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BIODEGRADABLE PLASTIC FROM CASSAVA STARCH: A LITERATURE ANALYSIS

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ABSTRACT

Plastic is a synthetic polymer derived from petroleum and contains hazardous additives, such as heavy metals and chlorine. The use of cassava starch as the main ingredient in bioplastics, a natural polymer, can be an environmentally friendly and biodegradable solution. However, cassava starch has limitations, such as its hydrophilic nature, poor mechanical strength, and poor stability. To address these issues, plasticizers such as glycerol and sorbitol are used to improve tensile strength, flexibility, and moisture resistance. Meanwhile, the addition of fillers can increase tensile strength, thermal resistance, and reduce hydrophilic properties, thereby improving the stability of bioplastics. Therefore, this review of biodegradable plastic research focuses on the use of cassava starch with the addition of various fillers that can be degraded by various processing techniques. To analyze the quality of these plastics, various testing methods are carried out, including physical, mechanical, thermal, and biodegradability tests, as well as structural and morphological analysis. The results of this research provide innovations that can be developed by making biodegradable plastic from cassava starch by combining a mixture of cassava starch with the addition of PLLA and CMC fillers and acetic acid as well as the addition of a combination of glycerol and sorbitol plasticizers.

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Introduction

Plastic is a major contributor to solid waste in urban areas, particularly single-use plastics used for various packaging. Plastic waste has become a global challenge because it takes hundreds of years to decompose naturally, contributing to environmental pollution. Most conventional plastics are made from petroleum-based synthetic polymers containing additives such as heavy metals (e.g., cadmium and nickel) or chlorine, which are known to be harmful to human health and the environment. As a more environmentally friendly alternative, the use of cassava starch as a raw material for bioplastics offers great potential. Cassava starch, a natural polymer derived from plants, has advantages such as abundance, biodegradability, and environmental compatibility. However, cassava starch has disadvantages, including high hydrophilicity, low mechanical strength, and less stability compared to synthetic polymers [8].

To overcome these limitations, plasticizers such as glycerol and sorbitol need to be used to increase elasticity by reducing interactions between polymer chains, while sorbitol, which is more stable in the environment, contributes to flexibility and tensile strength. The combination of the two provides a synergistic effect in producing biodegradable plastics with better physical and mechanical properties [1].

However, plastic made from cassava peel starch has several weaknesses, namely, poor water resistance due to the hydrophilic nature of starch which can reduce stability, and also has poor mechanical properties. Therefore, a solution is needed to overcome the weaknesses of biodegradable plastic made from cassava starch by mixing starch with chitosan because the more chitosan used, the higher the tensile strength value of biodegradable plastic. Chitosan is also a biopolymer with high biocompatibility properties that can be biodegraded, as well as bioadhesive, and bioactive, making it possible to be used in various applications. In addition, chitosan is hydrophobic which has a function to reduce the hydrophilic nature of biodegradable plastic. Chitosan was chosen as an alternative in converting plastic into environmentally friendly plastic because it has good biodegradation properties.[18][29].

The development of biodegradable plastic from cassava starch using glycerol and sorbitol plasticizers not only offers an environmentally friendly solution to the plastic waste problem but also supports efforts to increase the added value of local commodities. Furthermore, this material has significant potential for application in various sectors, such as food packaging, medical devices, and other environmentally friendly products.

To analyze the biodegradable cassava starch-based plastic, various methods were used to evaluate its physical, mechanical, thermal, and biodegradability properties such as Thickness Test, Color and Transparency Test. Mechanical Properties Testing (Tensile Strength Test, Tear Resistance Test, Hardness Test). Structure and Morphology Characterization (Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM)). Biodegradability Testing (Degradation Test in Soil, Degradation Test in Liquid Media, CO_2 Evolution Test). Hydrophobic Properties Analysis (Water Absorption Test). This study aims to develop an optimal combination of cassava starch, plasticizer, and other additives, to produce biodegradable plastic that is not only environmentally friendly but also meets the specific needs of the application.

