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INNOVATION IN MAKING BIOPLASTIC FROM CORN STARCH: A COMPREHENSIVE REVIEW

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ABSTRACT

Indonesia is the second largest producer of plastic waste in the world after China. Plastics are generally made from synthetic organic polymers derived from petrochemicals, because of their low cost and durability humans produce plastic in significant quantities. The main ingredients of biodegradable plastics include natural polymers such as starch, pectin, and gelatin, which contribute to the formation of the plastic structural framework. Biodegradable plastics can be made from corn starch that represent a promising alternative to conventional plastics due to their renewable nature and potential for biodegradability. Corn starch is processed through extraction, which is then converted into a raw material for bioplastics. These bioplastics can decompose in industrial composting conditions within approximately 21 to 90 days, significantly reducing environmental pollution compared to non-renewable plastics that may take hundreds of years to decompose. This review focuses on corn starch as the primary material for bioplastics, highlighting the mechanical properties and biodegradability when combined with various plasticizers, fillers, and additives. These combinations aim to optimize production processes and enhance the environmental benefits of corn starch-based plastics, making them a viable component in sustainable waste management strategies. The findings from the reviewed studies indicate that corn starch-based bioplastics exhibit promising characteristics, supporting their potential as a sustainable alternative to conventional plastics. To conclude, bioplastics are an effective alternative due to their biodegradable nature, the rate of bioplastic decomposition in the environment is influenced by their chemical structure, as well as environmental conditions such as humidity, temperature, and nutrient availability, all of which affect microbial activity.

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Introduction

The problem of plastic waste in Indonesia is still an unresolved problem with the increasing population in Indonesia, the volume of plastic waste generated from human activities will also increase. Indonesia is the second largest producer of plastic waste in the world after China, which reaches 187.2 million tons, this is related to data obtained from the Ministry of Environment and Forestry which states that plastic from 100 shops in just 1 year has reached 10.95 million valleys of plastic bag waste which is equivalent to an area of 65.7 hectares of plastic bags (Jhon & Haryanto, 2022). Almost every society and industry uses plastic as packaging, every year around 100 million tons of plastic are produced in the world for use in various industrial sectors to meet the need for plastic in everyday life and conventional petroleum-based plastic is produced every year, 7 million barrels of oil are needed per day.

Plastics are generally made from synthetic organic polymers derived from petrochemicals, because of their low cost and durability humans produce plastic in significant quantities. In addition, recycling plastic waste requires higher costs than producing it, and it even takes more than a century to decompose naturally. This is because the chemical structure of plastic makes it resistant to natural degradation. Fossil fuel-based plastics also produce more greenhouse gases than natural or plant-based polymers, so new thinking and technology are needed to make environmentally friendly plastics (Atchaya et al., 2023).

Bioplastics are an effective alternative due to their biodegradable nature, the rate of bioplastic decomposition in the environment is influenced by their chemical structure, as well as environmental conditions such as humidity, temperature, and nutrient availability, all of which affect microbial activity (Nizami, 2019). The main ingredients of biodegradable plastics include natural polymers such as starch, pectin, and gelatin, which contribute to the formation of the plastic structural framework. Additives are used to improve mechanical properties, stability, biodegradability and other aspects. Plasticizers are used to increase flexibility, shelf life, and performance limits (Nanda & Singh, 2022). Binders such as lactic acid are also needed to increase chemical reactivity and help in pH control and distilled water is used as an uncontaminated solvent and moisture regulator for bioplastics.

One of the main sources for the manufacture of bioplastics is starch, which can be obtained from various plant sources such as cassava, potatoes, and corn. Starch is a polysaccharide that has physical and chemical properties that can be modified to meet the needs of certain applications. In recent years, research on the manufacture of bioplastics from starch has increased because corn starch has significant advantages over other plant starches in bioplastic applications, especially due to its availability and chemical properties that support processing.

Corn starch contains a balanced proportion of amylose and amylopectin, providing strong and flexible film-forming ability compared to cassava starch which tends to be more brittle or potato starch which has a higher viscosity, in addition corn starch is easily modified for example through plasticization with glycerol to produce bioplastics that are more elastic and resistant to moisture (Nordin et al., 2020). Another advantage is the lower gelatinization temperature of corn starch, which reduces energy consumption in the manufacturing process compared to starch from wheat or sweet potatoes (Schulze et al., 2017). The global availability of corn starch is also an important factor because it can be produced on a large scale at a relatively low cost, making it an economical material for an environmentally friendly alternative to conventional plastics.

Research Methods

The methodology used in this study is a journal review or literature study, by reviewing international and national journals that discuss the manufacture of bioplastics using corn starch. This process involves collecting and analyzing various relevant literature, both those discussing the manufacture of bioplastics from corn starch raw materials with various additional additives to improve the mechanical properties of bioplastics, in addition the literature reviewed also includes various results of mechanical property tests and bioplastic characterization. The results of this study aim to provide recommendations on the best methods and additives that can be used in the manufacture of corn starch-based bioplastics in the future.

