EQUILIBRIUM JOURNAL OF CHEMICAL ENGINEERING
*Homepage:*https://jurnal.uns.ac.id/equilibrium

Biodegradable Wet Wipes from Palm Fiber Combined with Extract from Palm Leaves as Antibacterial Agent

Fadilah*, Divanda Sekar Rahayu Ningtyas, Audrey Vista Candra Dewi, Anita Budi Krisnawati, Reyza Fachrezy Putra

Chemical Engineering Department, Engineering Faculty, Universitas Sebelas Maret, Surakarta, Indonesia 57126

*Corresponding author: fadilah@staff.uns.ac.id

DOI: *https://dx.doi.org/10.20961/equilibrium.v7i1.71089*

Article History
Received: 30-01-2023, Accepted: 03-04-2023, Published: 13-04-2023

Keywords:

Palm Fiber, Wet Wipes, Biodegradable, Antibacterial, Palm leaves, Ethanol.

ABSTRACT. Palm fibers waste as the side-product of palm oil can be used as raw material for making green (biodegradable) wet wipes. It is proven that palm fiber contains cellulose by 87,3% of the results of cellulose analysis. Palm leaves are considered sufficient as an antibacterial agent due to containing their high-concentration polyphenol. This research aims to comprehend the process of making wet wipes from palm fiber, then combined with palm leaf extract as an antibacterial agent. Pulp, made from palm fiber, is separated into two parts, with-bleaching sample and un-bleaching sample. The bleaching sample needs three times bleaching with 120 mL H_2O_2 with a constant temperature of 70°C. The results of tissues with bleaching are stronger because the lignin content is reduced so that it is easy to bond with each other. The best bleaching tissue samples were obtained from the seventh experiment with a composition of 60 g palm fiber, 1,5 g tapioca, 1 g of *Polyvinyl Alcohol (*PVA), 3 g chitosan, and 10 mL of *Virgin Coconut Oil* (VCO). The characteristics of this bleaching tissue are bound cellulose, flexible textured paper, smooth texture, stronger when exposed to water, can absorb ethanol. The resulting product is tissue paper that will be dripped with palm oil ethanol extract. This biodegradable wet wipes pH test obtained 2 results, namely with pH paper and Ph meters of 7 and 7,29, respectively. The biodegradable wet wipes irritation test conducted on 4 volunteers showed no signs of irritation.

1. INTRODUCTION

Indonesia is one of the world's largest palm oil producers, with distribution on nearly all of its islands, including Sumatra [1]. The palm oil sector has witnessed a tremendous increase in production each year. Following the increase in *Crude Palm Oil* (CPO) production, palm oil waste, including palm coir, also increased. Palm oil area reached 10.9 million ha with a production of 29.3 million tons of CPO in 2014. Oil palm coir is a fibrous lignocellulosic biomass composed primarily of cellulose 42,7%-65%, lignin 13,2%-25,31%, hemicellulose 17,1%-33,5%, and holocellulose 68,3%-86,3% [2]. Palm coir is one of the solid wastes produced by palm oil mills, reaching 13% of the weight of fresh fruit bunches (TBS) that have been processed [3]. Palm coir waste has not been optimally employed; it is currently limited to usage as boiler fuel or disposal. Wet wipes are a substitute for palm fiber. The cellulose content of palm fiber is a critical element in pulp production. Cellulose is an abundant biopolymer that is renewable, biodegradable, and non-toxic. Wet wipes are composed of viscose, polyester fiber 70%, and plastic-containing synthetic fibers 90%. Its use, typically one-time and subsequently discarded, might pollute the environment since polyester fibers are difficult to disintegrate. The oil palm leaves are rich in polyphenolic compounds, including flavonoids, alkaloids, saponins, and tannins. In addition, oil palm extracts are efficacious as antibacterial, antioxidant, antihypertensive, antidiabetic, hepatoprotective, acute toxicity, and wound healing. Given the rise of non-biodegradable wet wipes, combining wipes with palm leaf extract is expected to be a solution.

