IJASRM

International Journal of Advanced Scientific Research and Management, Volume 3 Issue 11, Nov 2018

www.ijasrm.com

ISSN 2455-6378

Starch- Based Plastic: Strength, Degradation in Soil and Water Absorbance Ability

Manju Elizabeth Kuruvila[1], Nikhila Sudhakaran[2] and Varsha Madhu[3]

[1,2 &3] Department of Zoology, Alphonsa College Pala
Arunapuram, Kottayam District, Pala, Kerala 686574, India

Abstract

Plastic pollution adversely affects wild life, wildlife habitat, or humans. Most plastics are durable and degrade very slowly. The use of biodegradable material based on natural polysaccharides, particularly starch helps to reduce the usage of non-degradable materials. In this study, "Starch-based plastic: Strength, Degradation in soil and Water absorbance ability", three types of starch were used to produce the bioplastic sheets (potato, tapioca and colocasia). The bioplastic sheets were produced with the mixture of starch, water and acetic acid at 5 different concentrations (0.27 ml, 0.47 ml, 0.67 ml, 0.87 ml, 1.07 ml) of glycerol (plasticizer). Tensile properties (tensile strength and % of elongation at break), degradation rate and water absorption were studied. The three bioplastic sheets showed comparatively good tensile properties of which tapioca starch bioplastic sheet with 0.27 ml glycerol concentration had the greatest tensile strength while colocasia starch bioplastic sheets with 0.27 ml glycerol had the lowest tensile strength. All the three bioplastic sheets are completely degradable in soil within 12 days. Tapioca starch bioplastic sheet had the highest water absorption percentage (which has also the highest starch content); while colocasia starch bioplastic sheets had the lowest water absorption percentage.

Keywords: *Starch-based bioplastics, strength, degradation in soil, water absorbanceability*

1.Introduction:

Bioplastics are plastic derived from renewable biomass sources such as vegetable fats and oils, corn starch, or microbiota (Hong Chua *et al*., 1999). Bioplastics are used for disposable items, such as packaging, crockery, cutlery, pots, bowls, and straws as well as bags, trays, fruit and vegetable containers and blister foils, egg cartons, meat packaging, vegetables, and bottling for soft drinks and dairy products (Chen and Patel, 2012). These plastics are also used in non-disposable applications including mobile phone casings, carpet fibres, insulation car interiors, fuel lines, and plastic piping. New electroactive bioplastics are being developed that can be used to carry electric current (Suszkiw, 2005). In these areas, the goal is not biodegradability, but to create items from sustainable resources.

In the present study, three types of plant starch were used to produce bioplastic films and glycerol was used as a plasticizer. Owing to its complete biodegradability, low cost and renewability, starch is considered a promising candidate for developing sustainable materials like plastics. Starch-based bioplastic films have applications in food packaging industry, in agriculture and in the medical field.

2.Materials and Method

2.1 Starch extraction:

In order to extract starch from tubers of potato, tapioca and colocasia, 500 g of raw tubers were peeled, smashed and ground. It was mixed with water and the fibrous portion filtered off. The filtrate was then allowed to settle for 45 minutes. Starch settles and the supernatant decanted off. The sediment starch was again mixed with water and allowed to settle. This further purifies the starch. The process was repeated several times to extract pure starch.

2.2 Determination of starch concentration:

Starch concentration of potato, tapioca and colocasia were determined by Lugol's iodine test and intensity of colour was determined using colorimeter at 540 nm (Table No. 1).

IJASRM
International Journal of Advanced Scientific Research and Management, Volume 3 Issue 11, Nov 2018
www.ijasrm.com
ISSN 2455-6378

Table no 1: Starch extracted from tubers

Source of starch	Weight of source (g)	Amount of starch extracted (g)	Concentration of starch (gm/ml)
Potato	500	50-58	0.427
Tapioca	500	60-65	0.5468
Colocasia	500	50-58	0.4166

2.3 Preparation of bioplastic films: The following method was used in making bioplastics. 8.4 g of starch was mixed with 45 ml of water and subjected to acid hydrolysis to break some of the branches of amylopectin. For this, 1.5 ml of acetic acid was used. Then 1.07 ml of glycerol was added as the plasticizer. The mixture was heated on a stove and constantly stirred. Starch gelatinizes and turns into a cloudy white gel. On further heating, it turns into a translucent gel. Heating was continued until the mixture turned clear and transparent. The mixture was then spread out immediately on an aluminium foil to a uniform thickness. Dry the film for 24 hours or microwave at 50^0C. Once dried, the film can be peeled off.

