JOURNAL OF INDIGENOUS KNOWLEDGE AND DEVELOPMENT STUDIES
JIKDS 04(01)2022
ISSN (online) 2708-2830 ISSN (print) 2707 – 7640
www.bhu.edu.et/jikds

Corn cap Starch based Bio-plastic Production Technology

Gizachew Balcha Assefa [1*], Tilahun Teshome[1], Abu Fayisa [2]

[1]Department of Chemical Engineering College of Engineering and Technology, Bule Hora University, Ethiopia

[2]Department of Biology College of Natural and Computational Science, Bule Hora University, Ethiopia

*Corresponding author: hgizachew20202@gmail.com

Abstract

Bioplastic is plastically gotten from sensible biomass sources, like vegetable fats and oils, starch, or microbiota. Common plastics, as non-harmless to the ecosystem power source plastics, gotten from petroleum are dependent more upon oil auxiliaries (Sharma et al. 2018). The sign of this speculation is to supply the oil-based plastic with bioplastic produced using corn Cob starch. Plastics are difficult to decompose, resulting in environmental pollution, it is necessary to find alternative plastic that is made from bio-degradable materials These starchy-based polymers are safe for the environment. From starchy materials, bioplastics have mostly been created. The plasticizers utilized in this investigation to create bioplastic were corn cap starch, white vinegar, and glycerol. The aim of the research was to characterize bioplastic (compare the biodegradability of bioplastic to plastic derived from petroleum, investigate the mechanical properties of the plastic (tensile strength), and examine the water absorption qualities of bioplastic) and evaluate the impact of temperatures on plastic synthesis (at 70, 90, 95, and 100). We are anticipated to be surpassed by a palatable, non-toxic, and biodegradable plastic made from maize cap starch. Accordingly, the work was investigated via temperature, Glycerin, and vinegar, the bioplastic is portrayed by adaptability, water support, and biodegradability test. This was driven by the finding that the sound pressure increases with developing temperature and the water absorption of the plastic is reduced with temperature. The concentrate in addition tries to relate temperature and strength (stress) of the bioplastic; the strength increments from 5-15(N/m2) while the temperature increments from 70-100oc. Bio-plastics above 118.4oc cannot be made economically due to steady strain. Polylactic disastrous has several obliging properties like biodegradability, biocompatibility, waste cutoff, and low harmfulness to people than other reasonable polymers.

Keywords: biodegradability, corn starch, glycerin, vinegar, water absorption, tensile strength

1. Introduction

Plastic made from biomass sources, like starch, vegetable fats, or microbes, is known as bioplastic. (Joshi, S., Sharma, U., Goswami 2014). Typical plastics, as non-reasonable power source plastics, gotten from oil depend more on oil collaborators and produce more ozone devastating substances (UNEP 2018). Some, yet not all, bioplastics are relied on to biodegrade. Biodegradable bioplastics can segregate in either anaerobic or blasting conditions, reliant upon how they are passed on. There is a blend of materials that bioplastic can be made using, starches, cellulose, or other biopolymers (Ã–zdamar and AteÅŸ 2018). A couple of normal associations of bioplastics are bundling materials, eating utensils, food bundling, and security. Polylactic Acid (PLA), is the second most immense bioplastic of the world concerning use in volume (Ruixiang . et al., 2019) (Alonso-González et al. 2021).

Numerous plastic manufacturing facilities produce tons of products that are widely used by people due to their simplicity, affordability, and convenience. Because they are not biodegradable, they have a dangerously harmful effect on the environment (Sharma et al. 2018). The disposal of plastic garbage, a major contributor to environmental pollution, has a number of negative effects on human health, including a risk of cancer, the ability to reproduce, immune system problems, and hormone disruption (Thompson et al. 2009). Due to their simplicity, accessibility, and ease, a large number of plastic manufacturing facilities create a ton of products that are widely utilized by people. They have a gravely detrimental impact on the environment since they cannot decompose (Sharma et al. 2018). The improper disposal of plastic waste, a significant source of environmental pollution, has a variety of detrimental consequences on human health, including an increased risk of cancer, difficulties reproducing, immune system issues, and hormonal disturbance (Thompson et al. 2009).