Results and Discussion

This results and discussion section describes various findings obtained from literature studies on the manufacture of bioplastics from corn starch. This study analyzes various methods of making bioplastics, additives used, and the characteristics resulting from the combination. Based on the literature that has been reviewed, the most effective bioplastic test results from additives that can improve the quality of bioplastics will be identified, such as tensile strength, elongation, Fourier Transform Infrared Spectroscopy (FTIR) and degradation. In addition, this section also describes the testing of physical and mechanical properties of bioplastics to evaluate the performance of the resulting bioplastics.

Making bioplastics from corn starch is quite simple, namely by extracting starch from corn which is then dissolved and heated in distilled water or other solvents to improve the quality of its physical and mechanical properties. The dissolved

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starch solution is given other additives such as plasticizers to increase the flexibility of bioplastics, increase their flexibility and increase the durability of bioplastics. Plasticizers for making bioplastics include sorbitol, glycerol, lactic acid, Polyvinyl Alcohol (PVA). There are several types of plasticizers that will be described in Table 1, namely the Advantages of Various Plasticizers for Making Bioplastics.

Table 1. Advantages of Various Plasticizers for Bioplastic Production

Plasticizer	Chemical Formula	Superiority	Reference
Glycerol	$C_3H_8O_3$	Able to attract and hold water vapor from the air so that it can increase the mechanical properties, especially elongation.	Azsarinka et al. (2020)
Sorbitol	$C_6H_{14}O_6$	Able to increase strength and elasticity as well as biodegradability. Can increase solubility in water.	Yahia et al. (2023)
Fructose	$C_6H_{12}O_6$	Increase the tensile strength of bioplastics.	Abotbina et al. (2021)

Based on Table 1, it can be concluded that plasticizer is a very important component for the manufacture of bioplastics because it can increase the flexibility and elasticity of bioplastics. In addition, there are also additional additives needed to improve the quality of bioplastics, such as fillers whose purpose is to improve the mechanical properties, resistance to moisture and thermal resistance of bioplastics, in addition there are additional additives as catalysts during the synthesis process, as bioplastic dyes, and to improve other bioplastic parameters which will be described in

All bioplastic tests have standards that determine whether the test results are suitable or not based on the Indonesian National Standard (SNI). SNI for bioplastics regulates various aspects, from raw materials, manufacturing processes, to physical, mechanical, and biodegradability properties of bioplastic products. Based on SNI, each bioplastic product tested must meet certain criteria to ensure quality, safety, and minimal environmental impact and ensure that the product complies with the standards set for use in Indonesia. The following is SNI 7187:2015 on bioplastics.

Based on information from Table 3 referring to SNI 7187:2015 on bioplastics which explains various test methods and procedures used to assess the quality and characteristics of bioplastics. This test includes various parameters such as mechanical strength, elongation, biodegradability, FTIR (Fourier Transform Infrared Spectroscopy) and other properties relevant to the bioplastic quality standards set out in the SNI. This explanation aims to provide a clearer picture of how the testing process is carried out and ensure that the resulting bioplastic meets the technical requirements needed for safe and environmentally friendly applications.

In this literature study, the main focus of the parameter test results is on the mechanical, physical, and chemical properties of bioplastics. This is used to evaluate the strength, flexibility, resistance of the material to various types of pressure and load, how long the bioplastic decomposes, and review the changes in functional groups. The results of this property test are very important to ensure that the bioplastic produced has good quality, is reliable, and meets the established SNI.

Tensile strength test is a parameter test to analyze the maximum amount of tensile stress (stretching) that can be withstood by a material before tearing or breaking. It is important to know how well bioplastics can withstand pressure. This test procedure is carried out by cutting bioplastic samples into standard shapes for tensile testing measuring 25 x 20 cm. Then the bioplastic is soaked in distilled water until it expands. The test uses a universal testing machine/Tensile Strength Analyzer to hold the sample and then apply tensile force at a constant speed (usually 5 mm/min) until the sample breaks/tears. The machine will record load and elongation data during the test (Kustiyah et al., 2023).

Elongation test at break or elongation is a parameter test to measure how far bioplastic can stretch before breaking or tearing, this is needed to analyze the flexibility of a bioplastic (Nurulhasni, 2023). The procedure for this elongation test is to cut the sample to the required size and make sure all samples are the same size. Both ends of the sample are then clamped and a load is added. Bioplastic elongation is determined from the elongation of the bioplastic before it finally tears or breaks.

Biodegradability test refers to the ability of a material to decompose through biological processes such as microorganisms. This property is important for environmentally friendly parameters (Zhou et al., 2022). This test is usually carried out by cutting the sample into the same size and then burying it in the soil and observing it at a predetermined time until the sample degrades in the soil.

