SEAS (Sustainable Environment Agricultural Science) **E-ISSN 2614-0934**
http://ejournal.warmadewa.ac.id/index.php/seas
Volume 07, Numer 02, October 2023, Pages:130~138 http://dx.doi.org/10.22225/seas.7.2.6842.130-138

Physicochemical Properties of Porang *Nanocoating* with the Addition of Essential Oils

Ngakan Putu Gede Satria Kesumayasa[1*], Luh Suriati[2], I Nyoman Rudianta[3]

[1,2,3]Food Science and Technology, Faculty of Agriculture, Warmadewa University, Denpasar Bali

*Corresponding author. Email: ngakansatria97@gmail.com

Abstract

Porang nanocoating is a food coating that has the potential to be developed and is gaining popularity among the public to extend the shelf life of fruits and vegetables. Porang Nanocoating is a nano-sized edible coating made from porang tuber glucomannan. The addition of essential oils can increase the property of the nanocoating of people as a natural antimicrobial coating. Thyme, cinnamaldehyde and eugenol essential oils are known to have excellent antimicrobial properties. Antimicrobial ability is strongly influenced by the concentration of added essential oil. The purpose of this study was to determine the effect of the type and concentration of essential oils on the physicochemical properties of porang nanocoating. This study used a factorial completely randomized design (CRD) with two factors, namely the type of essential oil treatment including essential oils of thyme, eugenol, cinnamaldehyde. While other treatments are essential oil concentrations, namely 1%, 2%, and 3%. The results of this study indicate that the type of essential oil and its concentration affect the physicochemical properties of the porang nanocoating. The physicochemical properties of porang nanocoating based on the type of essential oil treatment gave the following average values: viscosity 16.67 m.Pa.s. – 17.50 m. Pa. s; degree of acidity (pH) range 6.29 – 6.33; color 13.50 – 13.95; transparency 89.40 – 89.56; has stable emulsion properties or there is no separation of the emulsion and in the microscopic test the oil droplets or bubbles are few. Treatment of essential oil concentrations gives physicochemical properties to Porang Nanocoating which has an average Viscosity value of 16.11 m.Pa.s. – 18.61m. Pa. s; The degree of acidity (pH) ranges from 6.25 to 6.39; Color 12.80 – 14.91; Transparency 89.39 – 89.52; has stable emulsion properties with few oil droplets or bubbles.

*Keywords**:** Edible coating, coating, nanocoating, porang, essential oil*

1. Introduction

The application of *edible coatings* is currently popular among the public to extend the shelf life of fruits and vegetables [1]. *Edible coating* is primary packaging made from edible materials and can protect products from environmental impacts [2]. *Edible coatings* that use polysaccharides as basic ingredients are often used to coat fruits and vegetables because they are able to act as selective permeable membranes in the exchange of carbon dioxide and oxygen gases [3]. The advantages of starch-based *edible coatings* are that they prevent dehydration, fat oxidation, reduce respiration rates by controlling the gas composition of O2 and CO2 in the internal atmosphere and prevent browning on the surface of the product being coated [4]. One of the *edible coating materials* that can be used is porang tubers.

According to [5], Porang (*Amorphophallus muelleri*) is a type of tuber that has many uses and is classified as a type of Non-Timber Forest Product (HHBK) . Porang (*Amorphophallus muelleri*) as a plant produces carbohydrates, fats, proteins, minerals, vitamins and food fiber so that this plant has long been used for food and exported as industrial raw material [6]. One of the Porang ingredients that can be used as an *edible coating* for Porang is glucomannan. Glucomannan is part of functional food fiber in the form of a polymer of mannose and glucose linked by β-1 bonds. Glucomannan has the main properties and characteristics of being able to form transparent thin *(edible) layers* , form a homogeneous viscous mass, expand more, form gels, be strong and elastic and can dissolve again in water [7].

The ability of *Edible coatings* is greatly influenced by molecular structure, size, and chemical content, therefore nanoparticles are used to increase the ability of *Edible coatings* which will later be called *Nanocoating* [8]. *Nanocoating* is a nano-sized thin layer that can be combined with active additives such as antioxidants, anti-aging and antimicrobial [9]. *Nanocoating* particles with a small size cause a larger surface area resulting in increased solubility, release of active compounds, absorption, and adhesion [9]. The application of *Nanocoating* also improves the appearance of bright and shiny fruit, retains moisture, prevents weight loss, and acts as an antimicrobial [9]. Sometimes, the phenolic content of essential oils can induce the overall phenolic content in fruits [10].

