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Chemical Characteristics of Biodegradable Packaging Made from Whey and Oil Palm Empty Fruit Bunch Juice

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ABSTRACT

Biodegradable packaging is a coating made from edible materials that act as a barrier to moisture, oxygen, and solutes in food. Biodegradable packaging is made from renewable materials such as starch, cellulose, and protein. Cheese whey is a protein source that can be used as a biodegradable material. In contrast, a starch source that can be utilized as a base material for biodegradable packaging is oil palm empty fruit bunches. This study aimed to determine chemical and physical change and also the properties of biodegradable packaging due to the addition of palm empty fruit bunch starch juice. The research design used was a completely randomized design with four treatments, namely without palm oil empty bunch juice (control) = A and with the addition of 0.75% = B, 1% = C, and 1.25% = D. The research results showed that the addition of empty oil palm bunch juice had a significant effect ($p < 0.05$) on thickness, water content and water vapor transmission, in the solubility and degradability tests the addition of empty oil palm bunch juice showed no significant effect ($p > 0.05$). The lowest thickness analysis result was 0.1420 mm; the lowest moisture content was 25.27%; the lowest water vapor transmission was 5.178 g/m2/day; the lowest solubility was 55.62%. All samples were composed entirely on the 7th day and 100% decomposed in the soil. The results of the test showed that the best treatment was found in the sample with the addition of 1.25% juice.

Key words: *Biodegradable; oil palm empty fruit bunch; whey*

INTRODUCTION

Plastic is one of the essential packaging materials for people in Indonesia. Jambeck *et al*. (2015) stated that Indonesia is the second country to produce plastic waste in the sea after China. Indonesia produces 1.29 million tons yearly, and China produces 3.53 million tons yearly. Indonesian people in 2021, if accumulated, collected as much as 5.4 million tons of waste per year, or 14% of the total waste, with the most significant contribution being plastic waste (Muamar, 2022). Plastic consumption per capita in Indonesia has reached 17 kilograms per year, with consumption growth reaching 6-7% per year (LIPI, 2016).

Plastic is used to protect and keep food or non-food products. Plastic waste is waste generated from inorganic materials. It takes very long time to decompose plastic waste with soil thoroughly. This thing if continue to be ignored, plastic waste will accumulate and can disrupt the environment and ecosystem. Plastic pollution is caused by the long time it takes to decompose plastic, plastic can decompose completely in approximately 500 years (Sivaprasad *et al*., 2021), causing plastic waste to accumulate and cause environmental pollution.

Generally, plastics are made of polyethylene and polypropylene, which are not easily degraded by environmental microorganisms. Another impact of plastic waste pollution is that the environment becomes unhealthy. Plastic particles contain toxic chemicals and can cause the death of soil-decomposing animals such as worms if it into the ground. Plastic that cannot be decomposed even though they are eaten by animals or plants will become toxic. Another effect of plastic waste is that it is difficult to decompose and can cause unpleasant odors and various diseases. Plastic waste can also disrupt the path of water that seeps into the soil, causing blockage of water and flooding effects (Gunadi *et al*., 2020).

Plastic waste is the cause of severe environmental pollution problems in every country. In Indonesia sector, especially in the food industry and flexible packaging, 80% of plastic packaging is used (Nasution, 2015). Every year, the amount of waste generated in Indonesia increase linearly with population growth (Pratama and Ihsan, 2017).

One of alternative that can be used as a substitute for plastic as food packaging is biodegradable packaging from whey protein. Biodegradable packaging is a coating made from edible materials, and as a barrier (moisture, oxygen, and solutes) to food; in addition, biodegradable packaging can be used to coat food, protect food from microorganisms, help the preservation process and carrier antibacterial or antioxidant compounds. Biodegradable plastics are derived from renewable natural sources such as corn, cassava, and sago (Fitriyani, 2018).

One of the affordable and abundant sources of protein compounds is whey from cheese making. Whey Whey is the remaining liquid after the process of separating casein and fat during the settling of milk in cheese making in the cheese making industry. Whey is known as food industry by-product, especially from manufacturing cheese and butter dairy products. Based on research by Juliyarsi *et al.* (2019), whey can be processed into environmental friendly edible packaging.