Meanwhile, the physical properties parameter test was carried out using the Fourier

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Transform Infrared Spectroscopy (FTIR) test to analyze the chemical composition and molecular structure of bioplastics by detecting the vibrational frequency of chemical bonds in the material. The FTIR test provides information about the functional groups present in the material to understand the chemical properties and interactions between components in bioplastics. This characterization test uses an FTIR instrument with a 100-Perkin Elmer spectrum. The test is carried out by taking samples that have been formed into pellets and inserted into a tablet holder that has been coated with KBr pellets. Then the sample is inserted into the FTIR instrument which is recorded using infrared light (Kustiyah et al., 2023).

Table 2. Advantages of Various Additive Substances for Making Bioplastics

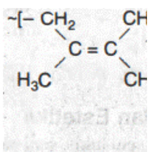
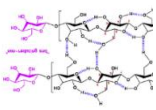
Additives	Chemical Formula	Superiority	Reference
Chitosan	$(C_6H_{11}NO_4)_n$	Antimicrobials to improve the mechanical properties of bioplastics such as tensile strength and stiffness.	Azzarinka et al. (2020)
Acetic Acid	CH_3COOH	Catalyst during the synthesis process and other additive solvents, regulating pH.	Azzarinka et al. (2020)
Euphorbia antiquorum (sap)		enhance the mechanical properties, flexibility, and biodegradability of bioplastics, as well as provide antimicrobial properties	Atchaya et al. (2023)
Microcrystalline	$C_5H_{10}O_5$	Improves mechanical properties, provides binding properties, increases biodegradability and increases water resistance.	Anugrahwati et al. (2022)
Kaolin	$Al_2Si_2O_5(OH)_4$	Improving the mechanical properties of bioplastics based on the barrier properties of CO_2 O_2 and moisture	Anugrahwati et al. (2022)
Turmeric	$C_{21}H_{20}O_6$	Reinforcing agents because they have high interfacial interactions between polymers and as bioplastic dyes, have water-insoluble properties, so they can produce water-resistant bioplastics.	Triawan et al. (2020)
Cellulose Nanoparticles		Increases tensile strength, thermal strength and strength and reduces water absorption.	Olusanya et al. (2023)
Graphene Oxide (GO)		Carbon-based nanomaterials from graphite oxide stripping to improve the mechanical properties of bioplastics.	Biha et al. (2021)

Table 3. SNI 7187:2015 on Bioplastics

Parameter Test	Condition
Tensile Strength (MPa)	Min. 13.7 MPa
Elongation (%)	40 – 112 % elongation
Biodegradation (%)	< 5% residual weight after 6 months

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Table 4. Collection of Bioplastic Manufacturing Materials and Test Results of Corn Starch-Based Bioplastic Parameters

No	Raw material	Plasticizer	Filler	Additives	Tensile Strength (MPa)	Elongation (%)	FTIR (cm^{-1})	Biodegradation (Sunday)	Reference
1	Corn Starch	Glycerol	calcium silicate	acetic acid, chitosan and EM4.	2.8	30	-	5	John & Haryanto (2022)
2	Corn Starch	Glycerol	-	-	2.58	24	-	4	Iheanacho et al. (2024)
3	Corn Starch	Glycerol	-	-	9.97	23.84	3416	2	Juliet et al. (2023)
4	Corn Starch	Glycerol	chitosan	acetic acid	2.86	10.33	-	3	Azsarinka et al. (2020)
5	Corn Starch	Glycerol	coconut fiber	acetic acid	21.23	58.66	3375.2	2	Nanda & Singh (2022)
6	Corn Starch	Glycerol	*Euphorbia antiquorum*	Polyvinyl Alcohol (PVA) +$Na_2S_2O_5$	-	-	-	3	Atchaya et al. (2023)
7	Corn Starch	Glycerol	Kaolin	Microcrystalline + Chitosan	1.44	37.6	3500	2	Anugrahwati et al. (2022)
8	Corn Starch	Sorbitol	-	Cardanol oil	11	30	3560	1	Yahia et al. (2023)
9	Corn Starch	Glycerol	-	acetic acid, turmeric	1,957	-	3280	2	Triawan et al. (2020)
10	Corn Starch	Glycerol + Fructose	-	-	20.36	33.87	3358.15	-	Abotbina et al. (2021)
11	Corn Starch	Glycerol	cellulose nanoparticles (CNP)	Dried Banana Fiber and Nanoclay	4.885	-	3275	-	Olusanya et al. (2023)
12	Corn Starch	Glycerol	Graphene Oxide (GO)	-	1.2	22.50	-	1	Biha et al. (2021)
13	Corn Starch	(PVA)	banana stem fiber	Zinc Oxide (ZnO)	29.16	-	-	2	Agus et al. (2023)
14	Corn Starch	Sorbitol	cellulose from sugarcane bagasse	-	2.9574	0.8896	-	2	Huwaidi & Supriyo (2022)
15	Corn Starch	Sorbitol	calcium carbonate and calcium silicate	-	1.9843	-	-	2	Radtra & Udjiana (2023)
16	Corn Starch	Glycerol	Cellulose from paper waste	-	1.65	37.5	-	2	Dewi et al. (2021)
17	Corn Starch	Glycerol	-	Polyvinyl Alcohol (PVA)	1.8	35	-	1	The Sunet al. (2022)
18	Corn Starch	Sorbitol + Glycerol	-	-	15	33.8	2917.82	-	Hazrol et al. (2021)
19	Corn Starch	Glycerol	-	Acetic Acid	50	90	-	1	Sari et al. (2023)
20	Corn Starch	Glycerol	Kaolin	-	1.44	35.64	3500	2	Anugrahwati et al. (2022)
21	Corn Starch	Glycerol	Silica powder	Hydrochloric acid Sodium hydroxide	1.6	77	3285	10	Azêvedo et al. (2020)
22	Corn Starch	Glycerol	-	Acetic Acid	1,059	-	3277	3	Din et al. (2022)
23	Corn Starch	Glycerol	-	PVA, sodium hexametaphosphate, sodium carbonate	9.18	125.66	1255	1	Yin et al. (2020)
24	Corn Starch	Glycerol	humus soil, carboxymethyl	-	6.50	23.07	-	1	Ihsan & Ratnawulan

