause oil color changes to be yellow faster and damaged due to high heating [2].

3.2 Density

Specific gravity measurements are made to determine the amount of mass of oil obtained per unit volume of material in addition to the known mass of oil, the level of purity and quality of oil can also be known. The specific gravity of ginger oil obtained is 0.865 g / ml this is the same as that obtained [1] but is below the SNI standard the difference in value obtained is influenced by the number and type of compounds contained in it, the higher the components that have long chains or have oxygen groups, the density of oil will increase [1,11]

3.3 Refractive index

The refractive index is the relationship between the speed of light and the rapid propagation of light in a medium. The refractive index is closely related to the components arranged in the resulting essential oil. The refractive index of ginger oil produced is qualified according to SNI with requirements is 1.4850 -1.492. What affects the value of the refractive index is the density of molecules, the density of liquids affected by temperature. The more long-chain components that are distilled, the density of the essential oil medium will increase so that the incoming light will be more difficult to refract [7]

3.4 Acid number

The acid number of an essential oil indicates the amount of free acid contained in the oil. Acidic compounds contained in essential oils are the result of oxidation reactions between oil and air catalyzed with the help of light. The essential oils obtained do not exceed the value of those standardized by SNI and are already classified as good. The acid number can also determine the quality and aroma of the essential oil produced [30].

3.5 Microencapsulation products

3.5.1 Moisture content

Moisture content is a parameter related to the stability of the product during storage. The water content of the resulting microcapsules is around 6.02 -7.20% as presented in Figure 1.

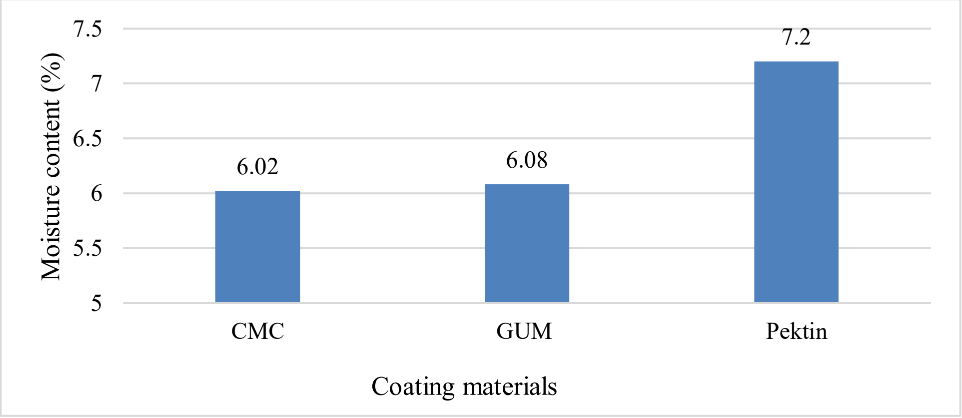

Fig. 1. Histogram of the effect of coating agents on the microencapsulated moisture content of red ginger essential oil.

In Figure 1. it can be seen that the highest moisture content is the use of pectin coating material, which is 7.2%. The high water content in pectin is due to pectin having higher water-binding properties compared to gum arabic and CMC, so in releasing water it is necessary to use a longer drying time [19]. The relatively high water content in the resulting product is thought to be due to the coating material used and the viscosity of the coating material can speed up the drying process, increase total solids and reduce the moisture content of food ingredients [23]. The higher the viscosity, the water content will also be high [28] According to [16] good moisture content ranges from 2-6%. The results of using gum arabic and CMC coating materials were 6.08% and 6.02% respectively, the results were lower when compared to using pectin. The result of moisture content using this coating material is good for more durable storage quality because it minimizes microbial growth. Moisture content which is a determinant of product quality related to product shelf life and durability. The low water content of microcapsules makes them more resistant to microbiological damage and damage due to hydrolysis of oil contained in microencapsulations [24].

3.5.2 Oil in surface

The percentage of oil on the surface is the amount of oil found on the outer surface of the microcapsule wall. The amount of oil on the surface is very important to know how much of the active ingredient is not coated [26]

Oil on the surface of the capsule indicates the amount of oil present on the outer surface of the capsule wall. The stability of the active ingredients affects the amount of oil present on the surface of the capsule so environmental conditions greatly influence [27]. The presence of oil on the outer surface of the microcapsule is undesirable because it can cause the core material to be very easily exposed to air, especially oxygen and water vapor, thus accelerating product damage. The effect of the coating material on the percentage of oil on the surface is shown in Figure 2. In Figure 2, pectin treatment has the highest oil surface content of 1.82% and the lowest using CMC 1.2%. The large value of oil on the surface indicates that many core materials are trapped. The amount of essential oils trapped can increase if skin formation takes place quickly. Because the amount of essential oil trapped increases, the amount of oil contained on the surface of the microcapsule decreases so that the value of oil on the surface produced is low. In addition, high viscosity causes a strong layer of skin formation that can reduce oil migration toward the outer surface of the microcapsule [29].