2. MATERIALS AND METHODS

2.1 Ingredients

Palm fiber and palm leaf obtained from Kalimantan Tengah, ethanol 96% dan 95%, sodium hydroxide (NaOH), hydrogen peroxide (H_2O_2), aquadest, Virgin Coconut Oil (VCO), tapioca ($C_6H_{10}O_5$), chitosan ($(C_6H_{11}NO_4)_n$), polyvinyl alkohol (PVA), acetic acid (CH_3COOH), methanol, ethyl acetate, zinc powder, hydrochloric acid, magnesium powder, boric acid powder, oxalate powder, simplicity powder, Bouchardat solution, Mayer solution, NaCl 10%, gelatin solution, $FeCl_3$, NaCl-gelatin solution, AlCl3, potassium acetate, HCl 2 N, reactor Wagner dan reactor Dragendorff.

2.2 Equipment

Rotary evaporator, water bath, pipette, hot plate, pH paper, pH meter, beaker glass, measuring cup, glass funnel, glass stirrer, thermometer, erlenmeyer, filter paper, magnetic stirrer, filter 80 and 100 mesh, oven, screen printing T120, digester, digital balance, cooler back, test tube, watch glass, spectrophotometry UV-Vis.

2.3 Methods

2.3.1 Pulping-Bleaching

Before entering the pulping step, the raw material for palm fiber is prepared by sun-drying the palm fiber for 90 minutes, and mashing with a blender and sifting the dry palm fiber through a 100-mesh screen. The fine palm fibers were then mixed with NaOH 0.1 N 1500 mL and the digester was operated for 1 hour at a temperature of 121 ^{0}C. Subsequently, portions of the pulp will be separated into those that will undergo. The bleaching was done for 60 minutes using H_2O_2 (50%) at 60-70^{o}C. This method yields cellulose pulp. This was repeated three times. The bleached cellulose will be filtered and rinsed with deionized water until the pH is neutral. The resulting cellulose with a neutral pH will be baked at 1000 °C until constant weight is achieved and pulverized using a blender [4].

Table 1. Bleaching Treatment

No.	Palm fibers (gr)	Bleaching Treatment
1.	150	Bleaching
2.	150	Un-bleaching

2.3.2 Sheeting

The pulp is heated to a temperature of 70°C using a hot plate. Tapioca is added gradually to prevent lumps while cooking. After the pulp and tapioca mixture has fused, a binder solution is created to adhere to the cellulose during the sheeting process. The binder solution is produced by heating distilled water to 70°C and combining PVA, chitosan, and VCO as supporting materials. All auxiliary components are slowly added to avoid clumping in the binder solution. The pulp and tapioca combination is then placed into a water-filled bath. Then, print with screen printing T120 and dry in the sun until approximately fifty% dry. Add binder by passing it through a tissue paper mould. The tissue paper moulds will then be placed in an oven at 100°C for 30 minutes to dry. The resulting product is tissue paper made from cellulose extracted from palm coir.

Table 2. Variety and Compotition Binder Solution

Sample	Oil palm coir (gr)	Variety of oil palm coir	Tapioca (gr)	PVA (gr)	Chitosan (gr)	VCO (mL)	Supporting Material
1	150	Bleaching	-	-	-	70	Talk (225 grams)
2	35	Bleaching	225	-	-	-	-
3	150	Bleaching	112.5	40	-	15	-
4	30	Bleaching	25	8	-	2	-
5	30	Bleaching	-	2	3	5	-
6	30	Bleaching	-	0.5	0.5	10	-
7	60	Bleaching	1.5	1	3	10	-
8	60	Bleaching	1.5	1	3	10	Paper waste of 20 grams
9	60	Unbleaching	3	2	6	20	-

2.4 Descriptive features of tissue paper

2.4.1 Alpha Cellulose Content

The pulp is dried in an oven at 105°C for 1 hour, and then 3 grams are weighed. The raw ingredients were transferred to an Erlenmeyer and macerated for one minute with 15 mL of 17.5% NaOH. Then NaOH (10 mL with a concentration of 17.5%) was added while stirring for 15 minutes, and the mixture was left to stand for 3 minutes. Then 3x10 mL of 17.5% NaOH was added after 7.5 minutes, then went for 30 minutes. Add 10 mL of water and allow the mixture to settle for 30 minutes. The mixture is then filtered. The residue was rinsed with 5x50mL of water, the deposition on the filter paper was moved and washed with 400mL of water, and 100mL of 2N acetic acid was added and agitated for 5 minutes. The residue was rewashed until all acid was removed. The remaining residue is dried in an oven heated to 105 degrees Celsius until its weight is constant.