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			cellulose						(2024)
25	Corn Starch	Glycerol	Gelatin	Citric Acid	12.5	6.8	-	4	Nasir & Othman (2021)
26	Corn Starch	Glycerol	*Zizania* L.	-	4.4	70	3340	-	Huang et al. (2023)
27	Corn Starch	Sorbitol	-	-	13,612	-	3000	1	Navasingh et al. (2023)
28	Corn Starch	Glycerol	Chitosan	-	10.49	31.73	-	3	Fathanah et al. (2022)
29	Corn Starch	Glycerol	-	Polyvinyl Alcohol (PVA)	1.8	30	-	1	Nordin et al. (2020)
30	Corn Starch	Glycerol	Corn Cob Cellulose	-	-	-	3345.99	4	Susanti (2021)
31	Corn Starch	Glycerol	-	Pullulan + Gallic Acid	18.63	65.75	3350	-	Zhang et al. (2023)
32	Corn Starch	Glycerol	-	Acetic Acid + vinegar	-	-	3278.94	2	Lee & Yeo (2021)
33	Corn Starch	Glycerol	-	Glacial acetic acid	-	-	3278	5	Ghizdareanu et al. (2023)
34	Corn Starch	Glycerol	banana stem waste	-	2.26	8	3400	10	Hernandez-Gil et al. (2022)
35	Corn Starch	Glycerol	Titanium Dioxide (TiO2)	-	4.72	-	3290	2	Atez & Kuz (2020)
36	Corn Starch	Glycerol	-	Acetic acid	0.57	63.02	3313	-	Nandiyanto et al. (2020)
37	Corn Starch	PVA	Chitosan + Maleic anhydride	Polyethylene waste, Bentonite, Diammonium Sulfate	-	-	3620	-	Hussein et al. (2021)
38	Corn Starch	Glycerol	Bamboo/Bamboo shoots	-	3.34	-	-	10	Casiño et al. (2023)
39	Corn Starch	Glycerol	Cinnamon + Palm Oil	Acetic Acid	-	-	-	2	Anggraeni et al. (2021)
40	Corn Starch	Glycerol	Chitosan	Microcrystalline, Oxidized Soybean Oil with Citric Acid	5.82	36.30	3277	-	Yang et al. (2022)

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The highest tensile strength value is in data number 19, namely research by Sari et al. (2023), of 50 MPa. These results have met SNI 7187:2015 concerning Bioplastics which have a minimum tensile strength requirement of 13.7 MPa. This bioplastic has a formulation consisting of corn starch, glycerol, and acetic acid. The lowest tensile strength value refers to data number 36, namely the research of Nandiyanto et al. (2020), of 0.57 MPa. Meanwhile, the data showing the number 0 MPa are several results that do not use tensile strength testing in their research.