Nanocoating ingredients other than glucomannan can be added essential oil. Essential oils have been used since ancient times as perfumes and traditional medicine [11]. According to [12], states that essential oils are the main bioactive compound produced by the substance acanthopod . Over time since the nineteenth century, the function of essential oils apart from being a flavoring agent is also used as a food preservative. The use of essential oils as antibacterials can be applied directly to food, as an additive for food preservatives or indirectly, namely with active antimicrobial packaging technology which is one of the food preservation systems [11].

Eugenol (clove), *Cinnamaldehyde* (cinnamon), and *Thyme* (thymol) oils are some examples of essential oils. *Thyme* oil (thymol) is an essential oil extracted from the thyme plant in such a process as essential oils in general [13]. Clove essential oil, both derived from flowers, flower stalks and leaves, contains *phenols* , one of which is *eugenol* , which *biologically* functions as an antimicrobial and antioxidant and is used traditionally as a flavoring agent and anti-microbial agent in food [14]. *Cinnamaldehyde* is a compound that has aldehyde and alkene functional groups conjugated with a *benzene ring* [15]. According to research conducted by [16], it shows that cinnamon bark essential oil has high inhibitory activity against *Escherichia coli, Salmonella, Staphylococcus aureus, Clostridium botulinum,* and *Bacillus bacteria* . Based on the description above, a study was carried out with the title " Porang *Nanocoating Physicochemical Properties* with the Addition of Essential Oils" to determine the effect of the type and concentration of essential oils on viscosity, degree of acidity, color, stability, microscopicity and transparency.

2. Material and Methods

This research was conducted from February - March 2023 at the Food Processing and Analysis Laboratory, Faculty of Agriculture, Warmadewa University. This study used a completely randomized design (CRD) factorial pattern with 2 factors. Factor I: Thyme essential oil (M1), Eugenol essential oil (M2) and Cinnamaldehyde essential oil (M3). Factor II: essential oil concentration of 1%, 2% and 3%. Each combination was repeated three times so that 27 experimental units were obtained. The parameters of this study were measuring viscosity with a viscometer, measuring the degree of acidity (pH) using a pH meter, color using *a color reader*, testing stability with a centrifuge, microscopy using a microscope. The data obtained were analyzed by means of ANOVA. The results of the variance which showed a significant ($P<0.05$) to very significant ($P<0.01$) effect were followed by a 5% BNT test. If the results of the treatment variances showed interaction, then it was continued with Duncan's Multi Range test.

3. Results and Discussion

3.1 Viscosity (Viscosity)

Analysis of variance showed that the type of essential oil treatment and the concentration of essential oils and their interactions had no significant effect (P>0.05) on porang *nanocoating*. The results of the analysis of the viscosity of the porang *Nanocoating* with the addition of *Eugenol type essential oil* and *Thyme* showed the same average viscosity value of 17.50 m. Pa.s is also the highest average value of the viscosity test. *Cinnamaldehyde* oil has the lowest average value of 16.67 m.Pa.s. The results of the analysis of the viscosity of the porang *nanocoating* with the addition of essential oils can be seen in Table 3.1.

Table 3. 1
Viscosity Test Value (m.Pa.s) of Porang *Nanocoating* With the Addition of Essential Oils

Treatment	Essential Oil Concentration			Average
	1%	2%	3%	
Oil Type				
Thyme	18.33	17.50	16,67	17.50 a
eugenol	19.58	16,25	16,67	17.50 a
Cinnamaldehyde	17,92	14.58	17.50	16,67 a
Average	18.61 a	16,11 a	16.94 a	

Note: The average value followed by letters in the same row or column means that the difference is not significant in the 5% BNT Test

Nanocoating with the addition of Eugenol and *Thyme* essential oils had a higher average viscosity value compared to *Cinnamaldehyde*. Essential oil with a concentration of 1% added to porang *Nanocoating* has the highest viscosity value. A high viscosity makes it difficult for the liquid or layers in the fluid to flow and vice versa if it has a low viscosity, the liquid or layers in the fluid will easily flow [17].

The less oil concentration added to the Porang *Nanocoating*, the higher the viscosity (thickness), because the glucomannan content in Porang predominates which causes the thickness of the Porang *Nanocoating* to be higher. Porang contains glucomannan which has the property of forming *cross-linking bonds* which affect the viscosity properties of the porang *nanocoating* itself [18].