2.4.2 Color Test

In this test, the substance was immersed in distilled water for 60, 70, 80, and 90 minutes to determine if a colour change occurred [5].

2.4.3 Irritation Test

In this irritation test, we collected samples from four participants (18-25 year old) and placed a tissue beneath their ears for two hours.

2.4.4 pH Test

The pH meter test is conducted in both digital and pH paper formats. I measured the pH digitally using a pH meter calibrated with a pH 7 buffer solution or alkaline buffer until the instrument displayed the pH value. To conduct pH paper experiments, palm leaf extract was smeared on the paper until the colour varied according to the pH values.

2.5 Palm Leaf Extract

We are using the maceration process to produce palm leaf extract. Two hundred grams of palm leaves are steeped for four days in a solution containing 1,500 millilitres of 96% ethanol. Then the filtrate is filtered and the dregs are macerated once. The filtrate is filtered twice before being combined with the initial filtrate. After that, the filtrate was raised in viscosity using a rotary evaporator with a temperature of 750C for 30 minutes; this process was done four times. The outcome is a concentrated palm leaf extract.

2.6 Characterization of Palm Leaf Extract

2.6.1 Qualitative UV-Vis Spectrophotometry

a. Flavonoid Test
   1-2 mL of the extracted sample, was supplemented with 4-5 drops of magnesium powder, HCl 2N and ethanol each, then mixed uniformly. If the selection contains flavonoids, it turns green to red, yellow, or orange.
b. Alkaloid Test
   Put the filtrate sample in three test tubes and add 4–5 drops of Wagner reagent and Dragendorff reagent to each. Filtrate samples that test positive for alkaloids will become yellow-purple and orange in hue.
c. Tanin Test
   A few drops of $FeCl_3$ were added to the percentage of palm leaves' ethyl acetate filtrate. A change in shade and the production of a green-black precipitate show the presence of tannins.
d. Saponin Test
   The 1 mL of ethyl acetate was diluted with water and rapidly shaken for 10 minutes. The production of stable foam suggests the presence of saponin.

[6]

The flavonoid concentration of the extract was determined by dissolving it in ethanol. This investigation determined the total flavonoid concentration using standard solutions with a concentration of 10µg/mL. After adding AlCl3, potassium acetate, and distilled water to the resolution, it was placed in a dark area. Absorbance measurements were carried out by UV-Vis spectrophotometry. The formula calculates the overall flavonoid content.

$$\text{Flavonoid total} = \frac{Concentration\ x\ extract\ volume\ x\ 100}{Extract\ Weight}$$

2.7 Characterization of Biodegradable Wet Wipes Composed of Palm Fiber and Palm Leaf Extract as an Antibacterical Agent. Biodegradable Test.

2.7.1 Biodegradable Test

The samples will be evaluated for biodegradability utilizing the ASTM 6400-99 (Standard Specification for Compostable Plastics) approved soil burial test method. The steps were to cut the selection with a size of 2.5 × 2.5 cm and then weight of the initial mass after it was buried in a container filled with soil to a depth of 3 cm from the soil surface. The jar is kept at room temperature, and 100 mL of water is added daily. Every week for up to 21 days, samples were inspected, cleaned, and weighed. The sample mass will decrease due to chemical processes, specifically breakdown and microbial activity (Rodrigues et al. 2020).

3. RESULTS AND DISCUSSION

3.1 Pulp

3.1.1 Palm Coir Cellulose Pulp

Palm Coir Cellulose Pulp. The brown pulp produced by the pulping or delignification process has a mushy consistency. This pulp is subsequently bleached to make white cellulose.

