KnE Engineering

JICOMS
Jakarta International Conference on Multidisciplinary Studies towards Creative Industries
Volume 2024

Research Article

Utilization of Palm Oil Waste into Liquid Smoke in Cellulose Commercial Starch Nano Fiber Composite as Antimicrobial Substances in the Manufacturing of Food Packaging

Efrizal Siregar*, Yusnia Sinambela, Khairil Anwar, Romel Sinaga

Departement of graphic technique Politeknik Negeri Media Kreatif, Indonesia

ORCID
Efrizal Siregar: https://orcid.org/0009-0003-2778-1863

Abstract.
The high demand for plastic use today will result in environmental damage because the plastic that is widely used cannot be broken down. This plastic waste is dangerous for the sustainability of the food chain, pollutes water and soil, causes global warming, and causes air pollution. This research synthesizes a cellulose nanofiber composite with commercial starch in a 1:1 ratio with the influence of the addition of smoke liquid from palm oil waste. This research aims to process cellulose nanocomposite fibers combined with commercial starch and use them in biodegradable plastic by testing the effect of giving smoke liquid on the development of microbial substances in environmentally friendly biodegradable plastic food packaging. So the resulting product is expected to have the potential to reduce dependence on the use of synthetic plastic. This research aims to determine the optimum concentration of liquid acid from empty oil palm fruit bunches as an antimicrobial agent in the resulting bioplastic. The addition of liquid smoke changes the bioplastic properties of FTIR and XRD the attractive strength of bioplastic. The sample with the highest concentration of liquid smoke had the greatest tensile strength (2.34 MPa). The addition of liquid smoke concentration from empty oil palm shells showed a good inhibitory area for the development of bacillus cereus (10.8 mm).

Keywords: liquid smoke, plastic biodegradable, food packaging, antimicrobial

Corresponding Author: Efrizal Siregar; email: efrizalsiregarchems@gmail.com

Published 7 March 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the JICOMS Conference Committee.

1. Introduction

The use of plastic food packaging is very common and is everywhere around us. Plastic is used for various types of needs, one of which is plastic as food packaging. Generally, plastic food packaging is used because it is cheap, easily available and durable, but is not environmentally friendly [1]. The overall use of plastic polymers to date has reached 8.3 billion ton of plastic which has been made for various uses. Of this amount, only 6.3 thousand tons of plastic or around 9% is recycled, 12% of plastic waste is burned and the remaining 79% accumulates in the land, sea or in landfills and becomes waste that has not been utilized and causes pollution on land, water and air [2]. Plastic production continues to increase at this time and there is a lack of awareness regarding waste disposal as well as a low percentage of waste processing for recycling, so that in 2050 the sea is predicted to be filled with plastic waste so that marine biota such as coral reefs and fish will disappear [3]. Therefore, the use of plastic must be abandoned. One effort that can be made is to replace synthetic plastic materials with more environmentally friendly plastic materials such as bioplastics or biodegradable plastics [4].

Biodegradable plastics made from cellulose nanocomposites that come from nature have properties that are almost similar to the plastic polymers used today. Biodegradable plastic does not have a negative impact on the environment and can reduce waste management and pollution problems. Biodegradable plastic has different physical properties from the synthetic plastic polymers that are currently used [5]. However, the use of bioplastics still needs to be improved, especially from the aspect of food packaging hygiene. Bioplastics have a rougher and stiffer texture and have morphological characteristics with slightly larger pore sizes compared to synthetic plastics [6]. Therefore, if bioplastics are used as food packaging wrappers, it will have an impact on health. Because it allows microbial substances to live and develop in the pores of the bioplastic used in food packaging. This research aims to make food packaging made from biodegradable plastic that is resistant to the growth of microbial substances or bacteria that are not good for health with the help of smoke liquid synthesized from solid palm oil waste [7].

Liquid smoke or smoke liquid can be made by utilizing palm oil waste in Indonesia, especially North Sumatra. The availability of empty palm oil shell waste has the potential to be processed into liquid smoke and used in making bioplastics which can inhibit the growth of microbes or bacteria so that packaged food is safer and healthier. Liquid smoke is commonly used as a preservative for fish, tofu, meatballs or meat because it can inhibit the growth of microbes that cause food spoilage [8]. This liquid smoke technology has the potential to be a combination material for making bioplastics from cellulose nanocomposite fiber composites or commercial starch which protects bioplastics from the growth of microbial substances or bacteria. From the above background, the researcher wants to conduct competitive research with the title Utilization of Palm Oil Waste as Smoke Liquid in Commercial Cellulose Fiber/Starch Nano Composites as an Anti-Microbial Substance in Food Packaging Production [9].

