film

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The impact of chitosan at the physical performance of the coffee skin-based edible film

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Abstract: Coffee is one of the most popular commodities in decades. The expansion of coffee plantations and processing indirectly increases the number of coffee skins. Coffee skin is a problem for the community because it can pollute the environment, and cause an unpleasant odor and an unsightly view. Processing coffee skins into edible films will help overcome the problem of coffee skin waste. Chitosan can be added to increase the functional value of coffee peel-based edible films. Chitosan can form layers, does not affect taste, or aroma, and is safe for consumption. Chitosan also contains a variety of antimicrobial bioactive compounds and can act as a selectively permeable membrane for CO2 and O2 gas exchange. The purpose of this observes turned out to be to determine the impact of the quantity of coffee skins and the concentration of chitosan and on the physical properties of edible films made from coffee skins. The study design used a randomized block two factors, namely the concentration of chitosan (1.0 and 1.5%) and the number of coffee skins (7, 14, 21, and 28%). Each treatment was repeated three times, to determine the physical properties of the coffee skin edible film, namely color (ΔE), transparency, film performance, structural density, thickness, and acidity. The results showed that the number of coffee skins and the concentration of chitosan affected the physical characteristics of edible films made from coffee skins. A concentration of 1.5% chitosan with 21% coffee skin produced the best edible film.

Keywords: edible film; characteristics; chitosan; coffee skin; physic

1. Introduction

Coffee is a plantation commodity that has high economic value. Kintamani Arabica (*Coffea arabica* L.) is Indonesia's leading coffee which is gaining popularity today because it has antioxidant activity, and a very specific aroma and taste (Suhandy & Yulia, 2018)(Fibrianto *et al*., 2018)(Mangkua *et al*., 2022). The coffee processing process produces 55-60% green beans and 40-45% coffee skin (Klingel *et al*., 2020)(Arpi *et al*., 2021). The improvement of coffee plantations additionally not directly will increase the range of coffee skins produced, namely cherry pulps, cherry skins, parchment skins, and silver skins (Sangta *et al*., 2021)(Sunarharum *et al*., 2022). According to (Klingel *et al*., 2020), coffee cherry skin contains 4% -12% protein, 1-2% of lipids, 6-10% minerals and 45-89% total carbohydrates. Phenolic compounds and caffeine are also present (1.3%) in the cherry pulp. (Martuscelli *et al*., 2021), said that coffee skin contains 8-11% protein, 0.5-3% lipids, 3-7% minerals and 58-85% total carbohydrates. Total fiber contains 24.5%, cellulose 29.7% hemicellulose and 23.7% lignin. Coffee skin is a problem for the community because it can pollute the environment, and cause an unpleasant odor and an unsightly view (Torres-Valenzuela *et al*., 2020)(de Melo Pereira *et al*., 2020).

Plastic waste is also causing an increasing amount of environmental harm. The ensuing danger to lifestyles has created more interest in changing plastic with sustainable and biodegradable alternatives (Daniloski *et al*., 2021)(S. Kumar *et al*., 2021). Edible film is a form of packaging in the shape of skinny sheets, biodegradable, may be fed with packaged products, and is more secure than plastic packaging. The predominant additives in making edible films are polysaccharides, lipids, and proteins, with additional elements and plasticizers. The primary characteristics that edible films can present are: (i) protection against UV light; (ii) delivery of solutes, water vapor, natural vapors, and gases between food and the atmosphere; (iii) barrier against mechanical harm; (iv) increase the shelf-life of the product; (v) bioactive additives (e.g., antioxidants); and (vi) antimicrobial impact against bacterial duplicate and fungal contamination (Zhao *et al*., 2021)(Susmitha *et al*., 2021)(Xiao *et al*., 2022).

Research on edible films on food is currently increasing due to high consumer demand for the durability and good quality of fresh food. Based on current research, indicates that using polysaccharides derived from fruit peel waste produces edible films which have suitable mechanical characteristics (Díaz-Montes & Castro-Muñoz, 2021)(N. Kumar *et al*., 2021). Kintamani Arabica coffee pod skin is a by-product of coffee processing that has the potential to be used as an edible film, so it doesn't pollute the environment and cause problems for the community. There is no research on the characteristics of edible films made from coffee skins yet, it is necessary to carry out further research on the amount or proportion of coffee skins in making edible films.