3.2 Degrees of Acidity (pH)

Analysis of variance showed the type and concentration of essential oil and their interactions had no significant effect (P>0.05) on the pH value of Porang *Nanocoating with the addition of essential oil.* The results of pH analysis of porang *Nanocoating* with the addition of essential oils which had the lowest average pH value were porang *Nanocoatings with the addition of cinnamaldehyde* type essential oil with an average value of 6.29. Whereas porang Nanocoating with the addition of Thyme essential oil had the highest average pH value of 6.33. The results of porang *nanocoating* pH analysis with the addition of essential oils can be seen in Table 3.2.

Table 3. 2
Nanocoating pH Test Value With Addition Of Essential Oils

Treatment	Essential Oil Concentration			Average
	1%	2%	3%	
Oil Type				
Thyme	6,29	6,26	6,44	6,33 a
eugenol	6,28	6,29	6,33	6.30 a
Cinnamaldehyde	6,27	6,21	6,39	6,29 a
Average	6,28 a	6,25 a	6,39 a	

Note: The average value followed by letters in the same row or column means that the difference is not significant in the 5% BNT Test

The pH value is a measure to determine the physicochemical properties of porang *nanocoating* with the addition of essential oils. The pH measurement will indicate that the Porang *Nanocoating* is acidic if (0-6) and alkaline if (8-14). If the molecule touches the number 7 or has the number between the same acid and base then it is called neutral. Porang *nanocoating with the addition of Cinnamaldehyde* essential oil, it has the lowest degree of acidity, namely 6.29. Meanwhile, porang *Nanocoating with the addition of Thyme* essential oil had the highest average value of 6.33. The oil concentration in porang *Nanocoating* with the addition of essential oils which has the lowest value is a concentration of 2%, namely 6.25. Meanwhile, at a concentration of 3% it has the highest average value of 6.39. Judging from the type and concentration of oil added, it can be said that the *Cinnamaldehyde type essential oil* has the most acidic degree of acidity compared to the *Thyme* and *Eugenol types* and a concentration of 2% has the most acidic degree compared to concentrations of 1% and 3%.

This shows that *Cinnamaldehyde essential oil* has the most acidic degree of acidity. The acid value in cinnamaldehyde can inhibit the growth of bacteria because bacteria cannot grow in acidic conditions. In addition, the ability of *Cinnamaldehyde* as an antibacterial is by interfering with the biosynthetic process of enzymes in the bacterial body, binding proteins in the bacterial membrane and interfering with the formation of the main components of the bacterial cell wall, namely by inhibiting the synthesis process of peptidoglycan [19].

3.3 Color

Analysis of variance showed that the type of and the concentration of essential oil and their interactions had no significant effect ($P>0.05$) on the color value of porang *nanocoating* with the addition of essential oil. The results of the color analysis of porang *nanocoating* with the addition of essential oils which had the highest average value were porang *nanocoatings with the addition of Thyme* type essential oil, namely 13.95. Meanwhile, the lowest average value was porang nanocoating with the addition of *cinnamaldehyde essential oil*, which was 13.50. The results of the color analysis of porang *nanocoating* with the addition of essential oils can be seen in Table 3.3

Table 3. 3
Nanocoating Color Test Value With the Addition of Essential Oils

Treatment	Essential Oil Concentration			Average
	1%	2%	3%	
Oil Type				
Thyme	12.89	13.67	15,27	13.95 a
eugenol	11.75	13.91	15.30	13.65 a
Cinnamaldehyde	13.76	12.58	14,15	13.50 a
Average	12.80 a	13.39 a	14.91 a	

Note: The average value followed by letters in the same row or column means that the difference is not significant in the 5% BNT Test

The color test on porang *Nanocoating with the addition of Eugenol* type oil with a concentration of 3% showed the highest value compared to other types of essential oils. The higher the color value, the better the resulting liquid, this is in line with research conducted by [20], where the higher the color test value, the more transparent the porang *nanocoating* is made. The color value has a relationship with the effectiveness and stability of the gel.

Color testing in the Porang *Nanocoating analysis process* with the addition of essential oils is very important to determine the color value, because this color value is very decisive in the transparency test. This parameter is used as a subjective indicator of product quality, especially *Edible Coatings* [20]. So that the color variable becomes an important parameter in testing the physicochemical properties of porang *nanocoating* with the addition of essential oils.