The use of polymer plastic increases the amount of pollution in the environment. Pollutants found in the food chain pose a threat to human health. From this perspective, biodegradable plastic can be a solution to the problems caused by polymer plastic. Biodegradable plastic focuses on creating a more sustainable and greener world with less negative impact on the environment. Biodegradable plastic can also have the same properties as synthetic plastic, but has properties that provide additional benefits because of its minimal impact on the environment. Research on biodegradable plastic for sustainability has been carried out a lot in recent years [1]. Some biodegradable plastics currently produced and applied based on renewable resources include PLA, Cellulose fiber, and Starch which are biopolymers obtained from organic [10]. However, "biobased" is different from "biodegradable" or compost in that biobased products include renewable raw materials and can be recycled through natural processes. Biodegradable products include polymers that can be degraded by microorganisms over a certain period of time in the environment [11]. Cellulose is one of the most abundant polymers in nature that can be easily derived from available biomass. Nano cellulose is also suitable for use in strengthening bioplastics because cellulose can produce nano-materials with a high strength to weight ratio and is expected to have lower costs in management when compared to other nano materials. Nano cellulose is biodegradable and environmentally friendly. Several research results state that cellulose has encouraging prospects for improving the mechanical and thermal properties of polymers [12], [13]. Two types of cellulose nanostructures can be applied as reinforcement in food packaging, namely cellulose nanocrystals and nanofibers. These two types of nano cellulose can strengthen polymer nano composites with higher strength and modulus due to more significant aspect ratios and fiber entanglement [4]. North Sumatra is one of the provinces in Indonesia which has quite extensive oil palm plantations. Apart from producing fresh fruit, palm oil also produces solid waste such as empty palm oil shells which can be processed into products that have high economic value, namely smoke liquid or liquid smoke. Liquid smoke is obtained by heating without the help of oxygen or what we call pyrolysis. The empty oil palm shells that have been collected weighing 4-6 kg are put into a container which is then heated without oxygen at a temperature of 300-380 0C. To produce liquid smoke, when heating the resulting gas is condensed to produce liquid smoke [14]. Liquid smoke has properties that can inhibit microbial growth (anti-microbial) because liquid smoke can reduce the work of microbes on a material so that the decay process does not occur. Therefore, liquid smoke can also be used to inhibit microorganisms, microbial substances in biodegradable plastic [13].

Based on data from the use of biodegradable polymers, bioplastic production has reached 7.5 million tons, this amount is 2% of the current use of synthetic plastic. The use of biodegradable plastic will continue to increase every year so that it will reduce dependence on the use of synthetic plastic. So from this data, biodegradable plastic has the potential to become sustainable food packaging[16], [17].

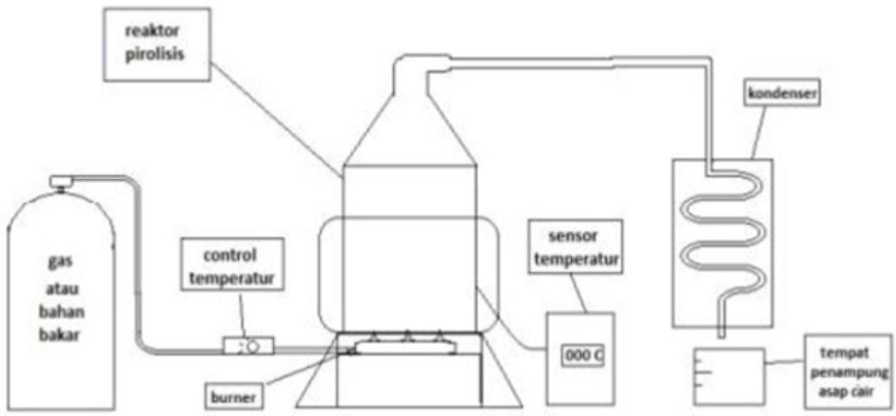

Figure 1: Scheme for Making Liquid Smoke from Empty Palm Oil Shells [15].