Besides being able to be consumed directly, edible films can also be combined with other components such as antimicrobial and antioxidant compound (Abdollahzadeh *et al*., 2021)(Moradi *et al*., 2021). This component can add functional value to edible films, one of which is chitosan. The edible film made from coffee skin and chitosan is an alternative packaging for food products that have high economic value and can be used as an alternative to plastic packaging for foodstuffs, vegetables, and fruits (Sultan *et al*., 2021)(Moradi *et al*., 2021). The optimal edible film, it is necessary to know its physical properties to extend the shelf life. Optimal physical properties for making edible films from coffee skins can be investigated by varying the concentrations of coffee skins and chitosan used. The purpose of this research was to determine the influence of the quantity of coffee skin and the awareness of chitosan on the physical properties of coffee skin-based edible film.

2. Materials and Method

This research is an experimental study using a randomized block design. Observation variables have been examined on the Food Analysis Laboratory, Faculty of Agriculture, Warmadewa University. The basic ingredients for Kintamani arabica coffee skin (cherry coffee) are obtained from Catur Kintamani Village in Bali and other ingredients are purchased in the city of Denpasar, Bali Province, Indonesia. The tools used are wearing blend, fine digital scale, basin, refrigerator, stirring spoon, tablespoon, chopsticks, gloves, masks, Bunsen, cups, and knives. as well as filters. The tools used in the analysis were dropper pipettes, 10 ml, 5 ml, and 2 ml volumetric pipettes, 100 ml, and 400 ml beakers, aluminum dishes, porcelain dishes, Petri dishes, measuring cups, Erlenmeyer, analytical balance Minolta CR-300 chromameter, pH-meter, hockey stick, jar, and test tube.

2.1. Research design

The research design used a two-factor randomized block design and three replications, to determine the physical properties of edible coatings made from coffee skin, namely color (ΔE), transparency, film performance, morphology and structure density, thickness, moisture content, and acidity. The first factor is the concentration of chitosan, namely 1.0%, and 1.5%, and the second factor is the amount of coffee skin, namely 7%, 14%, 21%, and 28%. The data obtained in this study were tested using statistical analysis.

2.2. Preparation of raw material for coffee skin by starch extraction method.

Coffee skin waste obtained in Wanagiri Village, Sukasada District, Buleleng Regency was ground using a blender and added water with a ratio of 400 grams of coffee skin: 200 ml of water. Then, it is filtered using gauze to get filtrate, with two to three repetitions, this is done to get more filtrate. The phytate is allowed to stand for 24 hours to produce two layers, namely, precipitate and liquid. The liquid above is then discarded so that only sediment is obtained. The precipitate was dried in the sun for 2 days. After drying, then pulverized using a mortar and sifted using a sieve with a size of 200 mesh.

2.3. The process of the edible film made from coffee skin

The process of making plastic films using the melt intercalation method uses a phase inversion technique with solvent evaporation. Variations of chitosan used were 1.0% and 1.5%, which was started by dissolving the chitosan using a stirrer first in 1% acetic acid for 30 minutes. After that, coffee skins were added according to the treatment and stirred for 30 minutes at 70ºC. The formula must always maintain its gelatinization temperature by measuring using a thermometer, then 1% glycerol is added as a plasticizer. After the ingredients were mixed, stirring was carried out for 120 minutes until the solution was homogeneous and left to stand at room temperature for a while. The film formula was then vacuumed for 20 minutes to remove any remaining water and oxygen content. The next process is film printing, but before the edible film formula is printed on a petri dish/glass plate, the solution must be left for 24 hours to remove any remaining air bubbles. This is intended so that the resulting edible film is not easily deformed/damaged. Next, the process of printing the coffee skin edible film solution on a petri dish/glass plate that has been cleaned using 96% alcohol. Then, the edible film was dried in the oven for 6 hours at 83ºC. The edible film made from coffee skins produced after the printing and drying process in the oven is stored in a desiccator at room temperature. Then it is released from the Petri/glass plate slowly and the coffee skin-based edible film is ready for use.