Numerous researches have been done to identify eco-friendly plastics that can be used as an alternative to reduce the usage of plastics that harm the environment. When bioplastics are discarded in the environment, their fast decomposition is made possible by the enzymatic activity of microorganisms (Tokiwa et al. 2009). The PLA is poised to play a big role as a suitable, biodegradable replacement as an increasing number of nations and states follow the lead of China, Ireland, South Africa, Uganda, and San Francisco continuing to utilize plastic staple packs in so-called "white demolishing" across the globe (Alonso-González et al. 2021).

In Ethiopia, different undertakings consume plastic things for various purposes. A huge piece of them included it for bundling and dealing with the finished results (Hiba 1998). The basic use of those plastics by those endeavors was full filled with getting plastics from far-off nations. Along these lines, those tries consumed a tremendous heap of money (McAllister 2015).

Notwithstanding this, the plastics are, Petroleum-based plastic and consume a huge piece of the day to very surprising and to wreck due to the sub-atomic protections that make the plastic so solid. Moreover, likewise, oil-based plastics are nonrenewable thusly, they can't remain mindful of realness (Ruas-Madiedo and De Los Reyes-Gavilán 2005).

Regardless of this since plastics by their inclination contain horrendous arranged substances and expecting that they are burned those toxics made blends like dioxin are given to the climate and maybe debase the climate (Belliveau and Lester 2004). Accordingly, it is head to substitute this oil-based plastic with other harmless to the normal design boundless and nontoxic unrefined substance. Therefore, bioplastic is the brilliant decision for this case ff late, standard unlimited assets (starch) have enough been utilized to make plastic that is biodegradable under unequivocal temperature and affirmation conditions (Joshi, S., Sharma, U., Goswami 2014). Starch-based plastics are fundamentally procured from wheat, potatoes, rice, and corn. Among these four starch sources, the corn cap is the most regularly utilized and is the most sensible wellspring of starch. Amazingly in our nation corn cap is suitably open considering the way that corn can be filled in most pieces of our country within a short period of progress. (Joshi, S., Sharma, U., Goswami 2014).

2. Materials and Methods

The experimental work has been done in the college of Engineering and Technology laboratory of the Department of Chemical Engineering, Wolkite University, Wolkite-Ethiopia. Sixteen (16) kgs of corn cap were collected from Wolkite city. and separated from contaminations, such as stones, cobs, dust particles, foreign grain material, and fine material.

2.1 Corn cap starch production

Using a manual process, the starch was created or removed from the corn cap (Zhang et al. 2021). Using a sieve, the corn cap was coarsely sieved to remove contaminants such as stones, dust, foreign grain material, and fine material. Then boiling water was added to 16 kg of corn cap (90°c). It entails preserving the ideal equilibrium between water flow and temperature. Last but not least, the corn cap was finely powdered to break up the endosperm cells and liberate the starch granules. This had carbs, protein, and fiber in it (Pavel and Supinit 2017). The protein in this milled corn cap totally dissolves in water since it was designed to do so. Fiber and starch were separated by filter cloth, but fiber and starch were not. There were two trials in all. The generated starch was dried for two hours at 40°C in an oven. To obtain the starch moisture specification, this was done.