2. Material and Methods

In this research, the material used was palm oil solid waste in the form of empty palm oil shells obtained from the PTPN IV Serdang Bedagai palm oil mill, North Sumatra. Solution of glucose, urea, distilled water, acetic acid, NaOH, NaOCl, Glycerol, and Ethanol. This research is an experimental research with a combination of physical processes, pyrolysis and chemical processes as well as a characterization test process for the resulting product. Product characterization tests consist of smoke liquid tests and biodegradable plastic food packaging under relevant environmental conditions. The empty palm oil shells were weighed at 3 kg, then washed with clean water and dried. Then put it into the pyrolysis combustion reactor to produce 500 mL of liquid smoke for approximately 9 hours. The liquid smoke then passes through a desiccator and produces liquid bio oil. Then the resulting liquid smoke will become a component for making NFC with variations of 1 mL, 1.5 mL and 2 mL. Making bioplastic from a mixture of starch suspension and NFC 2%+ glycerol using variations of 1 mL, 1.5 mL, 2 mL liquid smoke. Then the mixture is put into a mold measuring 15 x 15 cm and dried at room temperature. then characterization testing was carried out on the samples using FTIR, XRD, testing attractiveness and developmental bacterial influence [17].The design of this experimental study is displayed in Table 1.

To see the characteristics of the sample's functional groups in bioplastics, you can use the Thermos Scientific Nicolet IS50 FT-IR spectrometer test to read the graphic values in determining the functional groups. The entire spectrum was carried out with 32 scans with a resolution power of 4 cm-1. The wave number interval used is 400 to 4000 cm-1. IR wave measurements can be carried out after the thin sheet is dry

Table 1: Research Design.

Test	Sample X1 (1 mL + NFC 2% + Glycerol)	Sample X2 (1,5 mL + NFC 2% + Glycerol)	Sample X3 (2 mL + NFC 2% + Glycerol)
FTIR	X1F	X2F	X3F
XRD	X1X	X2X	X3X
Testing Attractiveness	X1T	X2T	X3T
Developmental Bacterial Influence	X1D	X2D	X3D

and deposited using ATR crystals. FTIR testing was carried out with 3 repetitions. Each sample that is in crystal form will be identified using X-rays which are carried out in the laboratory using the HD 2711N model. The resulting radiation can be processed at 40 kV and 44 mA is used for XRD 20 scans are carried out at a speed of 28/min with a temperature interval of 10-50 °C. Next, the samples will also be tested to measure the development of antibacterial activity of bioplastic films with a diameter of 2 cm. In this sample, nutrients will be placed on the surface containing a suspension of gram-positive bacteria (staphylococcus aureus. The Petri dish is incubated for 18 to 24 hours and then the development of the bacteria in the sample will be seen [17].

The variable in the research on making biodegradable bioplastic food packaging based on commercial Nano composite cellulose/starch with smoke liquid to prevent microbial substances is the variation in volume percent of liquid smoke (smoke liquid) mixed with nono-cellulose/commercial starch fiber composite in making biodegradable plastic to see the effectiveness in prevent the growth of microbial substances. Data collection used a non-factorial Completely Randomized Design (CRD) [18].

3. Result and Discussion

3.1. Fungsional Groups Analisys

The results of FTIR readings obtained data for the bioplastic sample with a wave number of 3265.4 cm-1 showing an absorption peak area which could be identified as a hydroxyl group (O-H) which was thought to come from commercial starch. The sample also shows the presence of the (C=H) functional group, identified from the absorption area of 2929 cm-1 which shows this group. The sample also shows the presence of the (C-O) group which shows a peak of 1640 cm-1 which comes from esters and carboxylic acid compounds. Some samples show a bend in the (C-H) group which shows the characteristics of the bioplastic samples produced. The difference in transmission that occurs is caused by the addition of liquid smoke from empty palm oil shells which can affect the transmission number in the form of a decrease which results in higher wave absorption. This research data is also similar to findings in previous research. The addition of liquid smoke as filler in empty palm oil shells affects hydrogen bonds [17].

