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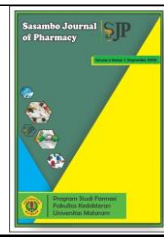

Formulation of edible film mucoadhesive cinnamon extract (*Cinnamomum burmanni*)

Makhabbah Jamilatun[1*], Pradea Indah Lukito[1]

[1] Department of Pharmaceutical and Food Analysis, Health Polytechnic of Health Ministry Surakarta, Indonesia.

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Abstract: Antioxidants can neutralize free radicals, playing a role in preventing degenerative diseases. Cinnamon has very strong antioxidant activity. Edible film can function as carriers of antioxidant compounds. This research was conducted to determine the physical quality and antioxidant activity of cinnamon extract mucoadhesive edible film. The research method used is quantitative experimental. There are four edible film mucoadhesive formulas with different concentrations of cinnamon extract added, namely 0% at F0, 5% at F1, 10% at F2 and 15% at F3. The test results for organoleptic F0 are clear white, odorless, thin, and sticky sheets, pH 7.54; thickness 0.026 mm; weight uniformity 30.93; water content 32.61%. The organoleptic test results for F1 are dark brown, have a typical cinnamon smell, are thin and non-sticky sheets, pH 6.78; thickness 0.063 mm; weight uniformity 30.52; water content 17.32%. The organoleptic test results for F2 are dark brown, have a typical cinnamon smell, are thin and non-sticky sheets, pH 6.21; thickness 0.073 mm; weight uniformity 24.53; water content 12.81%. The organoleptic test results for F3 are dark brown, have a typical cinnamon smell, are thin and non-sticky sheets, pH 6.29; thickness 0.08 mm; weight uniformity 15.42; water content 15.74%. The antioxidant activity was weak in F0, very strong in F1, F2, and F3. Edible film mucoadhesive cinnamon extract in formulas F1, F2, and F3 produces good physical properties according to standards and has very strong antioxidant activity. The conclusion of this study shows that cinnamon extract can be formulated into Edible Film Mucoadhesive, as seen from its antioxidant activity in F3, with an extract concentration of 15%.

Keywords: Edible Film; Mucoadhesive; Cinnamon Extract; Antioxidants.

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Introduction

Oxidative stress can be defined as when the number of free radicals is not balanced with the amount of endogenous antioxidants produced by the body. Oxidative stress can play a role in triggering degenerative diseases, such as atherosclerosis which underlies cardiovascular disease, diseases related to the heart, blood vessels, and stroke (Parwata, 2016). Until now, cardiovascular disease is a non-communicable disease that is still a problem throughout the world. WHO reports that deaths caused by cardiovascular disease are 17.9 million people and it is estimated that this will increase to 23.6 million people in 2030 (WHO, 2021). In Indonesia, based on 2018 Riskesdas data, heart disease has a prevalence for all ages, 1.5% of the total population of Indonesia (Riskesdas, 2018).

The number of heart diseases is thought to be increasing due to changes in diet, namely a diet that is high in saturated fat, protein, and salt, but low in fiber and unsaturated fat, thereby increasing free radicals which play a role in the formation of atherosclerosis (Nugroho et al., 2022; Jamilatun, Hikmah, et al., 2025). The large influence of free radicals on human health means that the body requires an intake of compounds, namely antioxidants (Yuslianti, 2018). Antioxidants can

Email: makhabbah.j@gmail.com *(*Corresponding Author)*

absorb or neutralize free radicals. This causes further reactions, cell damage can be avoided, and the induction of a disease can be stopped, so it can be included in the prevention of degenerative diseases such as cardiovascular. Antioxidants can suppress the secretion of Density Lipoprotein (VLDL) cholesterol in the liver by reducing the inhibition of the flow of free fatty acids in adipose tissue (Parwata, 2016).

Antioxidants to prevent oxidative stress, the body's resistance to it through endogenous antioxidants. The body needs antioxidant intake obtained from food or medicine (Jamilatun & Lukito, 2025). An antioxidant that is commonly consumed every day as a spice in cooking is cinnamon. Cinnamon *(Cinnamomum burmanni)* is known to function as an antioxidant. Cinnamon contains several compounds such as eugenol, calcium oxalate, tannins, safrole, cinnamaldehyde. (Helmalia et al., 2019; Antasionasti & Jayanto, 2021).

