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The effect of additional orange Pangkep (*Citrus maxima*) peel oil on characteristics and microbial inhibition of corn flour-based edible film

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Abstract. The edible film is a thin layer of hydrophilic materials made of proteins, carbohydrates, and fats that replaces plastic packaging. This study was carried out to determine the effect of adding the Pangkep orange peel (*Citrus maxima*) oil on edible films based on corn flour. Treatments applied in this research were concentration of corn flour (2%, 4%, and 6% (w/v)) and concentration of Pangkep orange peel (*Citrus maxima*) oil (1%, 1.5%, and 2% (v/v)). Measurement parameters were tensile strength, elongation, thickness, moisture content, and inhibition of *Escherichia coli* and *Staphylococcus aureus*. The results showed that the composition of Pangkep orange oil (*Citrus maxima*) and corn flour had a significant effect on the elongation, thickness, moisture, and inhibition of *Escherichia coli* and *Staphylococcus aureus*. The best formula treatment was obtained with a combination treatment containing 4% corn flour and 1% Pangkep orange peel oil (*Citrus maxima*).

1. Introduction

The edible film is a thin layer of proteins, carbohydrates, and fats or mixtures of hydrophilic materials that act as an environmentally friendly packaging material as an alternative to plastic packing [1]. The elastic, renewable, and edible properties of edible films favor corn flour due to its properties, a possible raw material for the production of edible [2]. Corn contains high molecular weight polymers such as 27% amylose and approximately 73% amylopectin and its hydrophilicity [3]. The branched structure of amylose and amylopectin in the amorphous region results in poor mechanical properties such as low tensile strength, and elongation [2].

Edible films as a coating can prevent the development of microorganisms during storage by adding antimicrobial agents [4]. Addition of essential oils as antimicrobial agents to inhibit microbial growth for high-quality and safe food production [5]. Because of the antibacterial activity contained in these compounds, so they can be used as natural antibacterial agents [6]. Limonene and other metabolites belonging to terpenoids, alkaloids, flavonoids, steroids, and cardiac glycosides be classified as *Citrus* spp. The active ingredient inhibits bacteria such as *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhimurium*, and *Bacillus cereus*. Presence of antibacterial compounds in citrus fruits. Allows antibacterial substances to also be present in the peel of Pangkep oranges (*Citrus maxima*). [7, 8]. The mechanism of microbial damage caused by secondary metabolites, i.e., saponins, flavonoids, and terpenoids, works by changing the permeability of the cytoplasmic membrane of bacterial cells [9]. The next mechanism is the denaturation of proteins by phenolic compounds. Tannins, alkaloids, and phenolic



compounds cause further damage by inhibiting enzymatic processes within the cell, leading to the death of the bacterial cell [10].

The process of making edible films means making edible films [11]. According to the properties of thickness, water transmission, and transparency, the best preparation is the cling film with 2.5 g of corn starch content, 0.8 g of carrageenan content, and 1 ml of glycerol. while the addition of essential oils suggests a study by [12] that cling films with 1.25% galangal essential oil added have the best antimicrobial activity and 1.5% the best resistance.

Based on this description, it is expected that the study can improve the physical and mechanical properties of edible films and inhibit the growth of *Escherichia coli* and *Staphylococcus aureus* microorganisms. Therefore, you should consider adding the essential oil of Pangkep orange peel (*Citrus maxima*) to edible corn flour films.

2. Materials and Methods

2.1. Materials

The ingredients used in this study were Mugo brand cornmeal, Pangkep orange peel essential oil extract by microwave distillation, kappa carrageenan, glycerol USP 99.7, and aqua dest. Materials used in the analytical procedure were Merck brand MHA (Mueller Hinton Agar), Mcfarland turbidity equivalence 0.5 standards, *Escherichia coli* ATCC 8739, and *Staphylococcus aureus* bacteria.

2.2. Method of films preparation

In this study, the treatment was between corn flour and the essential oil content of Pangkep orange peel (*Citrus maxima*). The composition is shown in Table 1.

Table 1. Treatment to make edible film corn flour with essential oil of Pangkep orange peel (*Citrus maxima*).