3.4 Transparency

Analysis of variance showed that the type of essential oil and the concentration of essential oil and their interactions had no significant effect (P>0.05) on the transparency value of porang *nanocoating* with the addition of essential oil. The results of the color analysis of porang *nanocoating* with the addition of essential oils which had the lowest average value were porang *nanocoatings* with the addition of essential oils of *the Cinnamaldehyde type*, namely 89.40. While the highest average value was Porang *Nanocoating with the addition of Thyme* essential oil, namely 89.56. The results of the porang *nanocoating* analysis with the addition of essential oils can be seen in Table 3.4.

Based on Table 3.4, the lowest average value of transparency is found in Porang *Nanocoating with the addition of Cinnamaldehyde* essential oil with an average value of 89.40%. The lower the transparency value, the more transparent the porang *nanocoating* is made, and vice versa, the higher the transparency value, the more turbid the porang *nanocoating* is made [20]. The concentration of 1% essential oil has the lowest average value of 89.39%. The less oil concentration is given, the smaller the transparency value obtained. This is in line with research by [21], the concentration of oil affects the level of transparency of porang *nanocoatings* with the addition of oil.

Table 3. 4
Transparency Test Value (%) of Porang *Nanocoating* with the Addition of Essential Oils

Treatment	Essential Oil Concentration			Average
	1%	2%	3%	
Oil Type				
Thyme	89.56	89.46	89.65	89.56 a
eugenol	89,18	89.64	89.49	89.44 a
Cinnamaldehyde	89.42	89.37	89.41	89.40 a
Average	89.39 a	89.49 a	89.52 a	

Note: The average value followed by letters in the same row or column means that the difference is not significant in the 5% BNT Test

3.5 Stability

Analysis of the stability of the porang *nanocoating* with the addition of essential oils showed that there was no precipitate in the porang *nanocoating* with the addition of essential oils. This indicates that the *nanocoating properties* of porang with the addition of essential oils are stable. The results of the stability analysis of porang *nanocoating* with the addition of essential oils can be seen in Table 3.5.

Table 3. 5
Porang *Nanocoating* Stability Test With The Addition Of Essential Oils

No	Sample Code	Precipitation (separat		
		1%	2%	3%
1	Thyme Oil	Stable	Stable	Stable
2	Eugenol Oil	Stable	Stable	Stable
3	Cinnamaldehyde Oil	Stable	Stable	Stable

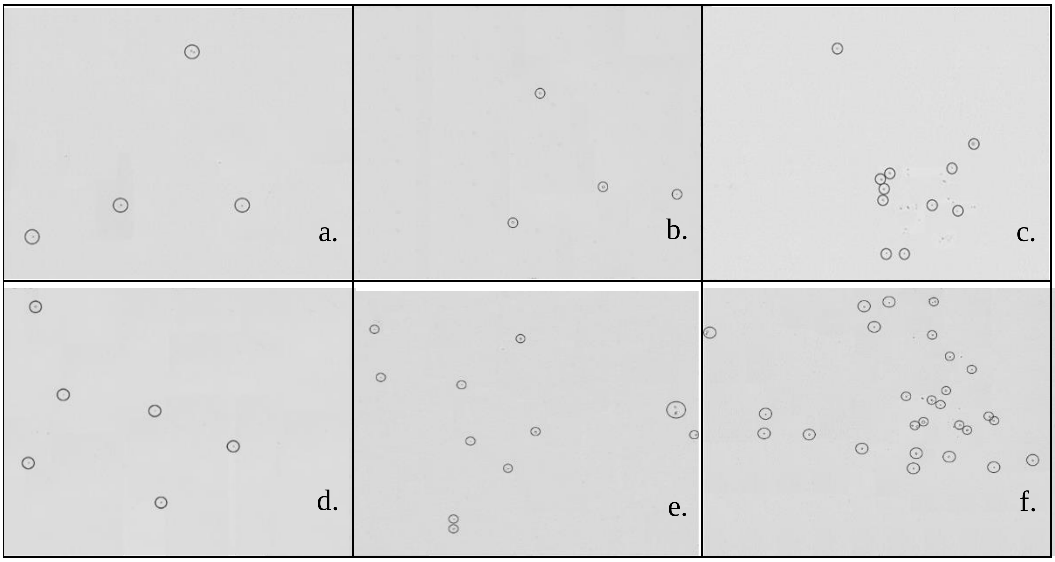
Note: Stable (No Precipitation Or No Emulsion Separation Found)

Based on Table 3.5, it can be seen that when the stability test was carried out for 30 minutes at 4000 *rpm*, no precipitate was found or no emulsion separation was found in porang *nanocoating* with the addition of essential oils. This indicates that the porang *nanocoating* with the addition of essential oils is stable because the emulsion does not separate after centrifugation for 30 minutes [22].