The highest elongation value is in data number 23, namely Yin's research.et al. (2020), amounting to 125.66%. These results do not meet SNI 7187:2015 concerning Bioplastics which have an elongation requirement of 40 – 112%. This bioplastic has a formulation consisting of corn starch, glycerol, PVA, sodium hexametaphosphate, and sodium carbonate. The lowest tensile strength value refers to data number 25, namely the research of Nasir and Othman (2021), amounting to 6.8%. This bioplastic has a formulation consisting of corn starch, glycerol, gelatin, and citric acid. Data that meets the SNI elongation requirements, namely in number 5 of the research of Nanda and Singh (2022) amounting to 58.66% with a formulation of corn starch, glycerol, coconut fiber, and acetic acid; number 19 of the research of Sari et al. (2023) amounting to 90% with a formulation of corn starch, glycerol, and acetic acid; number 21 research by Azêvedo et al. (2020) of 77% with a formulation of corn starch, glycerol, silica powder, hydrochloric acid, and sodium hydroxide; number 26 research by Huang et al. (2022) of 70% with a formulation of corn starch, glycerol, and Zizania ltifolia; number 31 research by Zhang et al. (2023) of 65.75% with a formulation of corn starch, glycerol, pullulan, and gallic acid; and number 36 research by Nandiyanto et al. (2020) of 63.02% with a formulation of corn starch, glycerol, and acetic acid.

Most studies have an FTIR wavelength of 3416-3275 cm-1. This indicates a change in normal polymerization with the widening of the OH functional group, namely for the wavelength value. According to Nandiyanto et al. (2019), a wavelength of 3400-3200 is the wavelength for alcohol and hydroxyl functional groups which indicates the presence of normal "polymeric" OH stretch. Several studies also show wavelength values between 3560-3500 cm-1 which represent the presence of dimeric OH stretch. In study number 23 from Yin et al. (2020), a wavelength of 1255 cm-1 indicates the presence of skeletal CC vibration. In study number 18 from Hazrol et al. (2021), a wavelength of 2918 cm-1 indicates the presence of methyne CH stretch. The wavelength value of 3000 cm-1 in the study of Navasingh et al. (2023) whose functional group is unknown. The new functional groups that appear indicate that there are other chemical reactions from the manufacture of bioplastics in the study (Ningsih et al., 2019). From this explanation, most of the studies have undergone polymerization chemical reactions.

The longest biodegradation time of bioplastics was in data number 21 of the study from Azêvedo et al. (2020), number 34 research from Hernandez-Gil et al. (2022), and number 38 research from Casiño et al. (2023), which is 10 weeks or 2.5 months. This result meets SNI 7187:2015 on Bioplastics which have a biodegradation requirement of <5% residual weight after 6 months. This bioplastic has a similar formulation consisting of corn starch and glycerol, but different additives and fillers. In the study from Azêvedo et al. (2020) has a filler formulation of silica powder, hydrochloric acid additives, and sodium hydroxide. In the study of Hernandez-Gil et al. (2022) has a filler formulation of banana stem waste without other additives. While in the study of Casiño et al. (2023) has a bamboo filler formulation without any other additives. The data showing the number 0 Weeks are some of the results that do not use biodegradation testing in their research.

Based on the journal of bioplastic production from corn starch that has been reviewed, Bioplastic from corn starch is a promising innovation in reducing the environmental impact of conventional plastics. Corn starch, which is a renewable resource, has great potential to be processed into environmentally friendly bioplastic materials. The manufacture of corn starch-based bioplastics still has weaknesses in the mechanical properties of bioplastics, therefore additional additives are needed to improve their mechanical properties. The best plasticizer is a combination of glycerol and fructose or sorbitol by research by Abotbina et al. (2021) because they obtained high tensile strength parameter test results, namely above 20 MPa, in addition to PVA with additional Zinc Oxide Additives based on research by Agus et al. (2023).

Other additional additives for the manufacture of bioplastics are fillers, the addition of fillers can increase the tensile strength and mechanical properties of bioplastics. Chitosan and coconut fiber are recommended fillers for future research because they produce quite high elongation parameter tests, namely above 50% and above 30% based on research by Nanda and Singh (2022) and Yang et al. (2022). The addition of PVA can also strengthen the shelf life of bioplastics so that they decompose longer, but if you want high biodegradability, Carboxymethyl Cellulose (CMC) can be added to accelerate the degradation process because CMC has good water binding ability so that it is suitable for the growth of decomposing

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microorganisms.

Conclusion

Corn starch-based bioplastics are a promising alternative to conventional plastics due to their biodegradable and environmentally friendly properties. The combination of various plasticizers, fillers, and additional additives has been shown to improve the mechanical properties and biodegradability of bioplastics, making them a viable component in sustainable waste management strategies. Studies have shown that these bioplastics have great potential for widespread application in the packaging and consumer products industries, supporting the reduction of plastic pollution and the utilization of renewable resources.

References

Abotbina, W., Sapuan, S. M., Sultan, M. T. H., Alkbir, M. F. M., & Ilyas, R. A. (2021). Development and characterization of cornstarch-based bioplastics packaging film using a combination of different plasticizers. *Polymers*, *13*(20), 1–18. https://doi.org/10.3390/polym13203487

Agus, J., Ramadhani, S., Sabrini, P. N., Wulandari, D. R., & Ruslan, Z. A. (2023). Pengambangan Biofoam Berbahan Dasar Pati dari Ekstrak Jagung Pengembangan Biodegradable Foam Berbahan Dasar Pati dari Ekstrak Jagung dengan Penambahan Serat dari Pelepah Pisang. *Jurnal Chemica*, *24*(1), 78–86.