Research Methods

This literature review procedure is used to formulate the stages of activities to be carried out and outline the steps for collecting journal references to be used. The purpose of this literature review procedure is to serve as a reference in selecting journals and articles so that the subsequent process can proceed in a planned and systematic manner. Determining the stages in a literature review begins with the source of ideas obtained from collecting several journals, followed by the problem formulation stage, compiling a literature review, and collecting data. The final stage is analyzing and comparing data based on previous research, which can ultimately be processed into the results of the study to be conducted later.

Results and Discussion

In this literature review, several studies have been conducted, summarizing the use of various additives and plasticizers as raw materials for making biodegradable plastic from cassava starch. The results of this literature review are supported by the existence of national qualifications. The best results for each parameter used are determined by comparing various research results with the required specifications. The best results for each material studied are then compared with qualifications that meet SNI 7188.7:2016. The best test results for each additive can be assessed for their suitability by comparing them with national standards. From the test results obtained, the composition of good biodegradable plastic can be determined.

Table 1SNI Tests for Biodegradable Plastics

Parameter	Unit	Conditional Value	Standard
Tensile Strength	M Pa	10 – 50	SNI 7188.7:2016, ASTM D638

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Elongation	%	5 - 200	SNI 7188.7:2016, ASTM D638	
Young's Modulus	M Pa	1000 - 4000	SNI -7188.7:2016, ASTM D638	
Degradation Level	D ay	90 - 180	SNI 7188-7:2016	

Table 2. Literature Study Results of Biodegradable Plastics Made from Cassava Starch with Various Additives

		Parameter					Reference
Material	**Method**	**Tensile Strength (MPa)**	**Extension (%)**	**Young's Modulus (MPa)**	**Biodegradability (Days)**	**FTIR cm⁻¹)**	
CC Cassava Starch orbitol	Conventional mixing			4	1		1]
assava Starch oly Vinyl Alcohol lyceri n	Microencapsulation Vinyl Alcohol	4.87			-	H : 3430 H : 2920 =C : 1650 C : 1040	3]
assava starch, Ocimum tenuiflorum extract, Glycerol	Conventional mixing	,808	2.72	,715	0 1		4]
assava Starch Acetic Acid Glycerol	Chemical modification	057.4	4.09	629		9	5]
assava Starch Polyvinyl Alcohol (PVA) Glycerol inc (II) Oxide	Conventional mixing	7.38	.2	2		1	6]
assava starch Glycerol Oregano oil Citric acid	Composite	9	.2	143	-	H : 3600 H : 3100	7]
assava Starch Glycerol TiO_2 NP	Conventional mixing	8.3	1	7.3	-	300	8]

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assava Starch Glycerol	Thermoplastic extrusion	5		1	2		11]
olylactic Acid							
assava Starch Acetic Acid Tofu Dregs Sorbitol	Chemical modification	2.3	5	4	1		12]
assava Starch Glycerol Metakaolin	Conventional mixing	.1	21.5	3	2		13]
assava Starch Calcium Silicate Sorbitol	Chemical modification	.767	.2		5		14]
DPE (Low							
igh Density Polyethylene),	Microencapsulation	.25	2.67	8.93	6	420	15]
assava starch Sorbitol							
assava starch							
oly Lactic Acid Glycerol	Chemical modification	8	2		-.		16]
cetic Acid							
assava Starch Glycerol Lignocellulose	Chemical modification	5.7	3.59	0	2		17]
assava Starch Chitosan Sorbitol Acetic Acid	Chemical modification	2.6672	5	0	1		18]
hitosan Cassava Starch	Chemical modification	.398	6.67	2	1	C alkane 2850 - 2970 roma tic ring CH	19]
cetic Acid Glycerol							