3.1.2 Bleaching Pulp

The pulp bleaching method uses two variations of H_2O_2 concentrations.

Table 3. Variations of H_2O_2 concentrations

Palm Oil Coir	Concentrations H_2O_2	Volume H_2O_2 (L)	Repetition	Result
150 grams	10%	1	4 times	Brown
150 grams	50%	0,25	3 times	White

3.1.2.1 Analysis of α-Cellulose Content.

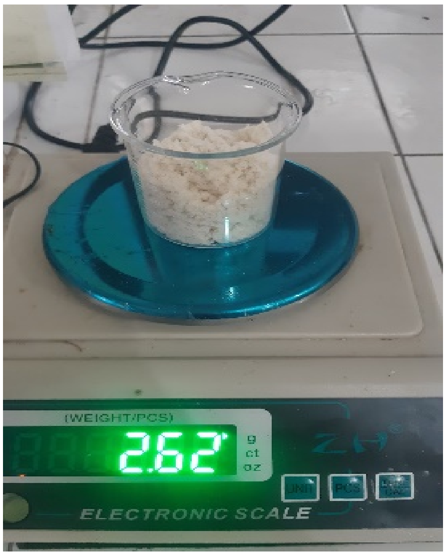


Figure 1. Cellulose Results

Cellulose content can be calculated by the equation:

$$\alpha\text{-Cellulose Content} = \frac{Weight\ of\ Cellulose\ Precipitate}{Sample\ Weight} \times 100\%$$

The cellulose content was determined to be 87.3% based on the computation. The following formula can be used to calculate the amount of cellulose extracted from palm coir that can be utilized for wet wipes based on the percentage yield of cellulose.

Potential cellulose (tonnes) = production of palm oil (tonnes) × % Palm Fiber x % cellulose x yield cellulose.

Based on theoretical estimations of the material's bulk, 1 tonne of Fresh Fruit Bunches (FFB) will generate 14.4% of palm fiber waste and 31,070,000 tonnes of palm oil.

Total palm fiber per year = 14,4% x 31.070.000 tons = 4.474.080 tons

Oil palm coir that has been utilized by 10% = 10% x 4.474.080 tons = 447.408 tons

Total oil palm coir that becomes waste = 4.474.080 - 447.408 tons = 4.026.672 tons

Theoretical cellulose potential with a content of 65% of oil palm coir = 65% x 4.026.672 ton = 2.617.337 tons

Total cellulose potential (tons) = 87,3% x 2.617.337 tons = 2.284.935 tons

Based on calculations obtained cellulose potential of 2.284.935 tons

[8]

3.1.2.2 Tissue Paper Sheets

We conducted trials 9 times with modifications in the pouring of the binder and the makeup of the elements in the binder solution. The following is a sample of the results of several experiments of the sheeting method with variations in the document and application of binder solutions:

Figure 2. The example resulted from multiple experiments of the sheeting process with modifications in the design and administration of binder solutions: (a) Sample 1; (b) Sample 2; (c) Sample 3; (d) Sample 4; (e) Sample 5; (f) Sample 6; (g) Sample 7; (h) Sample 8; (i) Sample 9.

The way of applying the binder solution also influences the outcome of the tissue paper. The following are numerous trials of assisting binder solutions and the implications of tissue paper.

Table 4. Methods for Providing Binder Solutions and Tissue Paper Outcomes.

Sample	Assisting Binder Solutions	Implications of Tissue Paper
1	Cooked together with pulp.	Cellulose cannot be bonded, is fragile, has a rough texture, decomposes rapidly when exposed to water, and is incapable of absorption.
2	Cooked together with pulp.	Cellulose is too dispersible, the base is gel-like, the paper has a rigid structure, and it decomposes rapidly when exposed to water.
3	Cooked together with pulp.	Cellulose is still too easily dispersed, paper has a rigid structure, is fragile, has a rough texture, decomposes rapidly when exposed to water, is incapable of absorption.
4	Cooked together with pulp.	cellulose has started to bond, paper has a rigid structure, has a rough texture, decomposes rapidly when exposed to water, isn't easy to absorb antibacterical compounds.
5	Cooked together with pulp.	cellulose has started to bond, component is more flexible, the texture is smoother, decomposes rapidly