Anggraeni, S., Nandiyanto, A. B. D., Nurjami, A. M., Hofifah, S. N., Putri, S. R., Girsang, G. C. S., & Fiandini, M. (2021). Palm oil and cinnamon (anti-microbial agent) on the physicochemical, mechanical, and biodegradation properties of micrometer-sized cornstarch-based bioplastic. *Moroccan Journal of Chemistry*, *9*(3), 446–453.

Anugrahwati, M., Nasution, M. D. P., & Fajarwati, F. I. (2022). Characteristic comparison of cornstarch-based bioplastics using kaolin, microcrystalline cellulose and chitosan as fillers. *Jurnal Pijar Mipa*, *17*(1), 73–78. https://doi.org/10.29303/jpm.v17i1.3304

Atchaya, R. K., Devipriya, U., Sreeja, K., & Buvanesh, P. (2023). Evaluation of Bioplastic Developed from Corn Starch and Euphorbia antiquorum Latex. *International Journal of Environment and Climate Change*, *13*(11), 1169–1177. https://doi.org/10.9734/ijecc/2023/v13i113267

Atez, M., & Kuz, P. (2020). Starch-Based Bioplastic Materials for Packaging Industry. *Journal of Sustainable Construction Materials and Technologies*, *5*(1), 399–406. https://doi.org/10.29187/jscmt.2020.44

Azêvedo, L. C., Rovani, S., Santos, J. J., Dias, D. B., Nascimento, S.S., Oliveira, F. F., Silva, L. G. A., Fungaro, D. A. (2020). Study of Renewable Silica Powder Influence in the Preparation of Bioplastics from Corn and Potato Starch. *Journal of Polymers and the Environment*. https://doi.org/10.1007/s10924-020-01911-8

Azsarinka, R., Saleh, D., & Djonaedi, E. (2020). Synthesis of biodegradable plastic from corn starch and corn husk filler with addition of glycerol as plasticizer and variation of chitosan composition. *IOP Conference Series: Materials Science and Engineering*, *902*(1). https://doi.org/10.1088/1757-899X/902/1/012037

Biha, A. A., Johannes, A. Z., Pingak, R. K., Bukit, M., Hadi, D., & Sutaji, I. (2021). Kajian Sifat Fisis Bioplastik Pati Jagung Dengan Penambahan Graphene Oxide Berbahan Dasar Tongkol Jagung Asal Kabupaten Kupang. *Jurnal Fisika Sains Dan Aplikasinya*, *6*(1), 44–48.

Dewi, I. M. P., Johannes, A. Z., Pingak, R. K., Bukit, M., & Sutaji, H. I. (2021). Pembuatan Bioplastik Berbahan Dasar Pati Jagung Dengan Penambahan Serat Selulosa Dari Limbah Kertas. *Jurnal Fisika : Fisika Sains Dan Aplikasinya*, *6*(2), 91–96. https://doi.org/10.35508/fisa.v6i2.6838

Din, M. I., Ahmed, M., Ahmad, M., Ghaffar, T., Hussain, Z., Khalid, R., & Samad, A. (2022). Novel and Facile Synthesis of Biodegradable Plastic Films from Cornmeal by Using the Microwave Polymerization Technique. *Journal of Chemistry*, *2022*. https://doi.org/10.1155/2022/5697099

Fathanah, U., Meilina, H., Febriani, F., & Utami, F. R. (2022). Sintesis Bioplastik dari Tongkol Jagung sebagai Active Packaging yang Ramah Lingkungan. *Jurnal Inovasi Ramah Lingkungan (JIRL)*, *3*(1), 1–5.

Ghizdareanu, A., Pasarin, D., Banu, A., Afilipoaei, A. I., Enascuta, C. E., & Vlaicu, A. (2023). *Corn Starch Films*.

Hazrol, M. D., Sapuan, S. M., Zainudin, E. S., & Zuhri, M. Y. M. (2021). *Corn Starch (Zea mays) Biopolymer Plastic Reaction in*. 1–22.