2.4. Determination of physical properties of edible films

Color (ΔE), and transparency measurements use the colorimeter spectral CS-280 to regulate the L*a*b* directs. The transparency value is generated from the following equation: Transparency = (1L2 + 1a2 +1b2)0.5. Value 1L = L* standard – L* sample, 1a = standard a∗ – a∗ sample, and 1b = standard b∗ – b∗ sample. The default values for white plates are L* = 97.51, a* = 5.35, and b* = 3.37. While measuring film performance visually. Morphology and structure tests of coffee peel-based edible films and thickness tests using a scanning electron microscope (JEOL, JSM 6300 SEM, JEOL 182, and Tokyo, Japan). The film samples were stored in a desiccator for one week to ensure the absence of water (0 percent theoretical RH in a desiccator). Pieces of the film were mounted on copper stubs and gold-plated, and an accelerating voltage of 10 kV below 185 high vacuum mode was discovered. Acidity became examined the usage of a virtual pH meter (Hanna HI 8424, Romania).

2.5. Statistical analysis

The use of SPSS 23.0.0 statistical software for Windows (IBM 200 SPSS model 24.0 Inst., Cary, North Carolina, USA) was adopted for statistical evaluation. All measurements have been executed in triplicate, and the mentioned outcomes are meaningful. The data was studied using a one-way ANOVA. The imply value changed into evaluated the usage of Duncan's take a look at with $p<0.05$ as statistical significance.

3. Result and Discussion

3.1. Color (ΔE)

Color is important in the selection of food elements by customers before they consider dietary cost and taste. The color parameter (ΔE) is used as a subjective indicator of product quality, even though the coatings that are often used are transparent and tend not to affect the color of the display (Suriati *et al*., 2022). Statistical analysis showed that the concentration treatment of coffee skin and chitosan had a very significant effect on the color (ΔE) of the edible film made from coffee skin. The results showed that the color with coordinates L*a*b* in the formulation with 14% coffee skin added and 1.5% chitosan showed the smallest E value (Figure 1). suppresses the possibility of discoloration, which leads to the retention of stability and effectiveness as an edible film. This manifestation results from the hydrolysis of the coffee skin starch polymer that occurs after the enzymatic reaction, which further increases the turbidity of the component (Klingel *et al*., 2020). On the other hand, a browning reaction was also observed, because the physical properties were strongly influenced by the presence of water, light, and heat. Direct contact with air causes brown pigmentation, while warmth and mildness catalyze the reaction, the sugar content strongly stimulates it. Edible film utility additionally features to enhance appearance (bright and shiny colors), maintain moisture, prevent weight reduction and act as an antimicrobial (Otálora González *et al*., 2021)(Díaz-Montes & Castro-Muñoz, 2021).

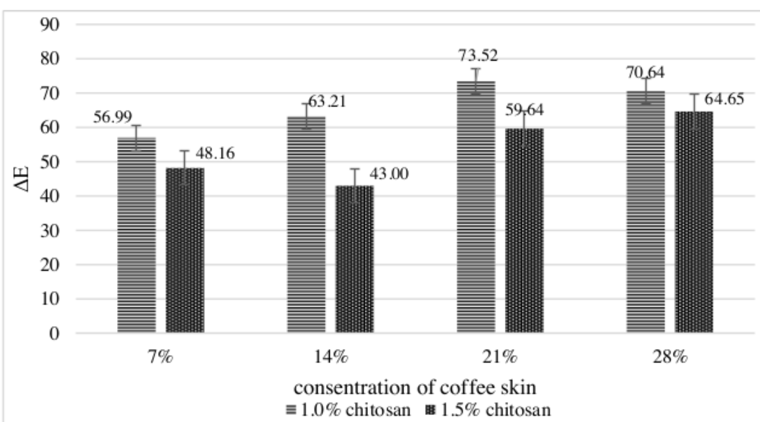

Figure 1. Color (ΔE) of an edible film based on coffee skin

3.2. Transparency

Transparency refers to the capability of a material to convey light. The results of the observations showed that the concentration of coffee skins, chitosan, and their interactions had a very substantial effect on the transparency of edible films made from coffee skins. The highest transparency value of 86.86 was obtained from the treatment with a concentration of 28% coffee skin and 1.0% chitosan as shown in Figure 2. This shows that an increase in the amount of coffee skin causes the edible film to be thicker/turbid so that when applied to it the product inside is not visible. The high transparency value is showed by the presence of increased turbidity in the edible film solution before it is printed and dried, due to the breaking of the acetyl bonds of the coffee skin starch polymer into slighter components (Mangkua et al., 2022). Affording to (Suriati *et al*., 2020)(Álvarez *et al*., 2021), the special characteristics applied to edible films are transparent, tasteless, odorless, water resistant, functioning as a barrier, permeable to, and able to tolerate pressure. On the other hand, edible film formulations must be safe from harmful additives, and technology costs and raw materials must be relatively inexpensive. The transparency of the edible film added with 1.5% chitosan tends to be more stable up to the addition of 21% coffee skin. According to (Sultan *et al*., 2021) the addition of the chitosan component can add to the functional value of the edible film.