Preventive steps to reduce the development of heart disease can be done by consuming supplements (Taherkhani et al., 2021). Among them are antioxidant supplements, supplements that contain concentrated antioxidant molecules (Mardhiati, 2016). This antioxidant supplement has the potential to be a supporting therapy in treating coronary heart disease and can reduce the appearance of complications. In the end, it can reduce the high morbidity and mortality rates due to heart disease (Astuti et al., 2019). Edible film is known to function as carriers of antioxidant compounds. Several research results show that edible films that contain antioxidants from natural active ingredients are experiencing rapid development (Santoso et al., 2020).

Drug delivery systems have been highly developed, one of which is mucoadhesive preparations. This preparation has good contact time with the buccal mucosa (Venkatalakshmi et al., 2012). Mucoadhesive materials can be made in the form of edible film. Films that release drugs into the buccal mucosa can avoid first-pass metabolism because they are absorbed through the venous system that flows in the cheek (Tanjung et al., 2021). Edible film can be used as an antioxidant (Soukoulis et al., 2014). The herbal edible film is a food product that resembles candy with the appearance of a thin, transparent layer that is cut to a certain length and width so that it is easy to place in the mouth. Edible film can immediately dissolve after contact with a little water (saliva), made from organic materials that can be consumed immediately and does not harm the body (Wahyuni et al., 2021). Based on the problems described above, research was carried out on the formulation of Edible Film Mucoadhesive Cinnamon Extract (*Cinnamomum burmanii*) as an Antioxidant Supplement, with the aim of knowing the physical quality (*Cinnamomum burmanii*).

Materials and Methods

The ingredients used are cinnamon, porang flour, CMC (Carboxyl Methyl Cellulose), Glycerol, Sorbitol, sodium benzoate, distilled water, magnesium powder, FeCL3, anhydrous acetic acid, Lieberman-Burchard, HCL, ethanol 96%, ethanol p.a, methanol p.a., quercetin, DPPH (2,2 diphenyl-2-picrylhydrazyl), filter paper, flannel cloth, plastic wrap, and aluminum foil. Equipment used: oven (Memmert), analytical balance (Labex), blender (Quantum), 40 mesh sieve, beaker glass (Pyrex), porcelain cup, stir bar (Iwaki), pH meter (Eutech), 5 mL and 10 mL volumetric flasks (Pyrex), dropper pipette, glass funnel (Pyrex), test tube (Pyrex), vortex, test tube rack, micropipette (Onemed) and tip, desiccator, measuring cup (Pyrex), cuvette and UV-Vis spectrophotometer (Innova).

Research procedures include sample preparation and making cinnamon extract, formulation and making of edible film, physical quality evaluation, and antioxidant activity test of edible film.

1. Sample preparation and manufacture of cinnamon extract. Cinnamon in powder form was weighed 10 grams and put into an Erlenmeyer flask. Add distilled water to 100 ml. The solution was heated for 60 minutes at 60°C. The heating process uses a water bath. The solution was filtered and centrifuged at 4000 rpm for 15 minutes and the filtrate was taken. The filtrate is used as an additive in making edible film (Karyantina et al., 2021).
2. Formulation and manufacture of edible film according to **Table 1**. refer to (Husni et al., 2020; Tanjung et al., 2021; Arsita Dewi & Mulya, 2019).

Table 1. Mucoadhesive Edible Film Formula

No	Material Name	Function	Concentration (%)			
			F0	F1	F2	F3
1	Cinnamon Extract	Active Substance	0	5	10	15
2	CMC	polymer	1	1	1	1
3	Porang Flour	polymer	3	3	3	3
4	Glycerol	Plasticizers	2	2	2	2
5	Sorbitol	Sweeteners & Plasticizers	2	2	2	2
6	Sodium Benzoate	Preservative	0.1	0.1	0.1	0.1
7	Aquades up to	Solvent	200	200	200	200

Description: F0 (addition of 0% cinnamon extract), F1 (addition of 5% cinnamon extract), F2 (addition of 10% cinnamon extract), F3 (addition of 15% cinnamon extract).

The edible film was made by referring to research (Husni et al., 2020), through several stages, namely, CMC was dispersed in 50 ml of distilled water, then heated and stirred continuously at a temperature of ±90 ^{0}C (A). Porang flour is added to solution A while stirring (B). Sodium benzoate and sorbitol are dissolved in hot water (70-80 ^{0}C), then added to mixture B. Glycerol and cinnamon extract were added to mixture B. The remaining distilled water was added to mixture B and stirred homogeneously. The final mixture is poured and spread evenly over the mold. Drying is carried out using an oven for 24 hours at a temperature of 50-60 ^{0}C, then removed from the mold and cut into pieces. Next, physical quality and antioxidant activity were evaluated.

