International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 1352-1355

Received: 13-05-2019
Accepted: 15-06-2019

R Shah
M. Tech Student, Department of Food Process Engineering, Vaugh Institute of Agriculture Engineering and Technology, SHUATS, Prayagraj, Uttar Pradesh, India

G Immanuel
2Associate Professor, M. Tech Student, Department of Food Process Engineering, Vaugh Institute of Agriculture Engineering and Technology, SHUATS, Prayagraj, Uttar Pradesh, India

S Mathur
Assistant Professor, CIPET Lucknow, Uttar Pradesh, India

Correspondence
R Shah
M. Tech Student, Department of Food Process Engineering, Vaugh Institute of Agriculture Engineering and Technology, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of corn starch on LDPE and its suitability as food packaging film

R Shah, G Immanuel and S Mathur

Abstract
This research work explores the possibility of incorporating corn starch to develop bio-plastics film using low density polyethylene (LDPE), glycerol, urea and talc powder. Corn starch incorporated LDPE film was made by twin screw extruder and blown film extrusion method with different proportion of corn starch T_1 (5%), T_2 (7.5%), and T_3 (10%). The film was then tested for the physical, mechanical and other properties for its suitability in food packaging. The thickness of the film was found in the range of 0.7 mm to 1.3 mm. The tensile strength was found better for T_2 (14.8 MPa). Similarly dart impact resistance of the film was found to be in the range of 0.8 N to 1.2 N. Water absorption of the bio-based film increases from 0.005% to 0.078%. This result was promising so that this biodegradable film can be used for food packaging and it will not deteriorate the environment. Bio-plastics can be easily manufactured in a larger scale if the required facilities are set up. The need for bio-plastics is now more than ever as the rate of plastic production and air pollution has increased at a rapid rate.

Keywords: Corn starch, biodegradable film, blown film extrusion, LDPE

1. Introduction
The last 10 years have seen an explosion in the level of research devoted to the development of new biodegradable materials, essentially due to the desire to protect the environment. The growing demand for biodegradable polymers by emerging technologies including tissue engineering and regenerative medicine, gene therapy, novel drug delivery systems, implantable devices and nanotechnology has resulted in the development of a range of biodegradable polymers, mainly based on already known chemistry. Nowadays, about 150 million tons of plastics are produced annually all over the world, and the production and consumption continue to increase. This is because plastics can be used in many application such as packaging, automobile parts, etc. Plastics are typically composed of artificial synthetic polymers. Their structure is not naturally occurring, so plastics are not biodegradable. Bio-plastics can be defined as plastics made of biomass such as corn, wheat, sugarcane etc. These substances have been increasingly highlighted as means for saving fossil fuels, reducing CO_2 emission and plastic wastes. Biodegradability of bio-plastics has been widely publicized in society and the demand for packaging is rapidly increasing among retailers and the food. The term "biodegradable" materials is used to describe those materials which can be degraded by the enzymatic action of living organisms, such as bacteria, yeasts, fungi and the ultimate end products of the degradation process, these being CO_2, H_2O and biomass under aerobic conditions and hydrocarbons, methane and biomass under anaerobic conditions (Kuorwel *et al*., 2011) [1]. Biodegradable plastic made from renewable resources will decreases dependence on petroleum and reduces the amount of waste material, while still yielding a product that provides similar benefits of traditional plastics.
To meet the growing demand of recyclable or natural packaging materials and consumer demands for safer and better quality foods, new and novel food-grade packaging materials or technologies have been and continue to be developed. Examples of these packaging materials include bio based polymers, bio plastic or edible polymer packaging products made from raw materials originating from agricultural or marine sources. It will help to reduce the packaging waste associated with processed foods and will support the preservation of fresh foods, extending their shelf life (Gacitua *et al.* 2005) [2]. The present study was undertaken to develop corn starch incorporated LDPE packaging materials at different composition and to evaluate physical, mechanical and biodegradability of film.