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Biodegradable packaging from whey protein has good properties as a packaging material because it has advantages such as transparent, soft, odorless and able to withstand the aroma of packaged food products, However, the disadvantage of biodegradable packaging for whey protein is that it is less strong and flexible. Research by Juliyarsi (2019) Edible film whey using 0.7% carboxymethylcellulose (CMC) and 0.15% sorbitol produces edible film with properties that are still stiff. Because there is still a shortage of polymer materials to create strong and flexible films, it is necessary to add polymer materials for biodegradable packaging, which could potentially be cellulose.

One of the sources of cellulose that can be used to manufacture biodegradable packaging is oil palm empty fruit bunches. Oil palm empty fruit bunches (EFBs) are waste from palm oil mills that contain much cellulose. The utilization is very rare (approximately 10%), so they can still be utilized as raw material for cellulose-based products (Wahyudi *et al.,* 2020). The cellulose content in oil palm empty fruit bunches is around 30%, so it has excellent potential to be used as a base material for biodegradable packaging (Isroi *et al*., 2017; Wahyudi *et al*., 2020). The use of oil palm empty fruit bunches in making biodegradable packaging not only reduces industrial waste but also creates Environment friendly products.

This study was conducted to determine the Chemical and physical change and also the properties of biodegradable packaging due to adding palm empty bunch starch juice.

MATERIAL AND METHODS

Material

The materials used in this research include cheese whey obtained from Lassy Dairy Farm in Agam Regency, Dist. Candung, Agam Regency, West Sumatra, palm empty fruit bunch starch juice obtained from Dharmasraya Regency, West Sumatera, 30 ml of glycerol, 10 g of Carboxymethyl Cellulose (CMC), ethanol (96%) and silica gel.

Methods

The research design used was a completely randomized design with four treatments, namely without palm oil empty bunch juice (control) = A and with the addition of 0.75% = B, 1% = C, and 1.25% = D.

Empty Fruit Bunch Juice Extraction

Empty fruit bunches (EFBs) are dried Under the heat of sun. EFBs are separated from the hard skin. The inside part of the EFBs are chopped with a chopping knife into 1-2 cm. Put the soft part of EFBs into a blender and squeezed using a cloth, and filtered to 100 mesh filter. The EFB pulp is discarded; after filtering with a 100 mesh filter, The water was sedimented for 24 h and the EFB sediment was taken using micropipette according to the amount of treatment.

Manufacture of Biodegradable Packaging

The plastic film was made by putting 25 ml whey in a beaker glass and adding 25 ml alcohol and 1.5 ml glycerol. Heated the solution using a hotplate magnetic stirrer at 70℃ for 10 min until gelatin was formed. After that, mix the EFBs juice as much as 0%, 0.75%, 1%, and 1,25% with additional ingredients CMC as much as 0.5 g. The solution was reheated and stirred for up to 20 min. The gelatinized solution was poured into a glass mold and then dried in an oven at 60℃ for 24 h. The method used in making films is the solution casting method with solvent evaporation.

Thickness Test of Biodegradable Packaging

The sample was measured using a micrometer at five different points with a micrometer accuracy of 0.01 mm. The measurement results were averaged as the sample thickness results.

Water Content Test of Biodegradable Packaging

Water content test according to Sitompul *et al*. (2017), Samples were weighed As much as 2-3 g and then dried for 24 h in an oven at 100 ° C-105 ° C using a petri dish with a constant weight. Then, the sample was placed in a desiccator for 30 min and weighed until a constant weight is reached. The moisture content is calculated using the formula:

$$\text{Water Content} = \frac{w1\text{-}w2}{w1} \times 100\%$$

Description:
w1 = Initial unit of weight
w2 = Final weight

Water Vapor Transmission Test of Biodegradable Packaging

Water vapor transmission test in the research of Sitompul *et al.* (2017), the sample was cut into 5 cm^2 and then covered in container one containing distilled water. Container one placed into container two which had been filled with silica gel which has been dried beforehand at 105°C for 5 h. After 24 h, the sample was weighed, then calculated by the formula:

$$\text{WVTR} = \frac{\Delta W}{t \times A}$$

Description:
ΔW = Weight change of sample after 24 h
t = Time (hour)
A = Area (m^2)