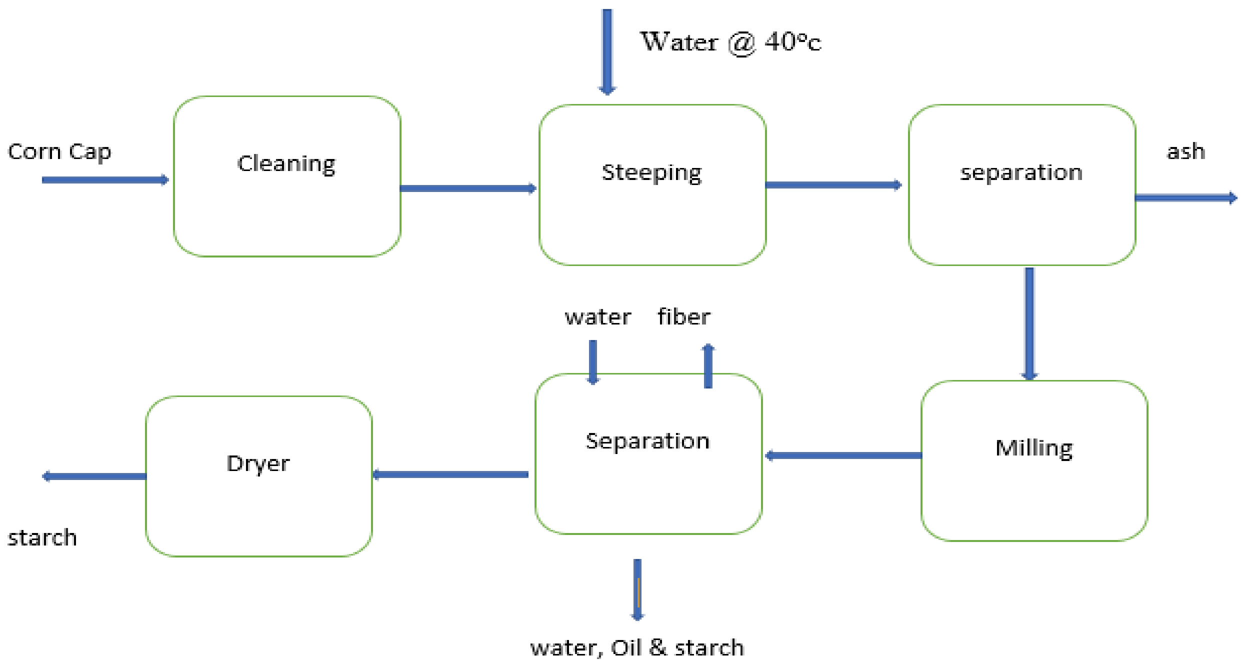

Figure 1 block flow diagram of starch production from corn

Bioplastic film preparation

To a 500 ml beaker, the following substances such as 60 ml water, 9.5g corn starch, 5ml of glycerin, and 5ml of vinegar were added. The prepared raw material was put on a water bath. Then temperature was adjusted to (70,90,95,100) and the sample was stirred in the weigh-in dish to remove air bubbles. Sample made to dry on the lab bench over Three days.

Table 1. Laboratory trials of Bioplastics film preparation

Type of bio plastic	Temperature (° c)	starch to water ratio	Residence Time(minute)
Bio plasic1	70	1:6.3	20
Bio plasic2	90	1:6.3	20
Bio plasic3	95	1:6.3	20
Bio plasic4	100	1:6.3	20
No vinegar	100	1:6.3	20
No glycerin	100	1:6.3	20

3.3 Characterization of bioplastic

A. Tensile strength test

A computerized tenso meter measure the tensile strength of plastics (Harris et al. n.d.). In this method, the area of sample calculated and known mass was applied until the hanged bioplastic was broken down.

- The force using the equation F=mg was calculated If the number of masses added to the sample

$$F= (m1+m2.......mn)\ g$$

A. water absorption test

Test Procedure**:** For the water absorption test, the specimens were dried in an oven for 30 minutes at 100°c and then placed in a desiccator to cool. Immediately upon cooling the specimens it was weighed. The material is then immersed in water at 25°C for an hour or until equilibrium. Specimens were removed, patted dry with a lint-free cloth, and weighed. Water absorption is expressed as an increase in weight percent. Percent Water Absorption = [(Wet weight - Dry weight)/ Dry weight] x 100.

B. Biodegradability test

Half kilo fertile soil and half a kilo of animal dang were prepared with 500ml of distilled water and then the specimen dried in an oven after weighing, then buried in the prepared soil-dung the bioplastic and petrol based plastic together for a week. Then mass loss calculation was done.

Mass lose=Mb-Ma

$$mass\ loss\ rate = \text{mass loss/No of buried day}$$

3. **Result and discussion**

3.1 Starch production

From the first trial, 612g of starch and the second trial 595g of starch were obtained. Totally 1207g of starch was obtained. Therefore: -

$$\%\ of\ starch = \frac{weight\ of\ starch}{weight\ of\ corn} * 100 = \frac{612 + 595}{2000} * 100 = 60.35\%$$

Comparison with the theoretical

The Theoretical production of starch is 67.6% (Palanisamy et al. 2020) so, the result of 60.35% was nearly the same as the expected value.