3.2. XRD Analysis

The XRD diffractogram of all bioplastic samples gives a diffraction peak value of 2θ at 15° and 20° which shows that the bioplastic samples have a crystalline form. Commercial starch is a semi-crystalline material with crystalline and amorphous units. The XRD characteristics of the entire sample show a change in the intensity angle of 2θ which causes the resulting crystals to be stiffer in both the 1 mL, 1.5 mL and 2 mL samples of liquid smoke added to the bioplastic production process which is caused by the interaction between hydrogen bonds and the sample. other ingredients [17].

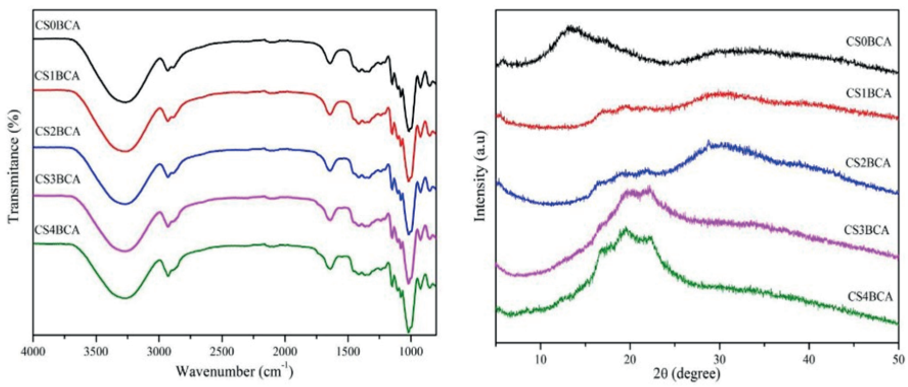

Figure 2: FTIR and XRD Bioplastic Sample [17].

3.3. Antibacterial Activity Test

To determine the ability of bioplastic to protect food from dangerous pathogens, an antibacterial activity development test was carried out. Bioplastic is seen for its ability to fight the development of bacteria with the addition of acanthopodium against bacillus cereus bacteria and E-coly bacteria. The results can be seen in table 2. The sample with the highest concentration of liquid smoke showed better ability to inhibit the growth of bacillus cereus bacteria and E-coly bacteria. The added liquid smoke extract provides slow microbial growth capabilities to the NFC film [4].

Table 2: Antibacterial Activity Test.

Bacteria	Sample	Average Diameter of Inhibition Zone	Antibacterial Activity
against bacillus	Sample X1 (1 mL + NFC 2% + Glycerol)	-	weak
	Sample X2 (1,5 mL + NFC 2% + Glycerol)	0.7	weak
	Sample X3 (2 mL + NFC 2% + Glycerol)	0.53	No Activity
E-coly	Sample X1 (1 mL + NFC 2% + Glycerol)	-	Weak
	Sample X2 (1,5 mL + NFC 2% + Glycerol)	0.6	Weak
	Sample X3 (2 mL + NFC 2% + Glycerol)	1.2	No Activity

4. Conclusion

The conclusion of this research is that this research has succeeded in producing liquid smoke from empty palm oil shells which can be added to the process of making bioplastic which has the potential to be used as an environmentally friendly material used in food packaging. The addition of liquid smoke from empty palm oil shells changes the transmission which affects FTIR absorption and affects sample crystallization in the XRD test. The tensile test showed the highest tensile strength with 2.34 MPa while the sample was able to inhibit bacterial growth with an inhibition zone of 10.8 mm. The results of this research also appear to be supported by the results of previous research. This research is one of the innovations in the field of active packaging because of its superiority in protecting food and microorganisms.

Acknowledgements

We want to say Thank you to the Creative Media State Polytechnic and P3M who have provided funding grants for this research with contract number 3380/PL27.15/PE/2023. Thanks also to the University of North Sumatra for giving permission to use the Basic Chemistry laboratory facilities.

References

[1] Moshood TD, Nawanir G, Mahmud F, Mohamad F, Ahmad MH, AbdulGhani A. Sustainability of biodegradable plastics: new problem or solution to solve the global plastic pollution? Curr. Res. Green Sustain. Chem. 2022;5(January):100273.

[2] Shafqat A, Al-Zaqri N, Tahir A, Alsalme A. Synthesis and characterization of starch based bioplatics using varying plant-based ingredients, plasticizers and natural fillers. Saudi J Biol Sci. 2021 Mar;28(3):1739–49.