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						(690-900) H alkene (675-995) H : (3200-3600)					
assava Starch Glycerol obusta Coffee LA Cassava Starch lycerol assava starch Carboxymethyl cellulose Sorbitol Soy lecithin Tocopherol	Conventional mixing	.09	6.51	6.44	5	1 6 4	H : 3400–2400 H : 3243 CH2 : 941	21] 22] 24]	assava Starch Glycerol Carboxymethyl cellulose acillus strains hitosan Cassava Starch cetic Acid Glycerol MC assava Starch Glycerol iO₂	Chemical modification Sol-gel Modification chemical and mixing Conventional mixing	3.03 5.07 .28 .48	.07 9.55 1.47 2	 5 2	- 9 1 4	25] 26] 27] 28]
											H : 3583.74 COOH : 1438.39 –H : 2922.16 =O : 1639.45 H = 3305 H = 2929

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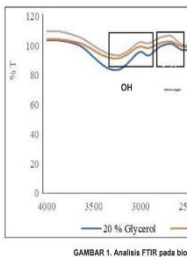
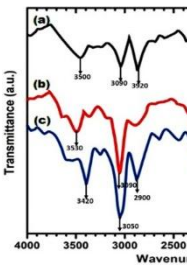
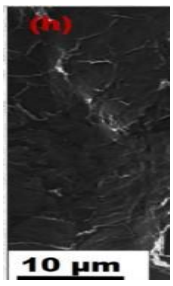
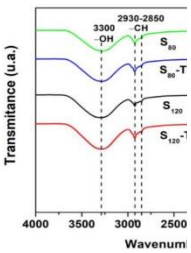
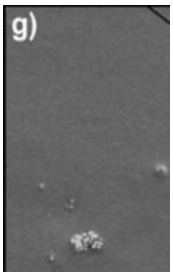
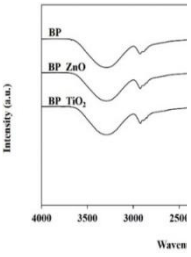
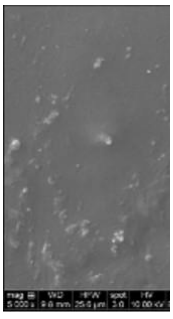
assava Starch Glycerol	Conventional mixing	.63	6		2		H = 3307 4 28]	
nO assava Starch Glycerol	-gel	Sol	.00646	23.29	.01033	0	1	29]
heese Whey assava starch Glycerol aCO3	Conventional mixing	.82	0:34	9.79	8	2	H : 3302 .08 =C : 1641 .08 H : 2942	30]
DPE assava Starch Glycerol alc Powder Urea	Extrusion	.95					-	32]
VA Cassava Starch lycerol	Extrusion	.6	21	.9			-	33]

DISCUSSION

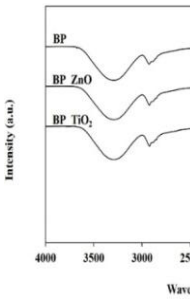
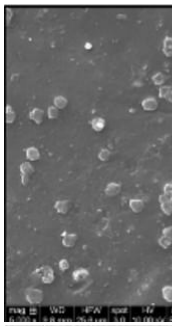
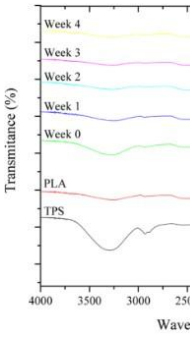
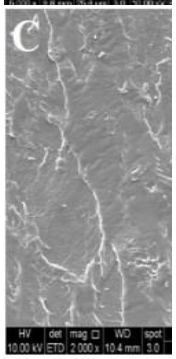
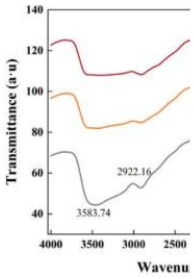
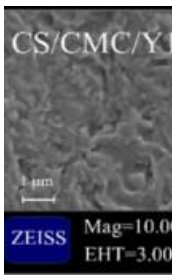
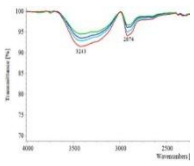
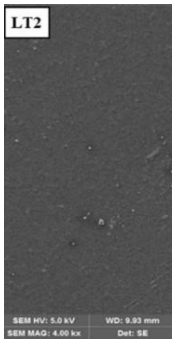
FTIR Results Analysis

FTIR analysis is used to identify the chemical composition and functional groups present in biodegradable plastics, one example being biodegradable plastic produced from cassava starch. Fourier transform infrared (FTIR) analysis of biodegradable plastics involves the use of infrared spectroscopy to identify and characterize the chemical composition of the materials. This technique complements mass spectrometry by providing structural information about the polymer and its additives.