Moisture content of the starch

The produced starch weighed after and before dying was calculated using the equation; -

$$Mn = \frac{(W1 - Wm) - (W2 - Wm)}{W1 - Wm} * 100$$

Where: W1=wet weight

W2=dry weight

Wm=plate weight

Mn=percentage moisture content of starch

$$Mn = \frac{(715-135)-(507-135)}{715-135}*100=36\%$$

The theoretical moisture content of starch is 20% (Slade et al. 1996); therefore, the starch contains the correct amount of moisture.

3.2 Plastic production

Bio plastic=f (vinegar, water, starch additives, temperature, and residence time) change or replacing one item changes the characteristics of plastic. For example, we have tried to observe the influence of glycerin by making plastic without glycerin also for vinegar as well in the laboratory.

Vinegar: - bioplastic without vinegar has characteristics

- ✓ easily breakable
- ✓ Tiny cracks were present on its surface this information tells what vinegar is.

From the above observation, vinegar is a polymerizing agent; it helps to connect the monomers to form the plastic (polymer) also makes the plastic hard.

Glycerin: -the trial bioplastic without glycerin is too hard and brittle (Filho et al. 2022) from this observation; glycerin helps bioplastic to be flexible plastic.

Therefore, it is possible to say that by changing the concentration of glycerin it is possible to make different materials that have different applications. This means when soft and flexible material is needed the concentration of glycerin should increase and when hard material like the plastic spoon is needed the concentration of glycerin decrease with respective the other compositions.

Tensile strength test

Table 2. Tensile strength data of bio plastic

Temperature (°c)	Residence time(m)	A.mass (g)	Li(cm)	Lf(cm)	Extension (cm)	Strain, ε= EXT/Li	load(N)	Stress δ= F/A(N/ mm^2)
70	20	145	10	10	0	0	2.917	5.45
90	20	145	11	11.25	0.25	0.023	3.69	11.86
95	20	145	12.5	13	0.5	0.04	4.93	10.86
100	20	145	13	14.6	1.5	0.115	6.217	14.86

Effect of temperature on stress of bio plastic

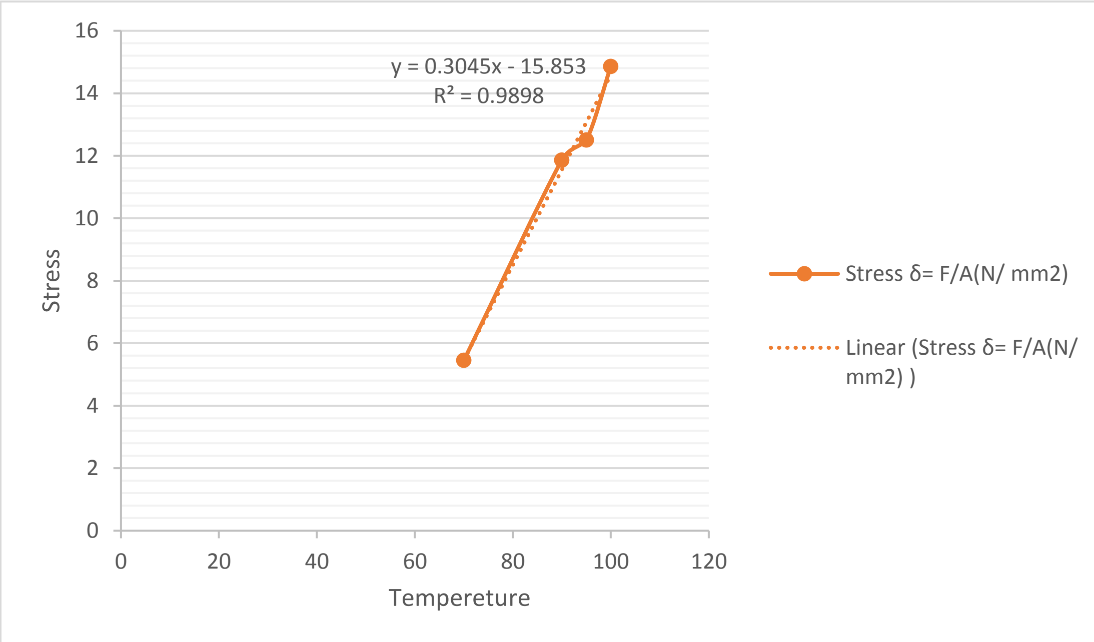

Figure 2. Stress Vs Temperature.