The addition of essential oils to the porang *Nanocoating* has an impact on his stability. This is in line with research conducted by [23], stated that the essential oil particles are in the crosslinks of the Porang *Nanocoating polymer* and contribute to its stability. So that the addition of essential oils in the porang *nanocoating* can maintain the stability of the porang *nanocoating.*

3.6 Microscopy

Microscopic analysis of porang *nanocoating* with the addition of essential oils showed the presence of bubbles in the porang *nanocoating* with the addition of essential oils. However, it can be seen that the least amount of oil bubbles was found in porang *nanocoating* with the addition of 1% concentration of *Cinnamaldehyde essential oil*. Meanwhile, the most abundant oil bubbles were in Porang Nanocoating with the addition of 3% concentration of *Eugenol essential oil* . The results of the *porang nanocoating* microscopic analysis with the addition of essential oils can be seen in Figure 3.1.



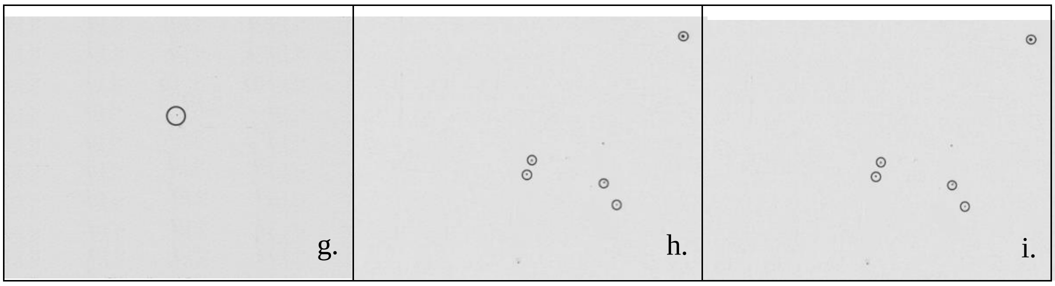


Figure 1
Nanocoating Microscopic Analysis Results Porang

Information:

a. *Nanocoating of porang with Thyme* essential oil with a concentration of 1%
b. *Nanocoating of porang with Thyme* essential oil with a concentration of 2%
c. *Nanocoating of porang with Thyme* essential oil with a concentration of 3%
d. *Nanocoating of porang with Eugenol* essential oil with a concentration of 1%
e. *Nanocoating of porang with Eugenol* essential oil with a concentration of 2%
f. *Nanocoating of porang with Eugenol* essential oil with a concentration of 3%
g. *Nanocoating of porang with Cinnamaldehyde* essential oil with a concentration of 1%
h. *Nanocoating of porang with Cinnamaldehyde* essential oil with a concentration of 2%
i. *Nanocoating of porang with Cinnamaldehyde* essential oil with a concentration of 3%

Based on Figure 3.1 the red circles in the figure are *droplets* or particles shaped like raindrops where these are oil particles contained in the porang *Nanocoating* with the addition of essential oils. The high content or percentage of water in porang *nanocoating* with the addition of essential oils causes lots of oil bubbles to appear [24]. In Porang *Nanocoating* with the addition of essential oils It can be seen that the higher the concentration of oil added, the more *droplet particles* are visible. This is in line with research conducted by [25], that the higher the concentration of oil used, the greater the number of droplets produced and the distribution of the droplets is also more even. In addition, the fewer the oil *droplet particles*, the more they spread in water so that the resulting emulsion is more stable, the emulsion referred to here is porang *nanocoating* with the addition of essential oils.

4. Conclusion

The physicochemical properties of porang *nanocoating* are influenced by the type and concentration of essential oils. The physicochemical properties of porang *Nanocoating* based on the type of essential oil treatment gave the following average values: viscosity 16.67 m.Pa.s. – 17.50 m. Pa. s ; degree of acidity (pH) range 6.29 – 6.33; color 13.50 – 13.95; transparency 89.40 – 89.56; and has stable emulsion properties with few oil droplets or bubbles are few. Treatment of essential oil concentrations gives physicochemical properties to Porang Nanocoating which has an average Viscosity value of 16.11 m.Pa.s. – 18.61m. Pa. s; The degree of acidity (pH) ranges from 6.25 to 6.39; Color 12.80 – 14.91; Transparency 89.39 – 89.52; and has stable emulsion properties with few oil droplets or bubbles.

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