Table 3.FTIR and SEM Test Analysis Results

Material	**FTIR**	**SEM**
Cassava starch Glycerol CaCO3		
LDPE (Low Density Polyethylene) Cassava starch Sorbitol		
Cassava Starch Glycerol TiO_2NP		
Cassava Starch Glycerol TiO_2		

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Cassava Starch Glycerol ZnO		
Cassava Starch PLA Glycerol		
Cassava starch Carboxymethyl cellulose Sorbitol Soy lecithin Tocopherol		
Cassava starch Glycerol Carboxymethyl cellulose Bacillus strains		

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Researchers [30] used Cassava Peel as a source of starch and glycerol concentrations of 20%, 30%, and 40% and Filler (CaCO3). The FTIR Spectrum results show the main functional groups in bioplastics, including Hydroxyl (OH) to increase water solubility. Carbonyl (CO) Provides structural strength and Ester contributes to the mechanical properties of the material. The result is that increasing the glycerol concentration reduces the wavelength intensity of these functional groups, reflecting the weakening of the bonds between starch and plasticizer molecules. FTIR analysis provides important insights into the chemical interactions in bioplastic materials. The addition of TiO_2NPs results in a broadening of the -OH bond spectrum at 3300 cm^{-1}, indicating a change in molecular interactions in the material matrix. Films at 120 rpm in SEM analysis show more homogeneous starch granules. The distribution of TiO_2 is more uniform in films with an extrusion speed of 120 rpm, indicating better processing [8].

Researchers [15] added LDPE to a PCS (Plasticized Cassava Starch) mixture. Increasing the PCS content with increasing incubation time in soil burial caused random biodegradation on the surface, resulting in the formation of voids and cracks, and creating a rough surface. These cracks continued to grow as the PCS content increased. These observations indicate that the LDPE film can be readily degraded by PCS under microbial conditions. The degraded areas, characterized by scattered cracks and openings, reflect damage to the surface texture of the LDPE film. The LDPE/PCS mixture showed a tendency to form clusters, as evidenced by the presence of widening voids, leading to almost continuous propagation of cracks, and ultimately to the collapse of the surface structure. The rate of crack formation increased and became more pronounced with increasing PCS content. In addition, the LDPE/PCS mixture gradually showed a decrease in strength and became more brittle with increasing PCS content and burial time.

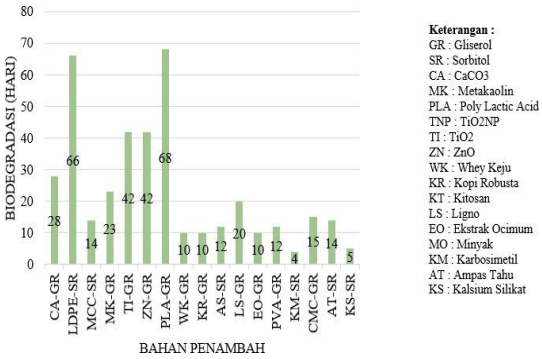
SEM analysis results of films with the addition of TiO_2 and ZnO. On the surface of bioplastics with the addition of ZnO, small spherical particles are evenly distributed with some agglomerates. These clusters may have agglomerated during the formation of bioplastics because no aggregation was found in the control and bioplastics with TiO_2. In addition, Zn–O–Zn bonds are formed between particles due to the presence of water molecules, which results in hard agglomerations. The surface of bioplastics with TiO_2 is smoother than the control film. The cause of this is the good dispersion of additives [28]. The results of FTIR analysis for composite films with ZnO and TiO_2 fillers, stretching of OH groups was observed at 3307 and 3305 cm^{-1}, respectively. The shift towards wavenumbers below 3325 cm^{-1} is caused by an increase in the number of hydrogen bonds with TiO_2/ZnO for hydroxyl groups in cassava starch. The shift of the CH stretching absorption band from 2931cm^{-1} in the control film to 2929 cm^{-1} with TiO_2 and to 2926 cm^{-1} with ZnO is caused by the electrostatic interaction between TiO_2/ZnO and starch [28].