3. Physical evaluation of cinnamon extract edible film refers to research (Arsita Dewi & Mulya, 2019), which includes organoleptics, pH measurements, film thickness, weight uniformity, and water content. In the organoleptic test, the taste, smell, texture, and color of each edible film formula were observed. pH measurement using a pH meter. The thickness test was carried out using a micrometer. In the weight uniformity test, ten edible films were randomly selected and weighed and the average weight was calculated. The water content test was carried out using the gravimetric method. Calculated by the formula:

   Water content (%) = $\frac{W1-W2}{W2-W0}$ x 100%

   Description:

   W_0 = weight of empty cup

   W_1 = cup weight + initial sample (before heating)

   W_2 = cup weight+initial sample (after heating).

Antioxidant Activity Test, DPPH method using a UV-Vis spectrophotometer (Antasionasti & Jayanto, 2021; Indah et al., 2021; Jamilatun, Lukito, et al., 2025). The stages of antioxidant activity analysis include preparing the DPPH solution, making a control solution, determining the maximum wavelength, determining the antioxidant activity of the reference solution, and determining the antioxidant activity of edible film (Masaenah *et al.,* 2019).

Result and Discussion

The results of the cinnamon extract were formulated into edible film and then the physical quality and antioxidant activity were evaluated with the results shown in **Table 2**.

Table 2. Physical Quality and Antioxidant Activity of Edible Film Mucoadhesive Cinnamon Extract

Physical Quality	**F0**	**F1**	**F2**	**F3**
Organoleptic				
Color	Clear white	Dark brown	Dark brown	Dark brown
Smell	No smell	Cinnamon special	Cinnamon special	Cinnamon special
Flavor	Bid	Sweet	Sweet	Sweet
Texture	Thin, sticky	Thin, not sticky	Thin, not sticky	Thin, not sticky
pH	7.54±0.058	6.78±0.043	6.21±0.030	6.29±0.012
Thickness (mm)	0.026±0.007	0.063±0.005	0.073±0.005	0.08±0.010
Weight uniformity (mg)	30.93±0.374 CV = 1.21	30.52±0.181 CV = 0.59	24.53±0.115 CV = 0.47	15.42±0.234 CV = 1.52
Water content (%)	32.61±2.266	17.32±0.510	12.81±0.707	15.74±0.486
Antioxidant Activity	**F0**	**F1**	**F2**	**F3**
IC_{50} (ppm)	415.32±1.273	35.47±0.127	29.39±0.029	16.94±0.266
Kategori	Weak	Very strong	Very strong	Very strong

Description: F0 (addition of 0% cinnamon extract), F1 (addition of 5% cinnamon extract), F2 (addition of 10% cinnamon extract), F3 (addition of 15% cinnamon extract). Antioxidant activity test using quercetin as a positive control with IC_{50} of 7.611 ppm, and F0 (formula without additional extract) as a negative control.

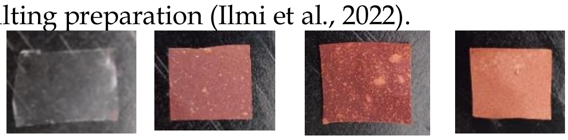
Research on the formulation of edible film mucoadhesive cinnamon extract aims to find out the physical quality and antioxidant activity of edible film mucoadhesive cinnamon extract (*Cinnamomum burmanii*). The material used is cinnamon simplicia obtained from Traditional Market in Surakarta. The cinnamon simplicia used was determined at the UPF Testing Laboratory of Traditional Health Services at RSUP Dr. Sardjito, Tawangmangu, Karanganyar Regency, Central Java, to find out whether the plants being studied are true or not, as well as avoid mixing materials with others and avoiding errors in collecting materials (Indriyani et al., 2022). Based on the Certificate of Determination Number: TL.02.04/D.XI.6/133.013/2024, it can be confirmed that the plant used in this research is cinnamon.

Table 3. Results of Cinnamon Extract Yield

Material	**Material Weight (g)**	**Extract Weight (g)**	**Rendement (%)**
Cinnamon Simplex	179.2347	86.3576	48.1812

The results of the Cinnamon Extract yield can be seen in 3. In previous research, the yield of cinnamon extract produced was 27.18% (Kementrian Kesehatan Indonesia, 2017). This difference in results could be due to differences in methods, plant collection location, process, type of solvent, time, and temperature (Wulan et al., 2024), as well as the size of the powder used (Rifai et al., 2018). The yield value can be interpreted as the active compound contained in a sample. The higher yield value indicates that there are more active compounds in it. The results obtained have met the requirements of the Indonesian Herbal Pharmacopoeia, namely for cinnamon bark extract the yield is ≥ 25.4% (Silverman et al., 2023).