Solubility Test of Biodegradable Packaging

Solubility test in the research of Sitompul *et al*. (2017), the sample was cut into 2 cm x 2 cm (± 0.16 g). Before soaking in distilled water, biodegradable packaging was dried in an oven at 105°C until the weight was constant. After soaking process 24 h, dry in an oven at 105°C until the weight is constant. After the final weight is obtained, calculated using the formula:

$$\text{Solubility} = \frac{(w1\text{-}w2)}{w1} \times 100\%$$

Description:
w1 = Initial unit of weight
w2 = Final weight

Decomposition Test of Biodegradable Packaging

In the decomposition test, according to Marichelvam *et al*. (2019), samples were cut into 4 cm^2 pieces planted near the roots with rich in nitrogenous bacteria, and 500 g of soil (having little moisture content) was collected and stored in a container. Five samples were buried in the soil at a depth of 2 cm for seven days under room condition. The weight of the samples was measured before and after the test. The equation measured the biodegradability test:

$$\text{Decomposition} = \frac{\text{w1-w2}}{\text{w1}} \times 100\%$$

Description:
w1 = Initial unit of weight
w2 = Final weight

RESULT AND DISSCUSION

Thickness of Biodegradable Packaging

Based on Duncan's test in Table 1. shows the addition of EFBS juice has a significant effect ($p < 0.05$) on the thickness of biodegradable in treatment D, significantly different ($p < 0.05$) to C and D but not significantly different ($p > 0.05$) to treatment B. The highest average thickness was found in treatment D, namely the addition of 1.25% EFBS juice, which had a thickness of 0.1596 cm. Meanwhile, the lowest thickness was found in treatment A, the control treatment at 0.142 cm. The highest average thickness was found in treatment D, namely with the addition of EFBS juice as much as (1.25%), namely 0.1596 mm.

This result has met the standard of Japan International Standard (JIS) 1975 which is a maximum thickness of 0.25 mm. This result is the same thickness compared to the standard of the best thickness results of Huri and Nisa (2014) made from apple pulp skin extract with the addition of glycerol concentration of 10-30%, and the thickness is about 0.015-0.020 mm.

Table 1. Result of biodegradable packaging thickness test

Treatment	Thickness (mm)
A	$0.1420^{a} \pm 0.008$
B	$0.1429^{a} \pm 0.009$
C	$0.1563^{b} \pm 0.004$
D	$0.1596^{b} \pm 0.007$

Note: Different notations or superscripts (abc) in the same column indicate significantly different ($p < 0.05$).

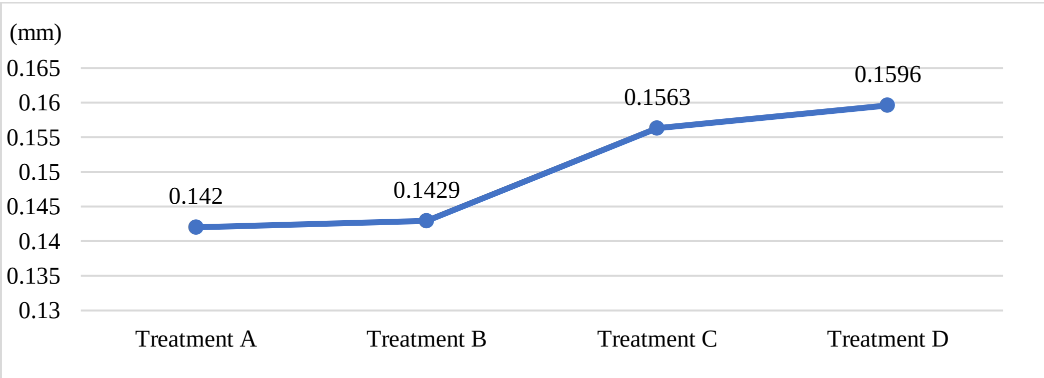

Figure 1. Thickness test results

In Figure 1, it can be seen that the thickness test results increased as the concentration of EFBS juice increased. The difference in thickness is due to the higher use of EFBS juice, causing a lot of starch (cellulose), which affects the thickness. According to Fatma *et al.* (2015), which states that the thickness of biodegradable is highly dependent on the composition, properties and content of the constituent polymers.