As shown in the figure 2 the temperature vs stress graph initially increases with the equation of $y=0.3045x^2-15.853$ but since the strength of the material cannot be infinitely increase as the temperature increases infinitely, it begins constant at point (100,15). This implies any increase with temperature more than 100^oc shows no increase in tensile stress of bio plastic.

4.2 Water absorption test

Effect of temperature on water absorption of bio plastic

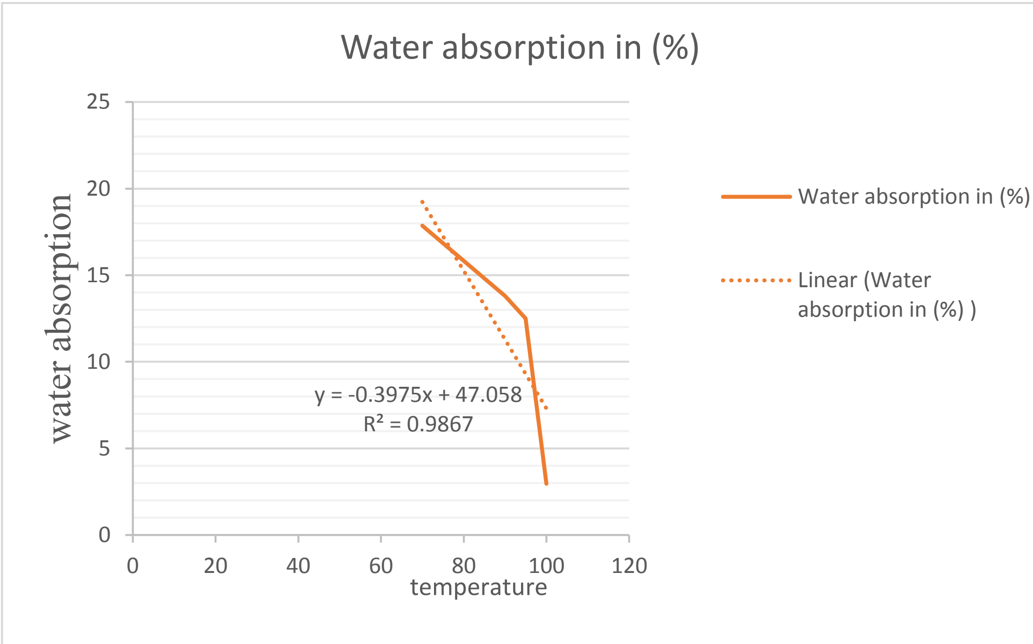

Figure 3. Water absorption Vs temperature

As shown in the figure 3 the water absorption property of bioplastic decreases with increasing temperature with equation y=-0.3975x+47.058

Since, the water absorption property of bioplastic cannot be zero while the temperature increases infinitely, it reaches a constant water absorption state; -

$$-0.3975x+47.058=0$$

$$X=\underline{118.4^{o}c}$$

Production of bioplastic above 118.4ºc cannot make the plastic decrease its water absorption property. a bioplastic, analyzing the effect of temperatures (100, 130 and 150 ◦C) on the mechanical and microstructural properties and water absorption capacity of the final matrices (Alonso-González et al. 2021).

Table 3 water absorption data of bio plastic

Temperature	Residence time(m)	Dry weight(g)	Wet weight(g)	Water absorption in (%)
70°c	20	2.8	3.3	17.86
90°c	20	2.9	3.3	13.8
95°c	20	1.6	1.8	12.5
100°c	20	2.7	2.78	2.96

4.3 Biodegradability test

Table 4 comparison of biodegradability bio plastic and petro plastic

Type of plastic	Initial mass(g)	Final mass(g)	Mass loss(g)	Time to disappearance (day)
bio plastic	25	23.99	1.01	250
Petro based plastic	0.81	0.81	0.0	∞

Mass loss of Bio plastic=25-23.99=1.01gm

Assuming equal mass is lost per day

Mass loss rate$=\frac{1.01gm}{7days} = 0.1442gm/days$

Maximum days needed to completely disappear the 25gm bioplastic is

N<u>o</u> days$=\frac{25gm}{0.1} = 250days$

this is the approximate value because it considers 1.01gm bioplastic loss per week, but in reality, this cannot happen due to the organisms around the bioplastic increasing exponentially from day to day because the bioplastic is used as food.