Organoleptic testing of edible film is carried out visually using the human senses (Andiva et al., 2023), (Jamilatun, Rusita, et al., 2025), to describe the smell, taste, color, and shape of the mucoadhesive edible film cinnamon extract. Based on Table 2, the organoleptic edible film in F0 is clear white, odorless, sticky and in the form of a thin sheet, while in F1, F2, and F3 it has the same organoleptic properties, namely dark brown in color, has a distinctive smell of cinnamon, is in the form of a thin sheet and is not sticky. The dark brown color in F1, F2, and F3 is due to the addition of cinnamon extract, which contains cinnamaldehyde and a cinnamon content that plays a role in giving the brown color (Ilmi et al., 2022). The shape of this edible film is in line with previous research, where film strips made from herbal juice have a thin layer (Wahyuni et al., 2021). Edible film is a solid preparation that comes in the form of a thin sheet and is used orally (BPOM, 2019). The sweet taste produced by edible film comes from the addition of sorbitol. Formulas F1, F2, and F3 produce an odor, namely the typical smell of cinnamon. The results of this research are by the statement that the higher the extract concentration, the darker or more intense the color of the resulting preparation (Ilmi et al., 2022).



F0 **F1** **F2** **F3**

Figure 1. Edible Film Mucoadhesive Cinnamon Extract

The pH of edible film is measured, to determine whether the preparation is safe when consumed (Jamilatun et al., 2024). Based on Table 2, the pH of cinnamon extract edible film F0 is 7.54±0.058; F1 of 6.78±0.043; F2 is 6.21±0.030 and F3 is 6.29±0.012. Good edible film must have a pH that is safe for consumption in the mouth so that it does not irritate. If the pH of the preparation is too acidic, it can irritate the oral cavity and if the pH of the preparation is too alkaline it can cause caries on the teeth (Micie Sariwating et al., 2022). The more extract used, the lower the resulting pH will be (Ain Thomas et al., 2022). The pH test results of the four formulations meet the specified requirements, namely pH 5.5–7.9 (Arsita Dewi & Mulya, 2019), so that the edible film resulting from this research is safe and does not irritate the oral cavity.

Edible film thickness checks are carried out using a micrometer (Ningsih & Arel, 2021). Thickness testing obtained average results of F0, F1, F2, and F3 respectively, namely 0.026±0.007 mm; 0.063±0.005 mm; 0.073±0.005 mm, and 0.08±0.010 mm. The results of this research indicate that the edible film thickness of the four formulas meets the requirements. The four edible film formulas in this study met the thickness requirements. The specified edible film thickness standard is a maximum of 0.5 mm (Tanjung et al., 2021). F3 is thicker than F0, F1, and F2. The film thickness produced in this research is by previous research (Ulyarti et al., 2022). The difference in thickness produced in each edible film formula is caused by differences in the concentration of the extract used. Increasing the extract concentration resulted in the edible film getting thicker. This is because the extract will solidify during the heating process. After all, all the water content will evaporate (Sulistijowati & Moomin, 2021; Gusti Amelia et al., 2023). Apart from that, adding large amounts of extract can increase the total solids so that the thickness of the edible film increases (Ma'rifah, 2022).

Weight uniformity testing on edible film aims to determine whether the resulting edible film has a uniform weight or not, as well as to ensure the consistency of a preparation (Ode et al., 2021). Uniformity of weights at F0; F1; F2; and F3 respectively, namely 30.93±0.374 mg; 30.52±0.181 mg; 24.53±0.115 mg and 15.42±0.234 mg. The results of the weight uniformity test have a coefficient of variation of 1.21 at F0, 0.59 at F1, 0.47 at F2, and 1.52 at F3. Of the four formulations, it shows that the edible film meets the requirements, and the maximum percentage variation in weight is no more than 6% (Departemen Kesehatan Republik Indonesia, 1995), by previous research, the uniformity of film weight is no more than 5% (Ode et al., 2021). The result values are different because the process of cutting edible film is done manually, so there may be slight differences in size between one film and another.