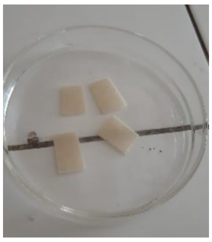
		when exposed to water, isn't easy to absorb antibacterical compounds.
6	Cooked together with pulp.	Bound cellulose, more flexible, the texture is smoother, decomposes rapidly when exposed to water, enough to absorb antimicrobia.
7	Smeared on a half-dry paper towel.	Bound cellulose, loose paper, smooth surface, firmer when exposed to water, can absorb antibacterical chemicals.
8	Smeared on a half-dry paper towel.	Bound cellulose, loose paper, texture not finer than sample 7, strong when exposed to water, can absorb antibacterical chemicals.
9	Smeared on a half-dry paper towel.	Cellulose can not be bonded, is brittle, has a rough surface, is easy to absorb water, and can not absorb antibacterical agents

From the experiment of 9 samples, the best quality of tissue paper was the 7th sample. in the 7th sample, the composition was 60 grams of palm oil, 1.5 grams of tapioca, 1 gram of PVA, 3 grams of chitosan, 10 mL of VCO with variations of bleaching pulp. binder solution is applied by dabbing on a semi-dry paper towel. Tissue goods with bonded cellulose qualities, flexible composition, smooth texture, firmer when exposed to water, can absorb antibacterical materials.

3.1.2.2.1 Tissue Paper Color Test

Soaking Sample 7 tissue paper with improved criteria in distilled water for 60, 70, 80, and 90 minutes is used to examine its colour**.**

Table 5. Color Test Results

Time (minute)	Color Test Results	Description
60		White
70		White
80		White

90		White

The results in the table indicate that the tissue paper's colour does not fade after 60, 70, 80, and 90 minutes of soaking in distilled water.

3.2 Palm Leaf Extract

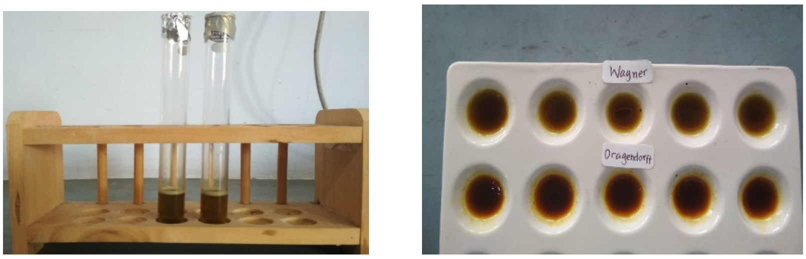
The extract of oil palm leaf yields a viscous palm leaf extract. In biodegradable wet wipes, palm leaf extract works as an antibacterical agent.

3.2.1 Qualitative Phytochemical Test

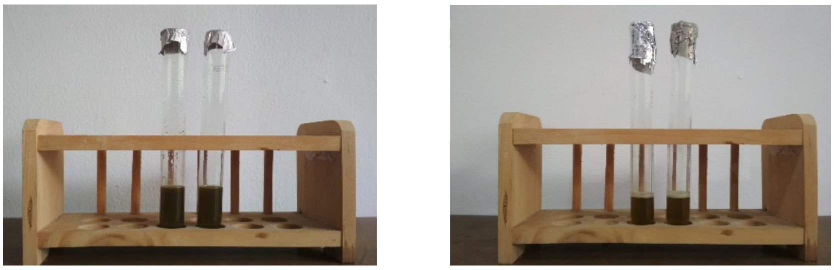
a. Flavonoid Test
   Palm leaf extract mixed with a bit of Mg powder, 2N HCl and ethanol, as much as 4-5 drops were then agitated, showing a change in colour to yellow, orange or reddish. This suggests that the extract of palm leaf includes flavonoid chemicals. Discolouration to red, yellow, or orange happens due to diminished flavonoids with Mg and HCl. Strong HCl is utilized to hydrolyze flavonoids into their aglycones by hydrolyzing O-glycosyl.
b. Alkaloid Test
   Oil palm leaf extract mixed with Wagner reagent and Dragendorff reagent as much as 4–5 drops generate precipitate and colour change correspondingly yellow-purple red and orange. This shows that the palm leaf extract includes alkaloid chemicals. A complex bond produces this brownish residue from potassium-alkaloid synthesized by K+ metal ions in potassium, establishing coordinating covalent connections with nitrogen in alkaloids.
c. Tanin Test
   The addition of a few drops of 0.1% $FeCl_3$ to oil palm leaf extract resulted in a change in colour and the production of a green-black precipitate. This implies that tannins are present in the palm leaf extract. The phenol group in the tannin compound will produce a complicated combination with Fe^{3+} ions resulting in a colour resembling blue ink or blackish green
d. Saponin Test
   Palm leaf extract is added as much as 5 millilitres of pure distilled water and then shaken rapidly for a few moments until foam or air bubbles are expelled. This indicates that oil palm leaf extract includes saponin chemicals generated by the hydrolysis of the glycoside content into glucose.