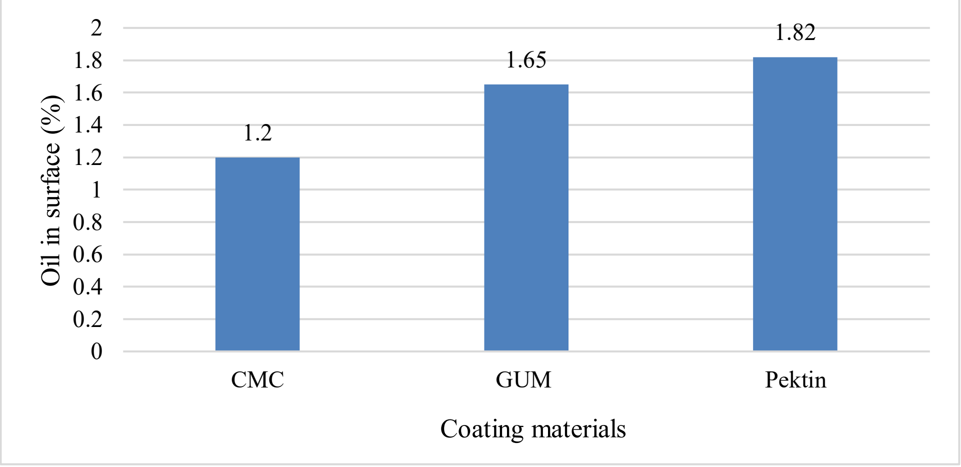

Fig. 2. Histogram of the effect of coating agents on oil on the surface microencapsulated red ginger essential oil.

3.5.3 Trapped oil

Microencapsulation is done to protect bioactive compounds, antioxidants, antimicrobials, vitamins, and aromatic compounds and damage or degradation during the packaging, storage, and transportation processes. There are several factors that can affect the efficiency of microencapsulation and the controlled release of bioactive compounds in essential oil microencapsulation. In addition, the selection of appropriate fillers, emulsifiers, and processing techniques is appropriate to achieve the desired controlled release of bioactive compounds. According to [25] the application of microencapsulation in food packaging to improve stability, safety, and product quality and slow release of bioactive compounds during ingestion or protection against pathogenic microorganisms. Trapped oil is a well-encapsulated oil that is inside the coating material [26] Encapsulations that have a high amount of trapped oil indicate that the amount of core material protected with a coating material is also high. Treatment using CMC has the highest oil value of 30.9%. And for treatment using gum arabic and pectin have lower trapped oil values of 26.90% and 22.56%. The oil trapped in the encapsulation is related to the concentration of the core ingredient and coating material [31]. The low-trapped oil that uses pectin due to the nature of pectin has the ability to form a gel can be utilized in microencapsulation to form a gel matrix that encloses the active ingredient to be encapsulated. Pectin can also form bonds with the active material to be encapsulated, either through hydrogen bonding or electrostatic interaction [32]. This can help maintain the stability of the active ingredients and prevent damage during the microencapsulation and storage process. Likewise, Gum Arabic has thickening properties and can form solutions with high viscosity. This allows Gum Arabic to be used as a coating agent to reduce the rate of release of the active ingredient from the microcapsules and extend their release time. However, when compared to CMC which has the ability to form a viscous solution that can thicken and form a strong gel, it allows CMC to be used as a coating agent to reduce the rate of release of active ingredients from microcapsules and extend their release time. CMC can interact with various active compounds and adjuvants in the microencapsulation process. In addition, CMC can also form hydrogen and electrostatic bonds with the active material, helping in maintaining stability and controlled discharge causing more trapped oil concentrations compared to gum arabic and pectin. On the other hand, the presence of high viscosity can reduce oil chemistry toward the outer surface of the microcapsule. As a result, a high percentage of trapped oil is produced in high-viscosity emulsions.

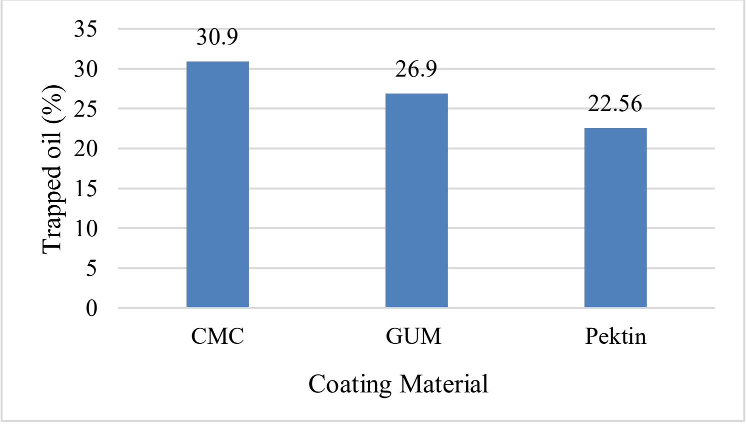

Fig 3. Histogram of the effect of the coating agent on the trapped oil microencapsulated red ginger essential oil.

4 Conclusions

The results showed that CMC, gum arabic and pectin were able to protect red ginger essential oil, during encapsulation where the trapped essential oil ranged from 22.56 – 30.90%, essential oil on the surface around 1.20-1.82% with an average moisture content of 6.02 – 7.20%. The best treatment is the use of CMC with water content (6.02%), the lowest surface essential oil (1.20%) and the highest trapped essential oil at 30.90%

Microencapsulation Technique The red ginger essential oil used in this study can also be applied to other similar essential oils. In microencapsulation, essential oils can improve the performance and effectiveness of essential oils in a variety of applications and can provide additional advantages in terms of stabilization, release, penetration, and product quality. Applications such as aroma control, raw materials for the food and beverage industry, as well as in cosmetic products. The advantages of this technology are that it can improve the stability of essential oils, especially against external factors such as oxygen, light, and temperature, thereby extending shelf life and maintaining their quality, and can allow control of the release of active ingredients such as in pharmaceutical, food, and cosmetic products and can improve product quality by adding additional effects such as improving the taste, aroma, and texture of food or providing a good aroma. more durable on products.

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