[3] E. Siregar, Y. Sinambela, and K. Anwar, "Characterization Of Cellulose Nano Fiber From Solid Waste Of Palm Oil Palm Empty Fruits As Basic Materials Of Bioplastic For Food Packaging," 2022, https://doi.org/10.4108/eai.16-11-2022.2326060..

[4] Otoni CG, Azeredo HM, Mattos BD, Beaumont M, Correa DS, Rojas OJ. The Food-Materials Nexus: Next Generation Bioplastics and Advanced Materials from Agri-Food Residues. Adv Mater. 2021 Oct;33(43):e2102520.

[5] Liwarska-Bizukojc E. Effect of (bio)plastics on soil environment: A review. Sci Total Environ. 2021 Nov;795:148889.

[6] El-Refai AA, Ghoniem GA, El-Khateeb AY, Hassaan MM. Eco-friendly synthesis of metal nanoparticles using ginger and garlic extracts as biocompatible novel antioxidant and antimicrobial agents. J Nanostructure Chem. 2018;8(1):71–81.

[7] efrizal siregar, parningotan simamora, and Y. Sinambela, "Characterization Of Organic Ink From Hydrochar-Based Cellulose Synthesis Of Durian Skin Waste Reinforced By Acasia Substance As Printing Ink Printing," pp. 1–7, 2022, https://doi.org/10.4108/eai.16-11-2022.2326061..

[8] Ni'mah L, Setiawan MF, Prabowo SP; L. Ni'Mah. M. F. Setiawan, and S. P. Prabowo, "Utilization of Waste Palm Kernel Shells and Empty Palm Oil Bunches as Raw Material Production of Liquid Smoke,". IOP Conf Ser Earth Environ Sci. 2019;366(1):012032.

[9] Lisa Ginayati M. Faisal, and Suhendrayatna, "Pemanfaatan Asap Cair Dari Pirolisis Cangkang Kelapa Sawit Sebagai Pengawet Alami Tahu,". J. Tek. Kim. USU. 2015;4(3):7–11.

[10] Jancy R. S., Shruthy, R., Preetha, "Fabrication of packaging film reinforced with cellulose nanoparticles synthesized from jackfruit non-edible part using response surface methodology.,". Int J Biol Macromol. 2020;14:263–72.

[11] Moohan E. J., Stewart, S.A., Espinosa, E., Rosal, A., Rodríguez, A., Larra˜neta, "Cellulose nanofibers and other biopolymers for biomedical applications," *A Rev*. Appl. Sc. 2020;10:65.

[12] Hong LG, Yuhana NY, Zawawi EZ. Review of bioplastics as food packaging materials. AIMS Mater Sci. 2021;8(2):166–84.

[13] Zhao X, Cornish K, Vodovotz Y. Narrowing the Gap for Bioplastic Use in Food Packaging: an Update. Environ Sci Technol. 2020 Apr;54(8):4712–32.

[14] Arun R, Shruthy R, Preetha R, Sreejit V. Biodegradable nano composite reinforced with cellulose nano fiber from coconut industry waste for replacing synthetic plastic food packaging. Chemosphere. 2022 Mar;291(Pt 1 no. P1):132786.

[15] Gea S, Zulfahmi Z, Yunus D, Andriayani A, Hutapea YA. The Isolation of Nanofibre Cellulose from Oil Palm Empty Fruit Bunch Via Steam Explosion and Hydrolysis with HCl 10%. J Phys Conf Ser. 2018;979(1):012063.

[16] Gea S, Panindia N, Piliang AF, Sembiring A, Hutapea YA. All-cellulose composite isolated from oil palm empty fruit bunch. J Phys Conf Ser. 2018;1116(4):042013.

[17] Gea S, Pasaribu KM, Sarumaha AA, Rahayu S. Cassava starch/bacterial cellulose-based bioplastics with Zanthoxylum acanthopodium. Biodiversitas (Surak). 2022;23(5):2601–8.

[18] B. Syam, M. Muttaqin, Mawardi, F. Rozi, Martgomi, and J. Hutagalung, “The application of empty fruit bunch (EFB) fibers of oil palm for the development of light structure materials and products,” *E3S Web Conf.*, vol. 52, pp. 1–8, 2018, https://doi.org/10.1051/e3sconf/20185200007..