10.21107/jps.v12i1.28981 Anjani et al. E-ISSN: 2527-7634

Hernandez-Gil, L., Caldas-Cortez, L., Contreras-López, D., & Jiménez-Sánchez, A. (2022). Evaluation of the use of banana pseudostem with thermoplastic corn starch for the elaboration of biodegradable dishes. *Revista Mexicana de Ingeniera Quimica*, *21*(3). https://doi.org/10.24275/rmiq/mat2893

Huang, J., Wu, W., Niu, B., Fang, X., Chen, H., Wang, Y., & Gao, H. (2023). Characterization of Zizania latifolia polysaccharide-corn starch composite films and their application in the postharvest preservation of strawberries. *Lwt*, *173*(December 2022). https://doi.org/10.1016/j.lwt.2022.114332

Hussein, A. H., Nasr, H. E., Abdel-Aziz, M. S., Mabrouk, M. R., El-Dars, F. M. S., & Samaha, S. H. (2021). Promising biodegradable composite derived from corn straw fiber and waste Polyethylene. *Egyptian Journal of Chemistry*, *64*(6), 3205–3213. https://doi.org/10.21608/ejchem.2021.64181.3376

Huwaidi, A. F., & Supriyo, E. (2022). Pembuatan Plastik Biodegradable Pati Jagung Terplastisasi Sorbitol dengan Pengisi Selulosa dari Ampas Tebu. *Equilibrium Journal of Chemical Engineering*, *6*(1), 45–49. https://doi.org/10.20961/equilibrium.v6i1.62552

Iheanacho, B. C., Ajoge, H. N., Ismail, U., Zoum, F. A., Ifeanyi-Nze, F. O., Okunbi, F. O., Edeh, C. F., Chimezie, N. N., Udoh, E. A., Nworie, J. O., Oseni, T. O., Mark, M. U., Akpowu, G. A., Kolapo, D. A., Odibo, A. O., Edun, O. J., Zogini, U. C., & Egwuonwu, C. O. (2024). A Comprehensive Study on the Production and Characterization of Eco-Friendly Biodegradable Plastic Films from Dent Corn Starch. *Archives of Advanced Engineering Science*, *XX*(March), 1–11. https://doi.org/10.47852/bonviewaaes42022946

Ihsan, M. B., & Ratnawulan, R. (2024). The Effect of Carboxymethyl Cellulose (CMC) Addition on The Quality of Biodegradable Plastic from Corn Cob. *Journal of Science and Science Education*, *5*(1), 10–16. https://doi.org/10.29303/jossed.v5i1.4000

Jhon, R., & Haryanto. (2022). The Effect of The Addition of Chitosan and Calcium Silicate on The Characteristic of Bioplastics from Corn Starch. *Research In Chemical Engineering (RiCE)*, *1*(2), 53–58. https://doi.org/10.30595/rice.v1i2.31

Casiño, V. J. A., Q. Delos Reyes Jr., N., Y. Casas, R., Jay P. Saldo, I., & Jade Peñafiel-Dandoy, M. (2023). Characterization of Cornstarch-Based Bioplastic Reinforced with Three Different Species of Bamboo Shoots. *American Journal of Environmental Protection*, *11*(1), 25–33. https://doi.org/10.12691/env-11-1-4

Juliet, A., Oluwafemi, O., Funmilayo, A., & Sunday, K. (2023). Preparation of Biodegradable Plastic Film from Sorghum bicolor (L.) Corn Starch. *Material Science Research India*, *20*(2), 122–129. https://doi.org/10.13005/msri/200205

Kustiyah, E., Novitasari, D., Wardani, L. A., Hasaya, H., Widiantoro, M. (2023). Utilization of Sugarcane Bagasses for Making Biodegradable Plastics with the Melt Intercalation Method. *Jurnal Teknologi Lingkungan*, 24(2), 300-306. https://doi.org/10.55981/jtl.2023.993

Lee, C. L. Y., & Yeo, W. S. (2021). A Basic Characterisation Study of Bioplastics via Gelatinization of Corn Starch. *Journal of Applied Science & Process Engineering*, *8*(2), 820–833. https://doi.org/10.33736/jaspe.3445.2021

Nanda, A., & Singh, N. (2022). Preparation and Antimicrobial Activity of Corn Cob and Coir Reinforced Biodegradable Starch Biocomposite Films for Food Packaging Application. *Asian Food Science Journal*, *21*(7), 53–66. https://doi.org/10.9734/afsj/2022/v21i730440

Nandiyanto, A.B.D., Fiandini, M., Ragadhita, R., Sukmafitri, A., Salam, H., Triawan, F. (2020). Mechanical And Biodegradation Properties Of Cornstarch-Based Bioplastic Material. *Materials Physics and Mechanics*, 44, 380-391. http://dx.doi.org/10.18720/MPM.4432020_9

Nandiyanto, A. B. D., Oktiani, R., Ragadhita, R. (2019). How to Read and Interpret FTIR Spectroscope of Organic Material. *Indonesia Journal of Science & Technology*, 4(1), 97-118. http://dx.doi.org/10.17509/ijost.v4i1.15806

Nasir, N. N., & Othman, S. A. (2021). The Physical and Mechanical Properties of Corn-based Bioplastic Films with Different Starch and Glycerol Content. *Journal of Physical*

Science, *32*(3), 89–101. https://doi.org/10.21315/jps2021.32.3.7

Navasingh, R. J. H., Gurunathan, M. K., Nikolova, M. P., & Królczyk, J. B. (2023). Sustainable Bioplastics for Food Packaging Produced from Renewable Natural Sources. *Polymers*, *15*(18). https://doi.org/10.3390/polym15183760

Ningsih, E. P., Ariyani, D., Sunardi. (2019). Effects of Carboxymethyl Cellulose Addition on The Characteristics of Bioplastic from Nagara Sweet Potatoes (Ipomoea batatas L.) Starch. *Indo. J. Chem*, 7(1), 77-85.