Treatment	Corn Flour: Essential Oil
A1B1	2% : 1%
A1B2	2% : 1.5%
A1B3	2% : 2%
A2B1	4% : 1%
A2B2	4% : 1.5%
A2B3	4% : 2%
A3B1	6 % : 1%
A3B2	6 % : 1.5%
A3B3	6 % : 2%

The procedure for making edible films carried out in this study was to use corn flour with a concentration of 2%, 4%, and 6% (w/v) then weigh the carrageenan with a concentration of 0.8 grams and make 1 ml of glycerol suspension by adding 100 ml of water. distilled and then heated the suspension on a hot stirrer plate at 70-85°C for ± 30 minutes. then cooled the suspension to 37°C [11] and added Pangkep orange peel essential oil with a concentration of 1%, 1.5%, and 2% (v/v total) [13]. Then pour 20 g of the suspension into a petri dish with a diameter of 9-9.5 cm using the solvent casting (SC) printing method. Dry the edible film with the mold at $\pm 50^\circ\text{C}$ for 12 hours and then cool the edible at room temperature for 15 minutes then remove the edible film from the Petri dish mold. carry out tests on edible films which include tensile strength, elongation, thickness, moisture content, and microbial inhibition [11].

Measurements of tensile strength and elongation were carried out in this experiment using a universal hydroelectric testing machine brand Jinan Factory WAW 500, film thickness using a digital micrometer (Krisbow, Indonesia) with an accuracy of 0.001 mm, testing for water content based on SNI 06-3735-1995 and inhibition of bacteria using the disc diffusion method. [13].

2.3. Data analysis

Analyzed experimental data using ANOVA (Analysis of Variance) and if a significant 5% ($p=0.05$) was identified, then it was continued with the DMRT (Duncan's Multiple Range Test). The statistical application used is IBM SPSS Statistics 21 software.

3. Results and Discussion

Test results properties such as tensile strength, elongation, and thickness of edible film obtained from corn flour with the addition of essential oil of Pangkep orange peel (*Citrus maxima*) essential oil. The properties of the edible film are shown in Table 2.

Table 2. Characteristics of Edible Film

Treatment	Parameters			
	Tensile Strength (N/mm ²)	Elongation (%)	Thickness (mm)	Moisture Content (%)
A1B1	3.58±1.59	6.75 ^{ab} ±1.13	0.19 ^a ±0.03	16.23 ^c ±0.20
A1B2	1.46±0.33	5.91 ^{ab} ±0.30	0.30 ^a ±0.06	17.37 ^e ±0.29
A1B3	1.32±0.10	14.12 ^c ±2.73	0.27 ^a ±0.03	19.53 ^h ±0.21
A2B1	1.74±0.65	8.19 ^b ±2.02	0.23 ^a ±0.02	16.58 ^f ±0.23
A2B2	3.42±2.45	4.97 ^{ab} ±2.03	0.44 ^{bc} ±0.15	11.62 ^b ±0.24
A2B3	0.72±0.38	6.18 ^{ab} ±2.72	0.48 ^{bc} ±0.01	14.22 ^d ±0.05
A3B1	2.26±1.16	4.13 ^a ±0.85	0.54 ^c ±0.05	13.42 ^c ±0.17
A3B2	1.92±0.67	5.33 ^{ab} ±1.01	0.41 ^b ±0.07	10.84 ^a ±0.17
A3B3	3.16±1.18	5.55 ^{ab} ±0.92	0.46 ^{bc} ±0.05	10.71 ^a ±0.08

Note: Different letters within the equal column imply sizable variations ($p<0.05$).

3.1. Tensile Strength

The maximum tensile force that bioplastics can hold up to strength is called tensile strength. According to the JIS (Japanese International Standard), the tensile strength of edible bioplastic films is at least 3.92 MPa [14]. The results of the dispersion test are shown in Table 2. It can be seen that the difference in the concentration of corn flour and the addition of essential oil had no significant effect ($P>0.05$) on the tensile strength of the edible film.

Using growing the tensile strength, the concentration of 1.75 essential oil increased in comparison to the tensile electricity on the concentration of 1.5% [15]. In general, the tensile strength of the fit-for-human consumption movies produced in this study did not meet the minimum tensile strength general for safe-to-eat movies based on the JIS, specifically 3.92 MPa (N/mm²). Therefore, [16] said that the decrease in tensile electricity changed due to the boom in the concentration of garlic oil inside the fit-for-human consumption film alginate, however, it could boom again at a sure awareness. The weakening of hydrogen bonds among starch chains reasons a lower inside tensile energy of edible films [17]. Furthermore, the lower tensile strength through increasing the awareness of essential oils is steady with the observation of [18] that the addition of critical oils as antimicrobial retailers tends to decrease the tensile energy cost of safe-to-eat films. That is because of the interaction between starch polymers and vital oils, which weakens the bonds between starch and plasticizer. The addition of vital oils reduces the tensile energy whilst the important oils are included between the polymer chain bonds. The important oil-polymer bond is weaker than the polymer-polymer bond [19].