2.4 Varying plasticiser concentration The procedure for making bioplastics was repeated with different concentrations of glycerol. In addition to the sample that used 1.07 ml of glycerol, sample films were prepared using 8.7, 6.7, 4.7 and 2.7 ml of glycerol.

2.5 Assessing strength of bioplastic

In order to know the influence of plasticizer on the strength of plastics, the tensile property of bioplastic films (that used different amounts of plasticizer) were measured and compared.

The tensile property testing was carried out using the Universal Testing Machine (UTM). 10 cm long and 2 cm wide samples were cut out and loaded in the machine. The parameters determined using UTM were Ultimate tensile strength (kgf/cm^2), Elongation at break (%), and Young's modulus (GPa) (Table No. 2).

2.6 Degradation rate in soil:

10 similar metal dishes were filled with equal amounts of soil. Each dish should contain an equal number of earthworms. Accurately weighed, square-shaped bioplastic films were introduced into each metal dishes. Bioplastic films were observed daily and measured for weight loss up to the day in which film was completely degraded. The three bioplastic films and conventional plastic films were observed in this manner (Tale No. 3).

Table no 2: Tensile strength properties

Source of starch	Glycerol(ml)	Maximum Tensile Stress(kgf/cm^2)	Maximum Load(kgf)	% Elongation at break	Modulus (Mpa)
Potato	0.27	80.86	4.36	6.85	140.87
	0.47	111.04	5.55	7.32	472.06
	0.67	137.86	7.44	7.13	377.55
	0.87	108.29	3.35	10.77	283.92
	1.07	78.41	2.97	8.33	214.26
Tapioca	0.27	154.46	5.83	2.13	988.32
	0.47	87.16	3.88	3.58	755.4
	0.67	52.45	4.34	3.31	376.43
	0.87	100.6	4.5	4.74	525.33
	1.07	68.97	2.3	14.6	355.28
Colocasia	0.27	0.36	0.07	11.13	2.47
	0.47	14.15	0.63	4.77	222.31
	0.67	26.19	0.88	2.87	297.58
	0.87	38.63	1.82	13	52.12
	1.07	64.64	5	4.88	273.76
Polyethylene		238.38	2.14	110.46	60.37

Table no 3 : Degradation rate of starch- based plastic films and polyethylene film

Day	Potato starch film	Colocasia starch film	Polyethylene film
1	0.71	0.94	0
2	4.87	2.68	0
3	11.3	9.31	0
4	27.23	14.17	0
5	35	19.42	0
6	48.02	38.4	0
7	54.26	45.34	0
8	63.26	51.56	0
9	79.47	71.94	0
10	92.32	85.5	0
11	100	95.05	0
12		100	0

2.7 Water absorbance ability of plastic films

Fill Petri plates with equal amounts of water. Accurately weighed, square-shaped plastic films were introduced into each Petri plates. Observe the films in each half an hour and determine the difference in weight. Water absorption percentage (%) = $\mathbf{(W_i - W_f) / W_f \times 100}$ Where W_i is initial weight (g) before immersion in water and W_f is final weight (g) after immersion in water (Table No. 4).

Table no 4: Water absorbance percentage of starch-based plastic films and polyethylene film

Time period (hr)	Potato starch films	Tapioca starch films	Colocasia starch films	Polyethylene films
0.5	50.3	86.62	49.76	0
1.5	58.38	86.77	52.5	0
2	63.78	86.95	62.24	0
2.5	64.3	87.35	63.11	0
3	67.74	89.15	63.38	0
3.5	70.34	99.98	63.77	0

3. Results and discussion

In the present study, the influence of the source of starch, plasticizer concentration, degradation rate in soil and water absorbance ability of starch-based plastic films were tested. The sources of starch were potato, colocasia and tapioca. The concentration of starch was greatest in tapioca (0.54 gm/ml) than potato (0.42 gm/ml) and colocasia (0.41 gm/ml).
In potato starch films, the tensile strength was initially found to increase and reached a maximum value at 0.67 ml glycerol (137.86). Thereafter it decreased. Tapioca starch films showed no relationship between glycerol concentration and tensile strength. Highest tensile strength was shown by the film with 0.27 ml glycerol (154.46) and lowest with 0.67 ml (52.45). Colocasia starch films showed much less tensile strength than potato and tapioca starch films at same glycerol concentrations. The tensile strength of colocasia starch film was highest at glycerol 1.07 ml (64.64) and lowest at glycerol 0.27 ml (0.36) which means it increased with increasing plasticizer (glycerol) concentration.