Water Content of Biodegradable Packaging

Based on Duncan's test in Table 2. shows the addition of EFBS juice in treatment D is significantly different ($p < 0.05$) from the water content in treatments

A, B and C. The average water content is highest in treatment A, the control treatment, which has a water content of 33.51%. Treatment C was not significantly different ($p > 0.05$) from treatment B but significantly different from treatment A. The highest average water content was found in treatment A, the control treatment, which had a water content of 33.51%.

The lowest water content was found in treatment D, namely the addition of EFBS juice of as much as 1.25% with a water content of 25.27%. This is because increasing the concentration of EFB extract will increase the amount of constituent polymers so that the amount of water content remaining in the biodegradable becomes lower.

Table 2. Result of biodegradable packaging water content test

Treatment	Water Content (%)
A	$33.51^{c} \pm 1.421$
B	$30.03^{b} \pm 1.737^{b}$
C	$30.07^{b} \pm 2.323^{b}$
D	$25.27^{a} \pm 2.543^{a}$

Note: Different notations or superscripts (abc) in the same column indicate significantly different ($p < 0.05$).

The maximum moisture content of biodegradable according to SNI 06- 3735-1995 in Nurdiani *et al*. (2019) is 16%. The results showed that the water content of biodegradable with the addition of EFBS juice did not meet the SNI standard, which is around 16%. Water content analysis data on biodegradables shows the results of water content do not match the existing theory; this is influenced by the use of glycerol, which is hydrophilic. Glycerol has the ability to act as a humectant which can bind air so that when the air dries it is difficult to evaporate (Winarti, 2018).

Water Vapor Transmission of Biodegradable Packaging

Based on Duncan's test in Table 3. shows the addition of EFBS juice in treatment A is significantly different ($p < 0.05$) to the water vapor transmission in treatment B. Treatment B is significantly different ($p < 0.05$) to treatments C and D. The lowest average water vapor transmission is found in treatment D, namely the addition of EFBS juice as much as 1.25%, which has a water vapor transmission of 5.178 g/m2.day.

Meanwhile, the highest percentage of water vapor transmission was found in treatment A, the control treatment at 9.254 g/m^2/day. Based on the lowest average percentage of vapor transmission is found in treatment D, namely with the addition of EFBS juice as much as 1.25% with an average vapor transmission of 5.178 g/m2 per day.

The resulting vapor transmission rate meets the Japan International Standard (JIS) (1975), maximum of 10 g/m2/day. The addition of EFBS essence will increase the amount of biodegradable forming polymers by improving the total solids to form thick biodegradable.

Table 3. Result of biodegradable packaging water vapor transmission test

Treatment	Water Vapor Transmission (g/m^2/day)
A	$9.254^{a} \pm 0.418$
B	$8.204^{b} \pm 0.890$
C	$6.165^{c} \pm 0.604$
D	$5.178^{c} \pm 0.605$

Note: Different notations or superscripts (abc) in the same column indicate significantly different ($p < 0.05$).

The increased amount of polymer will reduce the voids in the gel formed, so it can reduce the water vapor transmission rate because it is difficult for water vapor to penetrate. According to the opinion of Fahrullah *et al*. (2020), which explain that thicker biodegradable will inhibit gas transmission during respiration, which will accumulate ethanol.

Solubility of Biodegradable Packaging

Based on Duncan's test in Table 4. shows the addition of EFBS juice in treatment D is not significantly different ($p > 0.05$) from the biodegradable solubility in treatments B and C. The highest average biodegradable solubility is found in treatment A, the control treatment, which has a percentage of biodegradable solubility of 59.61%. In treatment B, it was not significantly different (p > 0 .05) from treatment A.

The highest average biodegradable solubility was found in treatment A, the control treatment, which had a percentage of biodegradable solubility of 59.61%. At the same time, the lowest percentage of biodegradable solubility was found in treatment D, which added 1.25% EFBS juice with a percentage of 55.62%.