In the PLA and TPS mixture, the peak in the range of 3400–2400 cm^{-1} indicates the presence of molecular interactions between the hydroxyl groups of PLA and TPS. These results support the changes in the physicochemical properties of the material due to the mixture, which then affects its mechanical performance and degradation. The surface changes of the TPS/PLA mixture during soil degradation showed that the surface of the film after degradation in soil conditions during the evaluation time, the surface became rough; depressions and scratches appeared on the surface of this mixture. After 30 days, there were cracks on the surface of each sample, cracks that would cause a loss of mechanical strength [22].

Biodegradation Test

Degradation testing on bioplastics is one way to find out how long it takes for the bioplastic to decompose into simple compounds such as water, carbon dioxide, methane, or biomass by microorganisms or under certain environmental conditions.

Figure 1. Biodegradation Test Graph with Various Additives



In biodegradable plastics, there are several factors that cause biodegradation, one example is the addition of other materials. Figure 1 shows that the use of carboxymethylcellulose (CMC) has the fastest biodegradation value, namely 4 days among other additives. Research [26] used carboxymethylcellulose in the manufacture of biodegradable plastics. Carboxymethylcellulose

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(CMC) in biodegradable plastics has a short degradation time due to its biocompatible and biodegradable properties. The presence of carboxymethyl groups increases the susceptibility of the polymer to microbial attack and degradation by enzymes, thus facilitating breakdown in the natural environment. In addition, the solubility of CMC in water allows better moisture penetration, which accelerates the degradation process. These characteristics make CMC-based composites an attractive option compared to conventional plastics, supporting sustainable development through a rapid decomposition process [34].

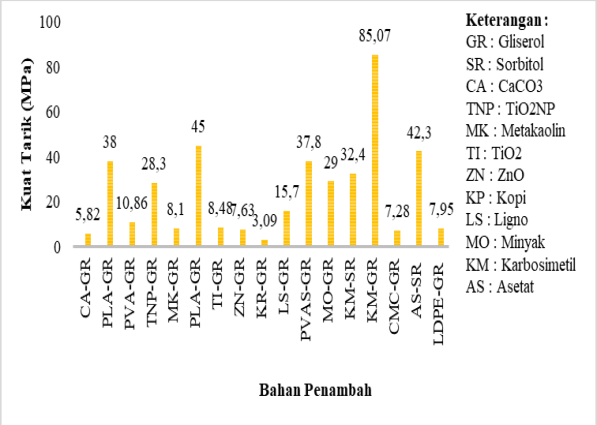
In the study [22] the use of PLA showed the longest biodegradation value of 68 days. The reason is that biodegradation generally occurs faster in the amorphous polymer area compared to the crystalline part. In addition, the degradation rate of high molecular weight polymers (PLA) is estimated to be lower compared to shorter macromolecules (TPS), which are more easily digested by microorganisms. Therefore, the PLA part in the TPS/PLA blend film with a ratio of 72:28 is more easily biodegraded compared to pure PLA (Sedničková et al., 2018). Biodegradation tests of various additives in the manufacture of other bioplastics show varying test results, one of which is the addition of Calcium Silicate. Research [14] using cassava peel, calcium silicate, and sorbitol as plasticizers with variations in plasticizer concentration (sorbitol) of 30%, 40%, 50% and variations in filler concentration (calcium silicate) of 1%, 3%, 5%, 7% obtained biodegradation test results of 81.7% for 5 days with variations in sorbitol concentration of 50% and variations in calcium silicate concentration of 7%. While the lowest biodegradation test results were 10% for 5 days with variations in sorbitol concentration of 30% and variations in calcium silicate concentration of 1%. This shows that calcium silicate can strengthen the interaction between materials and microorganisms, thereby accelerating the breakdown process compared to other fillers [37].