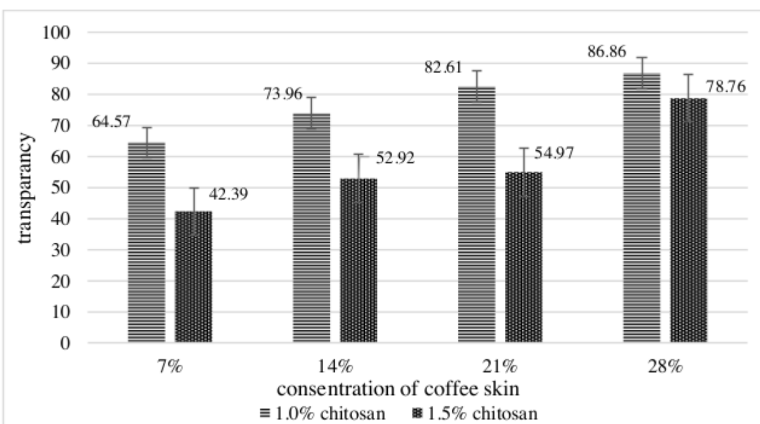

Figure 2. Transparency of edible film based on coffee skin

3.3. Film performance

The results of visual color observations showed that there were brighter and more transparent colors in the 25% coffee skin and 1.5% chitosan treatments. An edible film with the addition of more coffee rind produces a darker, thicker, and stiffer edible film color. Likewise, the edible film added with lower chitosan resulted in thicker and browner average performance. Chitosan with a higher concentration produces an edible film that is thinner, softer, and more elastic(N. Kumar *et al*., 2021)(Yuan *et al*., 2021). This variation shows the effectiveness of chitosan to produce better coffee skin-based edible films. Figure 3 shows the performance of edible film based on coffee skins with variations in the amount of coffee skin and chitosan. The antibacterial effect of the biodegradable films based on chitosan shows the highest inhibitory power (Randazzo *et al*., 2016)(Zhao *et al*., 2021).

Figure 3. Film performance of edible film based on coffee skin

3.4. Morphology and structure of the edible film

The morphology and structure of the surface state of coffee peel-based edible films using Scanning Electron Microscopy (SEM), can provide information about the density and distribution of the constituent particles. Observations showed that the surface particle size of the edible film at the edges was 573.8 nm and the average part at the center was 514.0 nm (Figure 4). The outcomes of the SEM observe indicated that the degree of homogeneity and heterogeneity of the film matrix relied on the compatibility of the hydrophobic additives and the character of the lipids delivered to the mixture (Thakur *et al*., 2017) (Thakur *et al*., 2018). The chitosan particles are evenly distributed among the starch polymer matrix from the coffee skins, giving good performance for edible films. The treatment of adding 21% coffee skin with the addition of 1.5% chitosan produced the best edible film appearance, namely thin, soft, transparent, and bright in color. The structure of the edible film made from coffee skin with chitosan shows a smaller particle size. Small particle size results in higher physical properties, such as surface area, reactivity, and color, which can be very different from conventionally sized materials (Luh Suriati *et al*., 2021). The properties of the fit to be eaten film are determined by the molecular structure, length, and additive content material. Opinion (Salgado-Cruz *et al*., 2021); (Salgado-Cruz *et al*., 2021)(Moalla *et al*., 2021), said that the addition of chitosan improved the polymer composition of the edible film matrix.