The relation of food (bioplastic) and several organisms is inversely related, this means as the number of organisms increases exponentially the amount of food (bioplastic) decreases by the same amount.

Therefore, the multiplication of bacteria is given by the equation

$$Y=Yo^{kt}$$

Where: -

y= number of bacteria after time t

Y_o=the initial number of bacteria

t= time

k= constant

As the result shown above the bioplastic loss amass of 1.01g per week. To estimate the time to completely degrade the whole mass of the bioplastic use the equation.

$Y=Yo^{kt}$ where y= is the mass lost

y_o=the initial mass in gm

t=the time needed to degrade an amount of mass

k=degradation constant

$$\ln 23.99=\ln 25^{7}$$

$$\ln 23.99=7k\ln 25$$

$$K=\frac{\ln 23.99}{7\ln 25}=0.141$$

Now we can estimate how much time is needed for bioplastic to reach its minimum amount of mass by using the equation; -

$$y=y_o^{-0.14t}$$

The drawback of this equation is, it is impossible to estimate the time that the amount of bioplastic reaches zero amount.

The petrol-based plastic has no any change in a week. But it is impossible to say that petrol-based plastic is non-degradable (Thompson et al. 2009).

However, the degree of degradability of bioplastic is much higher than petrol plastic.

5. Conclusion

From the results of this research, it can be concluded that the best tensile strength test was at 118.4ºC and 20 minutes with the result 0.8231 MPa. The best elongation test was at 118.4ºC and 25 minutes with the result of 68.75%. The best water absorption test was at 118.4ºC and 20 minutes with the result of 46.34%. The strength increases from 5-15nm2 when the temperature increases from 70-100ºc over this temperature give clear strain this tells us making bioplastic The biodegradable test showed the sample could be 100% decomposed for 250 days.

The current international biodegradation standards are notable in that they use higher temperature standards than the unmanaged environments they mimic (Narancic et al. 2020). These facts should be accounted for in shaping plastic waste policies. The design of a plastic product must also be informed by end-of-life possibilities.

Data Availability:

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Funding Statement:

No funding is received for this research work and publication. The publication is only for the academic purpose of Bule Hora University, Ethiopia.

References

Ã–zdamar, Esen GÃ¶kÃ§e, and Murat AteÅŸ. 2018. "Architectural Vantage Point to Bioplastics in the Circular Economy." *Journal of Architectural Research and Development* 2(5): 1–9.

Alonso-González, María, Manuel Felix, Antonio Guerrero, and Alberto Romero. 2021. "Effects of Mould Temperature on Rice Bran-Based Bioplastics Obtained by Injection Moulding." *Polymers* 13(3): 1–12.

Belliveau, Michael, and Stephen Lester. 2004. "PVC Bad News Comes in 3s : The Poison Plastic, Health Hazards an the Looming Waste Crisis." *Center for Health, Environment and Justice Environmental*: 1–100. www.preventharm.org.

Filho, Walter Leal et al. 2022. "Consumer Attitudes and Concerns with Bioplastics Use : An International Study." : 1–16.

Harris, Richard et al. "Make It and Break It: Bioplastics from Plant Starch with Incorporation of Engineering Practices." http://www.nuffieldfoundation.org/practical-chemistry/making-plastic-.

Hiba, Juan Carlos. 1998. *Improving Working Conditions and Productivity in the Garment Industry*.

Joshi, S., Sharma, U., Goswami, G. 2014. "Bio-Plastic From Waste Newspaper." *Interntional Journal of Engineering Research and Technology* 2: 24.

McAllister, Jesicca. 2015. "Factors Influencing Solid-Waste Management in the Developing World." *All Graduate Plan B and other Reports* 299: 1–95. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1537&context=gradreports.