Nordin, N., Othman, S. H., Rashid, S. A., & Basha, R. K. (2020). Effects of glycerol and thymol on physical, mechanical, and thermal properties of corn starch films. *Food Hydrocolloids*, *106*. https://doi.org/10.1016/j.foodhyd.2020.105884

Olusanya, J. O., Mohan, T. P., & Kanny, K. (2023). Effect of nanoclay (NC) on mechanical and thermal properties of cellulose nanoparticles (CNPs) filled cornstarch bioplastic film. *Journal of Polymer Research*, *30*(7), 1–14. https://doi.org/10.1007/s10965-023-03646-1

Radtra, A. H. A., & Udjiana, S. (2023). Pembuatan Plastik Biodegradable Dari Pati Limbah Tongkol Jagung (Zea Mays) Dengan Penambahan Filler Kalsium Silikat Dan Kalsium Karbonat. *DISTILAT: Jurnal Teknologi Separasi*, *7*(2), 427–435. https://doi.org/10.33795/distilat.v7i2.243

Sari, D. Y., Ratnawulan, -, Jonuarti, R., & Hidayat, R. (2023). Making of Biodegradable Plastic Based on Corn Starch (Amylum Maydis) with Addition of Acid (CH3 COOh) and Gliserol Plasticizer. *Pillar of Physics*, *16*(2), 152–161. https://doi.org/10.24036/15040171074

Schulze, C., Juraschek, M., Herrmann, C., & Thiede, S. (2017). Energy Analysis of Bioplastics Processing. *Procedia CIRP*, *61*, 600–605. https://doi.org/10.1016/j.procir.2016.11.181

Susanti, A. (2021). Pembuatan dan Karakterisasi Biodegradable plastic Berbasis Campuran Pati dan Selulosa Dari Limbah Jagung. *Eksergi*, *18*(2), 49. https://doi.org/10.31315/e.v18i2.5341

Sutanti, S., Pratiwi, M. A., Pratiwi, M. A., Hermawati, L., Rahayu, L. H., & Ramadhan, H. G. (2022). Karakterisasi Bioplastik Berbahan Kombinasi Pati Jagung dan Tepung Jagung dengan Perekat Poli Vinil Alkohol (PVA) dan PemLastis Gliserol. *Jurnal Ilmiah Teknik Kimia*, *6*(2), 89–96. https://doi.org/10.32493/jitk.v6i2.20912

Triawan, F., Nandiyanto, A. B. D., Suryani, I. O., Fiandini, M., & Budiman, B. A. (2020). The influence of turmeric microparticles amount on the mechanical and biodegradation properties of cornstarch-based bioplastic material: From bioplastic literature review to experiments. *Materials Physics and Mechanics*, *46*(1), 99–114. https://doi.org/10.18149/MPM.4612020_10

Yahia, R., Owda, M. E., Abou-Zeid, R. E., Abdelhai, F., El-Gamil, H. Y., Abdo, A. M., & Ali, A. A. (2023). Biodegradable, UV absorber and thermal stable bioplastic films from waxy corn starch/polyvinyl alcohol blends. *Biomass Conversion and Biorefinery*, *0123456789*. https://doi.org/10.1007/s13399-022-03683-8

Yang, J., Dong, X., Wang, J., Ching, Y. C., Liu, J., Chunhui Li, Baikeli, Y., Li, Z., Mohammed Al-Hada, N., & Xu, S. (2022). Synthesis and properties of bioplastics from corn starch and citric acid-epoxidized soybean oil oligomers. *Journal of Materials Research and Technology*, *20*, 373–380. https://doi.org/10.1016/j.jmrt.2022.07.119

Yin, P., Dong, X., Zhou, W., Zha, D., Xu, J., Guo, B., & Li, P. (2020). A novel method to produce sustainable biocomposites based on thermoplastic corn-starch reinforced by polyvinyl alcohol fibers. *RSC Advances*, *10*(40), 23632–23643. https://doi.org/10.1039/d0ra04523c

Zhang, M., Yang, B., Yuan, Z., Sheng, Q., Jin, C., Qi, J., Yu, M., Liu, Y., & Xiong, G. (2023). Preparation and performance testing of corn starch/pullulan/gallic acid multicomponent composite films for active food packaging. *Food Chemistry: X*, *19*(July), 100782. https://doi.org/10.1016/j.fochx.2023.100782

10.21107/jps.v12i1.28981 Anjani et al. E-ISSN: 2527-7634