Water content testing in this study was carried out to determine water content (Jamilatun et al., 2024) of cinnamon extract mucoadhesive edible film. The water content of a material determines the quality and durability of the material and its stability, especially during storage (Asiah & Djaeni, 2021). Dry food ingredients will last longer, if the water content is high it can cause the growth of bacteria, mold, and yeast, so changes will occur in the ingredients (Azhar & Kanetro, 2018). The results of the water content test on the edible film mucoadhesive cinnamon extract were 32.61±2.266% at F0, 17.32±0.510% at F1, 12.81±0.707% at F2, and 15.74±0.486% at F3. The water content requirement is below 20% (Tanjung et al., 2021). The water content in F0 (without cinnamon extract) did not meet the requirements, while F1, F2, and F3 showed results that met the requirements. The water content in the edible film formula decreased with increasing cinnamon extract concentration. This is because the cinnamon extract added to this edible film is in the form of a filtrate, and does not go through a process of total removal of dissolved solids. The dissolved solids in the cinnamon filtrate can bind water so that the water content decreases as the cinnamon extract used increases (Karyantina et al., 2021).

Analysis of antioxidant activity in this study was carried out to determine the antioxidant properties of cinnamon extract mucoadhesive edible film. Antioxidant activity testing uses the This method was chosen because the test is simple, the time is short and the sample used requires a small amount (Budi & Nastiti, 2022). The DPPH method is calculated based on the IC_{50} value. Inhibition concentration (IC_{50}) can be interpreted as the effective concentration value, a number that shows the concentration of the extract (micrograms/milliliter), which can inhibit 50% oxidation. The antioxidant activity becomes greater as the IC_{50} value becomes smaller (Moniung *et al*., 2022). Categorized, a compound has very strong antioxidant activity (IC_{50} value less than 50), strong (IC_{50} value in the range 50-100), moderate (IC_{50} value in the range 100-150), and weak (IC_{50} value in the range 151-200) (Santoso, 2020).

Quercetin is used as a standard because it is a flavonoid derivative which can act as an antioxidant used to inhibit DPPH free radicals (Melanie et al., 2023). The linear regression equation for the quercetin comparison solution was obtained, y=6.2042x+2.7743 with a value of R2 = 0.9971. So the IC_{50} value was obtained at 7.611 ppm in the very strong antioxidant category. By previous research, quercetin has a very strong antioxidant activity category with an IC_{50} value < 50 ppm. Furthermore, testing the antioxidant activity on cinnamon extract edible film samples obtained successive linear regression equations, namely y = 0.1492x - 11.966 with a value of R2 = 0.9984 at F0; y = 1.2027x + 7.3323 with R2 value = 0.9917 at F1; y = 0.6153x + 31.916 with R2 value = 0.9909 at F2; and y = 0.3044x + 44.842 with a value of R2 = 0.9996 at F3. Based on the linear regression obtained, the IC_{50} value for each formulation F0, F1, F2, and F3 respectively was 415.32±1.273 ppm; 35.47±0.127 ppm; 29.39±0.029 ppm; and 16.94±0.266 ppm. Based on the results obtained, F0 has a weak antioxidant category because the IC_{50} value is in the range of 150 – 200 ppm. This is because F0 does not contain additional extract. Meanwhile, F1, F2, and F3 have very strong antioxidant categories with IC_{50} values in the range of 0-50 ppm. F3 has very strong antioxidant activity with the lowest IC_{50} because it uses more of the active ingredient cinnamon extract. Of the three formulations, F1, F2, and F3 edible film, the cinnamon extract showed strong antioxidant activity. According to previous research, cinnamon extract is very strong (Rosa, 2023). Based on the phytochemical screening (Jamilatun, 2023) carried out in this research, cinnamon contains flavonoids, phenols, tannins, and terpenoids. This content can act as a source of antioxidants.

Health can be maintained by consuming foods that contain lots of antioxidants. Mucoadhesive edible films are included in the strip film type, solid preparation of traditional medicine which has a thin sheet texture, can be used orally (BPOM, 2019). Edible film has many advantages, is easy to consume by all age groups including pediatrics and geriatrics, is made from natural ingredients, increases residence time on the mucosa, and is easier to absorb quickly because it does not go through the first pass effect of metabolism. The antioxidant activity of cinnamon extract has the opportunity to become an active substance added to edible film preparations to maintain the body's immunity and as a preventive measure for degenerative diseases (Molnar et al., 2023). The cinnamon extract mucoadhesive edible film produced in this research has a very strong antioxidant activity value, so it can be developed as an antioxidant supplement.

Conclusion

Cinnamon extract can be formulated into Edible Film Mucoadhesive, as seen from its antioxidant activity in F3, with an extract concentration of 15%.

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