3.2. Elongation

Elongation is the proportion of alternate in membrane duration even as the membrane is stretched to break. The elongation charge is taken into consideration as poor if the charge is less than 10% [20].

The outcomes of the variance take a look at showed that the distinction in corn flour and crucial oil additive concentrations had a sizeable impact ($p < 0.05$) on elongation in all fit-for-human consumption edible remedies. The outcomes of this take a look at showed that elongation expanded when 2% essential oil changed into added to A1B3, A2B3, and A3B3 remedies. that is steady with the take a look at [21, 22] that will increase the elongation of vital oils. [23] who also confirmed an increase in elongation after the addition of crucial oils. The growth in elongation of fit for human consumption edible with the addition of crucial oils become due to the OH content material of the vital oil. The higher the concentration of vital oils, the better the amount of OH inside the edible film matrix. The addition of the OH group performs a function in increasing the polymer chain mobility of the fit-to-be-eaten edible matrix, so that the movie elongation is greater, while [22] the addition of vital oils typically reduces the bond electricity of the film. due to the enlargement of the heterogeneous structure of the membrane, which increases the elongation of the membrane. Glycerol can interact with starch to shape a starch-softening bond, wherein this bond will increase the elasticity of the safe-to-eat edible. The intermolecular area is full of a plasticizer, so the presence of a plasticizer reduces the interaction strain among starch molecules, growing the loose area among molecules, which reduces stiffness and increases flexibility and extensibility [24].

The elongation of the edible film elevated extensively though only up to 10% starch content, however, the elongation remained consistent when high quantities of starch were brought. primarily based on this, there is an advantageous limit for using starch content inside the production of food movies with the pleasant tensile fee [25].

3.3. Thickness

The thickness of the fit for human consumption film ovie in line with JIS 1975 is < 0.25 mm [14]. The effects of the variance take a look at confirmed in Table 2 that the distinction in corn flour and critical oil additive concentrations had a big impact ($p < 0.05$) on the thickness of all fit-to-be-eaten film remedies.

The growth of cornmeal and essential oil thickness in A1B2, A2B2, and A2B3 remedies on this take a look at may be due to the physical properties of the solution (density, viscosity, surface anxiety, drying time) and the effect of layer formation techniques. safe to eat thickness [26]. The boom in thickness with increasing cornmeal and vital oil content in A1B2, A2B2, A2B3, A3B1, A3B2, and A3B3 treatments in this take a look at is regular with the declaration of [27] that edible film thickness will increase. if the cornstarch content is higher. When making edible films with polysaccharides, the polymer content of the ingredients can increase the thickness and stability of the edible film at a certain limit. If more corn starch is used, the polymer structure of the resulting film changes to produce a thicker film.

3.4. Moisture Content

The moisture content of the fit-to-be-eaten film in line with SNI 06-3735-1995 is a maximum of sixteen%. The results are shown in desk 2, which revealed that the difference in corn flour and vital oil additive concentrations had a full-size effect ($p < 0.05$) on the moisture content material of the fit-to-be-eaten film.

Based totally on table 2, the effects of the moisture content material of the meals film for one-of-a-kind treatments tend to lower whilst the corn meal level increases through 2%, 4%, and 6%, the bottom water content become acquired at 6% cornmeal content and 2% essential oil from Pangkep orange peel (*Citrus maxima*). This is consistent with the statement that the small amount of water remaining in the film network is due to the amount of large polymer forming the film matrix and the increasing viscosity, it affects the increase in the thickness of the edible film so that the water content. decreases [28]. According to [29], terpene compounds with long carbon chains belonging to the hydrophobic group of essential oils have a low water-binding capacity. The low concentration of polysaccharides in the edible film-forming solution allows free water to participate in the polymerization reaction [30].

3.5. Microbial Inhibitory

The inhibition of *Escherichia coli* and *Staphylococcus aureus* microorganisms with the aid of the fit-for-human edible film is proven in Table 3.