Table 6. UV-VIS Spectrophotometryc Test

Compound	Qualitative Phytochemical Test Results	Test Description
Flavonoid	There is a change in colour to yellow, orange or reddish	+
Alkaloid	A precipitate formed, and the tint altered to yellow-purple and orange	+
Tanin	A colour change and the production of a green-black deposition occur	+
Saponin	Stable foam created	+



(a) **(b)**



(c) **(d)**

Figure 3. Qualitative Phytochemical Test Result. (a) Flavonoid; (b) Alkaloid; (c) Tanin; (d) Saponin

3.3 Biodegradable Wet Wipes

The biodegradable wet wipes obtained will be evaluated to establish whether they have good mechanical and physical properties

3.3.1 Biodegradable Wet Wipes Irritation Test

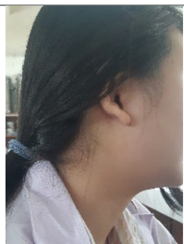
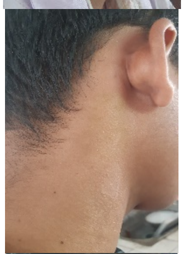
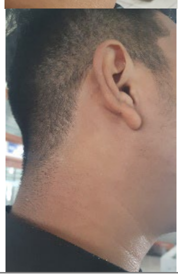
We took 4 participants aged 18-25 years, then tissue was attached to the area under the ears of 4 volunteers for 2 hours, and the following results were obtained

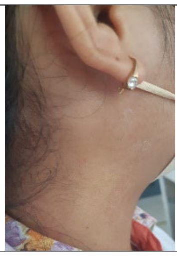
Table 7. Irritation Test Results

Volunteers	Irritation Test Results
1	-
2	-
3	-
4	-

Description:
(+) : Itch skin
(++) : reddish skin
(+++) : swollen skin
(-) : no irritation

Table 8. Irritation Test Results on Volunteers

Volunteers	**Attachment to Irritation Test Results**
A	
B	
C	

D	

3.3.2 pH test biodegradable wet wipes

The pH meter test is conducted in both digital and pH paper formats. The test findings reveal that the sample is on a scale of 7 - 7.29, which is safe for usage with a moist tissue pH standard of 7.2 - 7.4.

3.3.3 Test biodegradable wet wipes

The biodegradable wet wipes test used the soil burial test method following ASTM 6400-99 guidelines. The findings of the examination conducted on biodegradable wet wipes on July 7 indicated that all of the wipes had disintegrated. This research may differ from that undertaken by Rodrigues et al. Several factors can influence the biodegradability of a polymer, including the molecular geometry of long-chain bonds (related to the length of the polymer chain or its molecular weight), the complexity of the polymer structure (relating to the presence of long chains, amorphous and crystalline double chains), and the hydrophilic properties of the polymer (solubility).