Narancic, Tanja, Federico Cerrone, Niall Beagan, and Kevin E. O'Connor. 2020. "Recent Advances in Bioplastics: Application and Biodegradation." *Polymers* 12(4).

Palanisamy, Chella Perumal et al. 2020. "A Comprehensive Review on Corn Starch-Based."

Pavel, Shaharia, and Vijit Supinit. 2017. "Bangladesh Invented Bioplastic Jute Poly Bag and International Market Potentials." *Open Journal of Business and Management* 05(04): 624–40.

Ruas-Madiedo, P., and C. G. De Los Reyes-Gavilán. 2005. "Invited Review: Methods for the Screening, Isolation, and Characterization of Exopolysaccharides Produced by Lactic Acid Bacteria." *Journal of Dairy Science* 88(3): 843–56.

Sharma, Swati et al. 2018. "An Efficient Conversion of Waste Feather Keratin into Ecofriendly Bioplastic Film." *Clean Technologies and Environmental Policy* 20(10): 2157–67.

Slade, Louise, H. Levine, Martha Wang, and J. Ievolella. 1996. "DSC Analysis of Starch Thermal Properties Related to Funchonality in Low-Moisture Baked Goods." *Journal of Thermal Analysis* 47(5): 1299–1314.

Thompson, Richard C., Charles J. Moore, Frederick S.Votn Saal, and Shanna H. Swan. 2009. "Plastics, the Environment and Human Health: Current Consensus and Future Trends." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2153–66.

Tokiwa, Yutaka, Buenaventurada P. Calabia, Charles U. Ugwu, and Seiichi Aiba. 2009. "Biodegradability of Plastics." *International Journal of Molecular Sciences* 10(9): 3722–42.

UNEP. 2018. Single-use Plastic: A Roadmap for Sustainability *Plastics: A Roadmap for Sustainability*.

Zhang, Runyang et al. 2021. "Comprehensive Utilization of Corn Starch Processing By-Products: A Review." *Grain & Oil Science and Technology* 4(3): 89–107.

Table 5 Tensile strength data of bio plastic

Temperature(^{o}c)	Residence time(m)	A.mass (g)	Li(cm)	Lf(cm)	Extension (cm)	Strain, ε= EXT/Li	load(N)	Stress δ= F/A(N/ mm^2)
70	20	145	10	10	0	0	2.917	5.45
90	20	145	11	11.25	0.25	0.023	3.69	11.86
95	20	145	12.5	13	0.5	0.04	4.93	10.86
100	20	145	13	14.6	1.5	0.115	6.217	14.86

Table 6 water absorption data of bio plastic

Temperature	Residence time(m)	Dry weight(g)	Wet weight(g)	Water absorption in (%)
70^{o}c	20	2.8	3.3	17.86
90^{o}c	20	2.9	3.3	13.8
95^{o}c	20	1.6	1.8	12.5
100^{o}c	20	2.7	2.78	2.96

Table 7 Data table

T [K]	P [kPa]	Molar Heat Capacity (c_P) [J/(mol*K)]	State
258.15		122.30	Liquid
278.15		124.20	Liquid
278.15	100.000	122.55	Liquid
288.15	100.000	124.29	Liquid
293.15		126.38	Liquid
298.15		126.60	Liquid
298.15	100.000	125.45	Liquid
318.15		130.10	Liquid
333.15		133.82	Liquid
339.13		134.95	Liquid
345.16		140.34	Liquid

Glycerine

Formula	Molar Mass	CAS Registry Number	Name
C3H8O3	92.0938	56-81-5	Glycerine/propanetriol

T [K]	P [kPa]	Molar Heat Capacity (c_P) [J/(mol*K)]	State	Reference
86.79		49.79	Liquid	16
278.15		150	Liquid	16
289.7	100.000	225.9	Liquid	16
299.4	100.000	223.4	Liquid	16
298.1		207.9	Liquid	16
293.15		221.18	Liquid	16
301.2	100.000	221.7	Liquid	16
313.15		229.3	Liquid	16
333.15		229.45	Liquid	16
338.8		229.31	Liquid	16
346.15		229.14	Liquid	16