Table 3. Inhibitory Power of Edible Film Bacteria

Treatment	Parameters	
	<i>Escherichia coli</i> (mm)	<i>Staphylococcus Aureus</i> (mm)
A1B1	3.58±1.59	6.75 ^{ab} ±1.13
A1B2	1.46±0.33	5.91 ^{ab} ±0.30
A1B3	1.32±0.10	14.12 ^c ±2.73
A2B1	1.74±0.65	8.19 ^b ±2.02
A2B2	3.42±2.45	4.97 ^{ab} ±2.03
A2B3	0.72±0.38	6.18 ^{ab} ±2.72
A3B1	2.26±1.16	4.13 ^a ±0.85
A3B2	1.92±0.67	5.33 ^{ab} ±1.01
A3B3	3.16±1.18	5.55 ^{ab} ±0.92

Note: Different letters within the equal column imply sizable variations ($p < 0.05$).

The consequences of different microbial inhibition of corn flour suitable for eating film and crucial oil of Pangkep orange peel (*Citrus maxima*) may be visible in table three. The diffusion test results showed that the attention of corn flour and the addition of critical oil had an enormous effect ($p < \text{zero}.05$) on *Escherichia coli* and *Staphylococcus aureus* for the prevention of microorganisms in suitable for eating with film. Table 3 shows the differences in the inhibition of *Escherichia coli* bacteria with different concentrations of corn flour and Pangkep orange peel (*Citrus maxima*) volatile oil, the inhibition of *Escherichia coli* and *Staphylococcus aureus* bacteria tends to decrease when treated with the addition of 2% volatile oil. A decrease in the interaction between protein molecules leads to a structure that is not dense and porous, increasing the thickness of the membrane, so that the ability of essential oils to inhibit bacteria is reduced [31].

3.6. Determination of the Best Treatment

The selection results were based on the following criteria: (a) according to standard test parameters and (b) differences in Duncan's supplementary test result labeling. For follow-up outcomes, if they have the same label, it means that the treatments are not significantly different, while treatments with different labels have significantly different treatment differences. The bold criteria in Table 2 mean that they fulfill two criteria, namely the same standards and name.

The edible film is expected to act as a moisture, oxygen, taste, aroma, and oil barrier to improving meal satisfaction, and it can also provide mechanical protection to meals and decrease harm. desk 2 suggests the traits of every fit-to-be-eaten movie remedy. The tensile power of bioplastic fit-to-be-eaten movies is at least 0.923 MPa [14].

In Table 2, none met the necessities for the tensile strength of the fit for human consumption film.

In Table 2, the elongation of treatment A1B3 is 1.12%, which meets the elongation requirements of edible film.

The thickness of the healthy for human edible film in keeping with the usual JIS 1975 is 0.25 mm. Edible products that meet these requirements are treatments A1B1, A1B2, and A2B1. Treatment A1B3 was not significantly different from treatments A1B1, A1B2, and A2B1.

Moisture content is a test method for gravimetric determination of the amount of water contained in a material. The moisture content of the edible film in line with SNI 06-3735-1995 is a most of 16%. Edible films that meet these requirements are A2B2, A2B3, A3B1, A3B2, and A3B3.

The antibacterial impact may be visible with the aid of the formation of a clean quarter across the edible movie to which the antibacterial agent has been brought. Treatment A1B1 had the best inhibition of *Escherichia coli* of 10.13 mm among the other treatments. A1B1 treatment was not significantly different from A2B1, A2B3, and A3B1. For *Staphylococcus aureus*, the inhibitory power of the A2B1 treatment was 8.70 mm. A2B1 treatment was not significantly different from A2B2, A3B2, and A3B3. Based totally on the consequences in Tables 2 and three, the two fine-appearing standards were A2B1 remedies.

4. Conclusions

The results showed that the composition of Pangkep orange oil (*Citrus maxima*) and corn flour had a good sized impact on the elongation, thickness, moisture, and inhibition of *Escherichia coli* and *Staphylococcus aureus*. The excellent method remedy changed into received with a mixed remedy containing four% corn flour and 1% Pangkep orange peel oil (*Citrus maxima*) ensuing in tensile power of 1.74 N/mm², elongation of 8.18% and thickness of 0.23 mm, and water content material 16.58%, *Escherichia coli* inhibition diameter 9.33 mm, *Staphylococcus aureus* inhibition 8.70 mm.

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