Tensile Strength

The tensile strength (TS) of a film is defined as the maximum tensile stress that a sample can withstand under a tensile force up to the breaking point. TS is calculated using the equation (F, tensile force sustained at break; L, film thickness [mm]; and W, film width [mm]).

$$\text{Tensile Strength (MPa)} = \frac{F}{L\,X\,W}$$

Figure 2. Tensile Strength Test Results of Various Additive Materials



One of the mechanical properties, namely tensile strength, can measure the ability of the material to withstand the applied tensile force until the material breaks. In biodegradable plastics, there are several factors that affect tensile strength, one example is the addition of other materials. Figure 1 shows that the use of robusta coffee has the lowest value among other additional materials. Research [21] with dry robusta coffee skin, distilled water, and glycerol with variations in the addition of glycerol of 20%, 30%, and 40% relative to the weight of cassava starch and variations in Robusta coffee skin flour of 0%, 5%, 10%, and 15% relative to the weight of cassava starch. The test results showed that the tensile strength test value was 3.09 MPa at variations of 15% robusta coffee skin and 20% glycerol. These results indicate that the tensile strength of biodegradable plastics is not up to standard because it can be assumed that the cellulose does not decrease in size so that the mixture is not homogeneous which results in a low tensile strength value. In research [30] the use of CaCO3 as a filler with three concentrations of glycerol 20%, 30%, and 40% as a plasticizer. The results of the addition of 20% glycerol plasticizer showed a tensile strength of 5.82 MPa. This occurs because at this concentration, glycerol plays an optimal role as a plasticizer, increasing flexibility without reducing the strength of the material. With increasing glycerol concentration to 30% and 40%, the tensile strength decreased significantly [30]. Glycerol, which is hydrophilic, causes the bonds between starch molecules to weaken, so that the bioplastic becomes more brittle.

Tensile strength tests of various other bioplastic materials show varying test results, one of which is with the addition of titanium oxide nanoparticles (TiO_2NP). Researchers [8] have conducted research on the addition of titanium

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oxide nanoparticles (TiO_2NP) and extrusion speed on the physicochemical properties and biodegradability of biodegradable plastics from cassava starch. The addition of titanium oxide nanoparticles (TiO_2NP) to cassava starch-based bioplastics with an extrusion speed of 80 rpm (S80-TiO_2NP) resulted in a tensile strength value of 28.3 MPa. TiO_2NP is used to improve the mechanical and physical properties of bioplastics, such as tensile strength and elongation, by improving the internal structure of the material. The addition of TiO_2NP plays a role in increasing the gelatinization ability of starch, resulting in a more even distribution of materials and better physicochemical properties. The additive [24] that has the highest tensile strength value is obtained from the use of carboxymethyl.Carboxymethylcellulose is used as a filler in the manufacture of biodegradable plastics, increasing the attractive forces between its constituent molecules. Carboxymethylcellulose contains hydroxyl groups that bind intra-cellulose molecules and hydrogen bonds between them, which strengthen biodegradable plastics. Carboxymethylcellulose is a polysaccharide often used in the manufacture of biodegradable plastics because it is inexpensive, non-toxic, and produces good biodegradable plastic properties.[34].

Young's Modulus

Young's modulus is the mechanical ability of a material to tolerate compression or elongation with respect to its initial length. Young's modulus value is calculated using the following equation, σ is the applied pressure, ε is the strain associated with the applied stress, F is the force exerted by the object, A is the cross-sectional area, ΔL is the change in length, L0 is the initial length.