4. CONCLUSION

The findings of this study can be inferred as follows

a. The cellulose content of palm fiber pulp was 87.3%, and palm leaf extract was prepared by maceration method with the content of palm leaf extract in 10 mL ethanol, yielding 8.3% extract and 91.7% ethanol
b. The 7th sample had the optimal quality of composition and method of administering the binder solution, with a design of 60 grammes of palm oil, 1.5 grammes of tapioca, 1 gramme of PVA, 3 grammes of chitosan, 10 mL of VCO with a variation of bleaching pulp and the method of administration binder solution by smearing it on half dry tissue paper. Tissue products were developed with bonded cellulose qualities, flexible composition, smooth texture, stiffer when exposed to water, and could absorb antibacterical chemicals
c. Two results were obtained in the Biodegradable Wet Wipes pH test: 7 and 7.29, respectively, using pH paper and a pH metre. The wet tissue colour test yielded a white colour or no colour change after soaking in distilled water for 60, 70, 80, and 90 minutes. The irritation test of biodegradable wet wipes performed on 4 volunteers revealed no irritation
d. Based on the phytochemical test, it was determined that oil palm leaf extract contains flavonoids, alkaloids, tannins, and saponins that work as antibacterical agents in biodegradable wet wipes
e. Based on biodegradable wet wipes test, it demonstrates that Biodegradable Wet Wipes from Palm Fiber Combined with Extract from Palm Leaves as Antibacterial Agent can degrade in the soil within 7 days of immersion time.

ACKNOWLEDGEMENT

The researcher would like to express her deepest gratitude to the Oil Palm Plantation Fund Distribution Agency (BPDPKS) and the Ministry of Finance, who funded this research in a whole, and all parties who assisted and supported the researchers in completing this study.

REFERENCES

[1]. Putri, R.K., Junaidi, Robert., Mustain, "Pemanfaatan α-Selulosa Fiber Cake Kelapa Sawit Sebagai Alternatif Bahan Baku Nitroselulosa," Jurnal Pendidikan dan Teknologi Indonesia (JPTI), vol. 1, no. 9, pp. 351-356. September, (2021). doi: doi.org/10.54236/1.jpti.83
[2]. Rahmasita, M.E., Farid, M., Ardyananta, H., "Analisa Morfologi Serat Tandan Kosong Kelapa Sawit Sebagai Penguat Komposit Absorpsi Suara," Jurnal Teknik ITS, vol. 6, no. 2, pp. A787-A792. (2017). doi: dx.doi.org/10.12962/j23373539.v6i2.24332.
[3]. Susanto, J.P., A. D. Santoso dan N. Suwedi. "Perhitungan Potensi Limbah Padat Kelapa Sawit untuk Sumber Energi Terbaharukan dengan Metode LCA,". Jurnal Teknologi Lingkungan, vol.18, no. 2, pp. 165-172. (2017).
[4]. Septianto, "*Manufacturing of Tissue: The Effect of Material and Amount of Chitosan and Starch*," Skripsi Universitas Muhammadiyah Surakarta. 2019.
[5]. Lestari, S.I., Sigalingging, R., Panggabean, S., "*The Comparison Test of Composition of Several Types of Agricultural Waste as Materials of Recycled Paper*," Jurnal Rekayasa Pangan dan Pertanian, vol. 6, no. 4, pp. 851-859. (2018).

[6]. Setyaningrum, E. "Aktivitas Antibakteri Fraksi Etil Asetat Daun Sirsak (*Annona muricate L*) Terhadap *Staphylococcus aereus,"* Skripsi Sekolah Tinggi Ilmu Kesehatan Nasional. (2018).
[7] Rodrigues et al. 2020. "*Starch-Based Foam Packaging Developed from a By-Product of Potato Industrialization,"* Applied Sciences, vol. 10, no 2235. https://doi.org/10.3390/app10072235
[8]. Dewanti, D. P., "Potensi Selulosa dari Limbah Tandan Kosong Kelapa Sawit untuk Bahan Baku Bioplastik Ramah Lingkungan," Jurnal Teknologi Lingkungan, vol. 19, no. 1, pp. 8188. Januari, (2018). Doi: doi.org/10.29122/jtl.v19i1.2644