Table 4. Result of biodegradable packaging solubility test

Treatment	Solubility (%)
A	$59.61^{b} \pm 1.439$
B	$58.84^{ab} \pm 1.517$
C	$57.74^{ab} \pm 1.343$
D	$55.62^{a} \pm 3.453$

Notes: Different notations or superscripts (abc) in the same column indicate significantly different ($p < 0.05$).

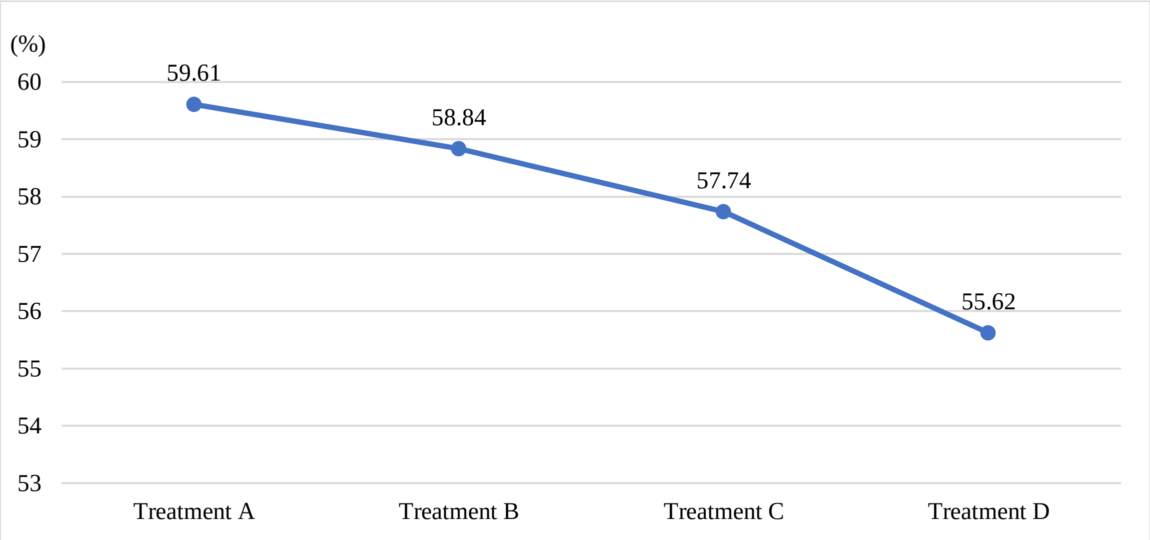

Figure 2. Solubility test results

In Figure 2. it can be seen that biodegradable made without the addition of oil palm empty fruit bunch juice has a higher solubility than other treatments, It can be known that the addition of oil palm empty fruit bunch juice affects the low solubility value.

According to (Ramadhan *et al.*, 2023), which prove that the addition of cellulose to biodegradable plastics affects the maximum water holding point more significantly. Based on Siswanto *et al.* (2020), the addition of cellulose will reduce hydrophilic properties because of cellulose has long chains and strong hydrogen bonds, making it difficult to interact with water.

Decomposition of Biodegradable Packaging

Based on the results of the decomposition test in Table 5. shows that the addition of EFBs juice has no significant effect ($p > 0.05$) on the decomposition test.

Table 5. Result of biodegradable packaging decomposition test

Treatment	Decomposition (%)
A	100
B	100
C	100
D	100

Notes: Superscript (ns) in the same column indicate no significant effect ($p < 0.05$).

The results of whey-based biodegradable decomposition show that on the seventh day, all samples tested have decomposed in the soil; biodegradable is easily decomposed because the ingredients used are natural, namely cheese whey, causing biodegradable to decompose easily (Dewi *et al.*, 2020).

CONCLUSION

The addition of EFBs juice to biodegradable with different concentrations has a significant effect on thickness, moisture content, water vapor transmission, and biodegradable solubility made from whey, but not significantly different on decomposition in soil. It can be concluded that the addition of 1.25% EFB juice given the best chemical properties of biodegradable packaging made from whey. However, the water content still needs to meet the standard rules with a maximum water content of 16%. Further research needs to be conducted to obtain suitable biodegradable plastics that can replace currently available commercial plastics.

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