$$Y\ (Mpa) = \sigma / \epsilon$$

$$Y(Mpa) = \frac{F\ L0}{A\Delta L}$$

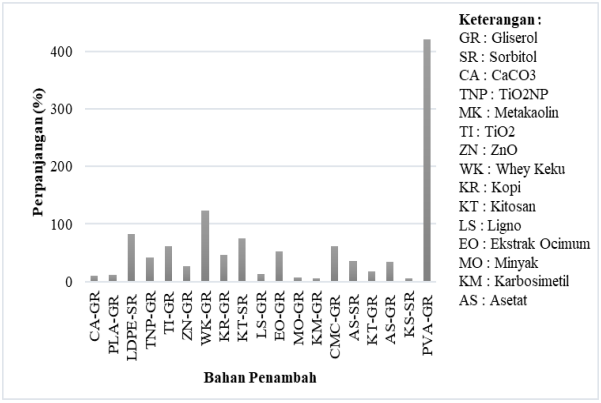


Figure 3. Graph of Young's Modulus Test Results of Various Additive Materials

The graph above shows that the mechanical properties of bioplastics, especially Young's Modulus (material stiffness), are greatly influenced by the type and concentration of additives such as glycerol, fillers ($CaCO_3$, metakaolin, TiO_2 nanoparticles), and TPS mixtures in PLA. Glycerol acts as a plasticizer, where increasing glycerol concentration increases flexibility but reduces material stiffness. Fillers such as metakaolin significantly increase the stiffness of bioplastics, as seen from the increase in Young's modulus from 26.4 MPa to 121.5 MPa with the addition of 15% metakaolin. This demonstrates the role of fillers in strengthening the bioplastic matrix by increasing density and intermolecular bonds [13]. The addition of TiO_2 nanoparticles increases the elastic modulus of bioplastics by up to 20%, indicating that nanoparticles can improve the mechanical properties of the material. Conversely, mixing TPS in PLA reduces Young's modulus from 100 MPa (pure PLLA) to 45 MPa (L75/S25), indicating that the addition of TPS reduces stiffness due to changes in the material matrix structure. Overall, the use of additional materials (fillers and plasticizers) and variations in composition can significantly affect the mechanical properties of bioplastics, so the selection of

The right ingredients and concentration are crucial to achieve the desired material properties according to application requirements [22]. Researchers [33] found that the addition of PVA resulted in low Young's modulus values in biodegradable cassava starch bioplastics, which can be explained by its lower flexibility and stiffness compared to other fillers. When PVA is added to bioplastics, it contributes to the creation of a more ductile and less rigid material, which impacts the overall mechanical properties. This flexibility allows the material to deform better under stress, resulting in a lower Young's modulus, which reflects the material's ability to stretch and absorb energy without breaking [32]. The highest Young's modulus value is found in oregano oil because it contains phenolic compounds such as carvacrol and thymol, which can interact with the starch polymer matrix through hydrogen bonding or hydrophobic interactions. These interactions increase the intermolecular cohesion in the plastic, which contributes to an increase in Young's modulus [33].

Elongation

Maximum elongation at break (EBA) refers to the maximum deformation a film can withstand before breaking. EBA is calculated using the following equation where (L, the elongated length

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of the film at the point of break [mm] and L0, the initial length of the film [mm]).