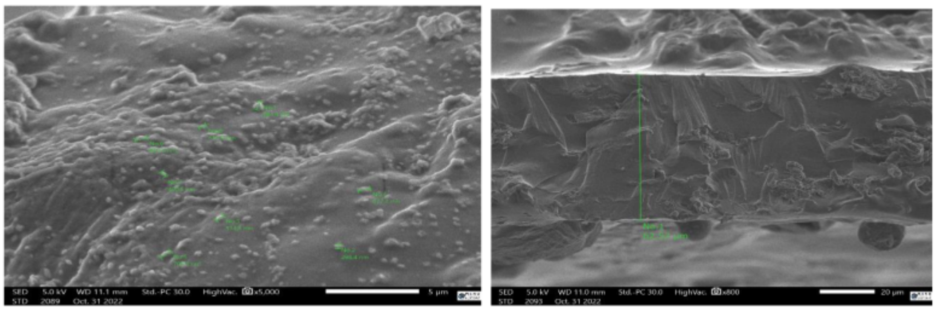

Figure 4. Morphology and structure of edible film based on coffee skin

3.5. Thickness

Thickness is directly associated with the barrier properties and optical properties of the edible film. The end result of thickness evaluation is a crucial parameter that affects the formation of edible films (Susmitha *et al*., 2021); (La *et al*., 2021). The thickness of the film changed into measured using a scanning electronic microscope (SEM) at five different locations and then the results were averaged. Based on the measurement results, the average thickness ranged from 40.75 μm to 68.05 μm. An edible film with a composition of 21% coffee skin and 1.5% chitosan added with glycerol has an average thickness that is evenly distributed between the edges and the middle of the coffee skin edible film. Figure 4a shows the edges of the edible film, while Figure 4b shows the middle part. The thickness of the coffee skin edible film will increase if the chitosan composition is dissolved more and more because the total dissolved solids will be greater which causes the resulting chitosan edible film to be thicker. The thickness of the film is also artificial by the volume of the solution poured into the mold. The size of the mold used is the same, which is 20 x 20 cm2 with a thickness of 5 mm. Chitosan can form films after reacting with acetic acid to form carboxylic and hydroxyl groups which play a role in the condensation polymerization process (Rodríguez *et al*., 2020) (La *et al*., 2021).

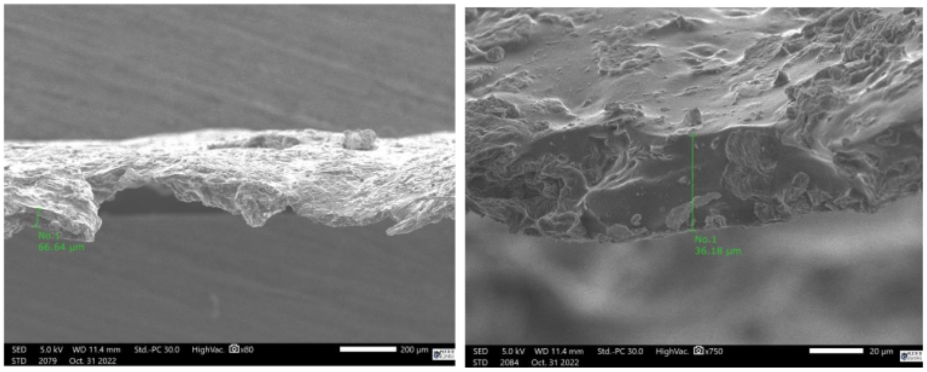

Figure 4. The thickness of edible film based on coffee skin

3.6. Acidity

The level of acidity is a constraint used to indicate the acidity of a constituent or solution. The results of the observations showed that the treatment of the number of coffee skins, the concentration of chitosan, and their interactions did not show a difference in the acidity of the edible film of the coffee skins. The average acidity value of coffee skin edible film ranges from 7.0-8.2 as shown in Table 1. This shows that coffee skin-based edible film has an acidity that tends to be neutral, in other words, it can be used in a wider range of food products. According to (Klingel *et al*., 2020), coffee cherry skin contains protein, lipids, minerals and total carbohydrates. Coffee incorporates large quantities of phenolic compounds together with chlorogenic and hydroxycinnamic acids and antioxidants including caffeine, melanoidins, and other Maillard reaction products and volatile compounds (Kwak *et al*., 2018).

Table 1. The acidity of edible film based on coffee skin

Coffee skin	Chitosan		Average
	1.0%	1.5%	
7%	7,2	7,8	7,5
14%	7,4	7,7	7,5
21%	7,3	7,8	7,5
28%	7,0	8,2	7,6
Average	7,2	7,8	

4. Conclusion

The effect of the amount of coffee skin, chitosan concentration, and their interaction on the physical properties of coffee skin-based edible film is presented. In addition, color differences (ΔE), transparency, film performance, morphology and structure of edible films, and thickness and acidity of edible films were studied. In conclusion, the number of coffee skins and the concentration of chitosan and their interactions affect the physical characteristics of edible films made from coffee skins. A concentration of 1.5% chitosan with 21% coffee skin produces the best edible film.

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