Sahari *et al*. (2013) conducted similar studies on the effect of plasticiser concentration on tensile strength of sugar palm starch (SPS) plastics. Polyethylene plastic sheets showed much higher tensile strength (238.38) than the three bioplastic films of the current study.

A general trend could not be observed in the % elongation at break of colocasia and potato starch films, but the tapioca starch films show increased % of elongation break with increased glycerol concentration and showed much greater elongation % than the other two films. Tapioca starch film with 0.27 ml (2.13) showed lower % of elongation at break and with 1.07 ml glycerol (14.60) showed higher % of elongation at break. In potato starch films, it is greater in 0.87 ml glycerol (10.77) and lesser in 0.27 ml glycerol (6.85). Colocasia starch film with 0.87 ml glycerol (13.00) showed the higher % of elongation at break and lesser at 0.67 ml glycerol (2.87). Polyehylene film showed more % of elongation at break (110.46) than the three bioplastic films.

The degradation rate of tapioca starch film could not be measured because it changed into a semi-liquid form by absorbing soil moisture even after one day of observation. Colocasia starch films and potato starch films were completely degraded within 12 days and 11 days respectively. All the three bioplastic films show complete degradability in soil. Polythene plastic sheets did not show any degradability in soil. According to Jurgen and Lorcks (1998), bioplastics based on starch use the benefits of natural polymerisation and the availability of raw material and process technology. He proved that starch bioplastics are completely biodegradable and compostable.
Greater water absorbance was shown by tapioca starch films. It showed 86.62% water absorbance even after 30 minutes of observation. A study of Rahmatiah and Kang (2016) proved that water absorbance of bioplastic film is increased with increased starch content. Tapioca has much more starch content (0.54 gm/ml) than potato and colocasia (0.42 and 0.41 gm/ml respectively), so the tapioca starch films absorb more water and the other two show low water absorbance. Polyethylene plastic sheets never show water absorbance ability.

4. Conclusion

Starch is a natural polymer developed from carbon dioxide and water by photosynthesis in green plants. Owing to its complete biodegradability, low cost and renewability, starch is considered a promising candidate for developing sustainable materials like plastics. By developing bioplastics from different starch sources, we can replace conventional plastic from the environment.
In the present study, the influence of the source of starch, plasticizer concentration, degradation rate in soil and water absorbance ability of starch-based plastic films were tested. It was found that starch content was greatest in tapioca tubers than potato and colocasia and tapioca starch films absorb more water compared to other bioplastic films. Also, tapioca starch film with 0.27 ml glycerol showed much higher tensile strength than the other bioplastic films of study. The three bioplastic films were completely degradable in the soil.

This study showed that starch-based bioplastic films are completely degradable in soil. They are a perfect alternative to reduce environmental pollution created by conventional plastics. Even though the properties of bioplastic films are smaller, it does not create any harm to the environment. Also, these properties can be improved by adding some additives which are naturally originated thus rendering it for applications where conventional plastics are used now. The innovation of this bioplastic technology is an excellent example for a sustainable development, which implies the responsible use of available natural resources and production processes that take environmental aspects and natural circulations into consideration.

References

[1] Chen, G, and Patel, M. 2012. Plastics derived from biological sources: Present and future: P technical and environmental review. *Chemical Reviews*. 112 (4): 2082–2099.

[2] Hong Chua, Peter H. F. Yu and Chee K. Ma. 1999. Accumulation of biopolymers in activated sludge biomass. *Applied Biochemistry and Biotechnology*. 78: 389–399.

[3] Lorcks and Jurgen. 1998. Properties and Applications of Compostable Starch-based Plastic Material, Polymer Degradation and Stability. *Carbohydrate polymers*. 59: 245-249

[4] Sahari, J, Sapuan, S. M, Zainudin, E. S, and Maleque, M. A. 2013. Biodegradability and mechanical behaviour of sugar palm starch based biopolymer. *American journal of applied science.* 11(10): 1836-1840

[5] E-sources: (www.ncbi.nlm.nih.gov)

[6] Rahmatiah Al Faruqy M Sujuthi and Kang Chang Liew. 2016. Properties of Bioplastic Sheets Made from Different Types of Starch Incorporated with Recycled Newspaper Pulp

[7] Suszkiw. 2005. Elecroactive Bioplastics Flex Their Industrial Muscle. News & Events. USDA Agricultural Research Service. Retrieved 2011-11-28.