$$\text{EBA (\%)} = \frac{L-L0}{L0}$$

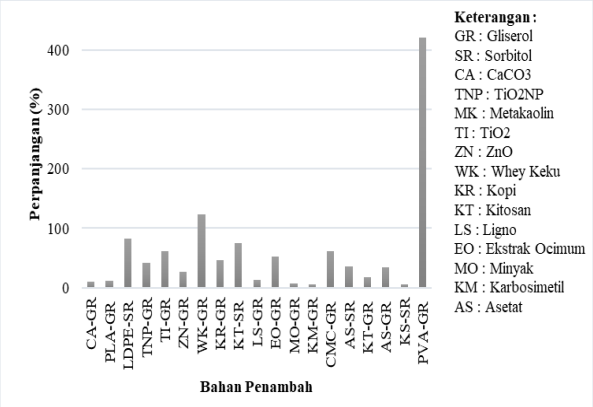


Figure 4. Elongation Test Results of Various Additive Materials

In a study of cassava starch-based bioplastics, S80 films had a higher elastic modulus but lower elongation than S120 films. The addition of TiO_2NPs to S120 increased the material's elongation compared to the control. TiO_2NPs contribute to increasing the elasticity of bioplastics, especially when combined with certain extrusion speeds. TiO_2NPs help improve material flexibility through better distribution and intermolecular interactions within the bioplastic matrix [8]. In another study, the addition of 15% metakaolin (BPMKB15) reduced the maximum elongation from 45.5% (without metakaolin) to 23.1% [13]. A similar decrease was also seen in bioplastics with TiO_2 fillers, which had an elongation of 26%, much lower than the control at 73%. This decrease indicates that TiO_2 strengthens the bioplastic matrix but reduces its ability to stretch.Research [29] with cheese whey, food-based glycerol (Netafarm, 98%), technical CMC, chitosan, and distilled water as the basic ingredients with various volumes of cheese whey, namely 20 ml, 25 ml, and 30 ml. In addition, various volumes of glycerol were also used, namely 5 ml, 10 ml, and 15 ml. The results of the test showed that the best elongation value was obtained from a variation of cheese whey of 30 ml with 15 ml of glycerol of 140.65%. This can occur due to the relationship between the low acidity of the solution which causes protein denaturation. This process allows the re-formation of sulfhydryl and hydrophobic bonds during the drying stage, thereby improving the mechanical characteristics of the edible film. In addition, the presence of amylose in cassava peel starch plays a role in forming hydrogen bonds, which contributes to the formation of a strong gel structure, supporting greater elongation [39]. According to [33] pure PVA (fully hydrolyzed and with medium chain size) has a melting temperature of 207 °C, then it is plasticized with glycerol so that the melting point is reduced to 177 °C. So that with a higher temperature the PVA can be completely melted, and the shear force in the extrusion process encourages better interaction with the polymer chain. Thus, the tensile strength and elongation at break of the material increase with increasing extrusion temperature profile.

The Idea of Combining Biodegradable Plastic Based on Cassava Starch

Based on the results of the review above, the idea that can be developed is to make biodegradable plastic from cassava starch by combining a mixture of cassava starch with the addition of PLLA filler, CMC, acetic acid and the addition of a combination of glycerol and sorbitol plasticizers. The goal is to maximize the mechanical properties, flexibility, and moisture resistance of cassava starch-based bioplastics with variations in sorbitol and glycerol, as well as the addition of PLLA filler and acetic acid modification agent [16] [22]. Plasticizers affect flexibility, but can weaken tensile strength. PLLA fillers increase tensile strength, but can reduce flexibility. Acetic acid modifies the properties of starch, thus helping to better integrate plasticizers and fillers. The use of sorbitol:glycerol ratios (1:1, 2:1, and 1:2), using PLLA filler in a ratio of 5%, 10%, and 15% of the total weight and the addition of CMC of 0.2-0.3 g [26][29], using acetic acid in concentrations of 2%, 4%, and 6% (wt/wt) to modify starch through the esterification process. Optimization of the combination of sorbitol, glycerol, PLLA and CMC fillers, and acetic acid modification agents can produce cassava starch-based bioplastics with superior mechanical, thermal, and biodegradation properties. This research also provides a strong foundation for the development of bioplastics on an industrial scale.

Conclusion

This research focuses on the production of biodegradable plastic using cassava starch with the addition of plasticizers (glycerol, sorbitol) and fillers. The results of the literature review indicate that this combination can improve the mechanical properties, flexibility, water resistance, and biodegradability of cassava starch-based plastics. Cassava starch is an environmentally friendly and easily degradable main ingredient, but has weaknesses such as hydrophilic properties and low mechanical stability. Plasticizers such as glycerol

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and sorbitol increase the flexibility and tensile strength of plastics. The addition of fillers can improve tensile strength, thermal resistance, and reduce hydrophilic properties. Testing methods include physical, mechanical (tensile strength, elongation), thermal, and biodegradability properties to evaluate the quality of plastics. The results show that the combination of cassava starch, plasticizers, and additives can produce biodegradable plastics with optimal characteristics according to application needs, such as environmentally friendly packaging. This research emphasizes the potential of cassava starch as an alternative in the development of biodegradable plastic materials that support environmental sustainability.

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