2. Materials and Methods
2.1 Materials
Materials used for production of biodegradable film were: corn starch obtained from the Oriental and Gums Biopolymer, Gandhinagar Gujarat. Materials used for film production were: corn starch, LDPE, talc powder, glycerol and urea. The LDPE were obtained from Ice Enterprizes Gaziabad, talc powder, glycerol and urea were all obtained from local market Jhusi, Prayagraj. Glycerol is a simple polyol compound. It is a colourless, odourless, viscous liquid and has a high boiling point and freezes to form a paste. It is the plasticizer used in the film production. A plasticizer is an additive that softens the material it is added to. Talc or talcum powder is a mineral that is naturally found in nature. It is the lubricant used in this work. It was used for easy flow of the mixture in the extruder. Urea was used as crossing link agent, that is, to make the starch and PVA compatible.

Apparatus used for cassava starch production were: electronic balance to weigh the sample materials so as to obtain the desired quantity of materials needed, a container to collect samples to be weighed, twin screw extruder for compounding of mixture and blown-film extruder for practical production of the biodegradable film. The mechanism of operation consist basically of extruding a tube of molten thermoplastic, and continuously inflating it to several times initial its diameter to form a thin tubular product that can be used directly or slit to form a flat film. The Universal Testing Machine (tensometer) was used to test for the mechanical properties of the film produced. The tensile strength and break on elongation of the film were tested and compared with polythene film.

2.2 Methodology
2.2.1 Film preparation
The various compositions of corn starch and LDPE mixture was prepared and then compounded through the twin screw extruder which has various temperature zone. The temperature in an extruder plays a very important role in the physical and mechanical properties of the extruded material. The closest zone to feed hopper is usually cooler than the rest to start cooling the mixture after plasticisation. The gelation of starch occurs in the middle zones, where its molecular weight decreases and crystallinity changes depending on shear rate intensity, till it reaches the last zone which is completely filled, and then it comes out as thermoplastic starch through a die. Thermoplastic starch rope needs to be cooled down before being cut into small resins. Zone 1 has temperature of 80^{o} C, while Zone 2 maintains 100-160^{o}C, and melt temperature was of 160^{o}C. The Extruder was operated at a speed 40rpm.

Then these biodegradable resins were passed through the Blown Film Extruder. In this, the polymer was melted by subjecting it into heat inside the barrel of an extruder and then forcing the molten polymer through a narrow slit in a die, vertically to form thin walled tube. The slit is in a circular form. Air is introduced in the centre of the die to blow up the tube like ballon, air ring blow on to the hot film to cool it (outside and inside the tube). The resulting thin film in the form of a tube, later often referred to as bubble. The tube passes through nip rolls where it is flattened. On winder the tube or film is wounded into roll.

2.2.2 Test for validity of the bio-based film
Various physical, mechanical and biodegradability test were performed for the prepared films. These include: thickness, tensile strength, water absorption, and soil burial test.

Physical Properties

1. Water absorption

The composite films were immersed in boiling distilled water for 2 h, according to the ASTM D570-98 method. The films were taken out and wiped to measure the water absorption in weight percent. The percentage of water absorption was calculated as following:

$$\text{Water Absorption} = W_2\text{-}W_1/W_1*100 \quad \text{…. (1)}$$

Where, W_2 and W_1 are the weight of wet and dry films, respectively.

2. Thickness

A micrometer sometimes known as a screw gauge is a device incorporating a calibrated screw widely used for precise measurement of the thickness of the film.

Mechanical Properties

Tensile strength and Elongation at break was carried out at Central Institute of Plastics Engineering and Technology (CIPET) Laboratory, Lucknow. Universal Testing Machine (Tensometer) was used to test tensile strength and elongation at break of biodegradable film and it as compared with polythene.

Biodegradability Test

1. Soil Burial Method

Different small identical pots were filled with the composted soil and the samples of each film were cut into 2 cm × 2 cm pieces and buried in the soil at the depth of 5 cm. The pots were placed in laboratory for some days to study the time for biodegradation. The moisture of the soil was maintained by sprinkling water into it at regular intervals of time. The weight loss of the sample over the time was used to indicate the degradation rate of soil burial test. And the weight loss % was calculated according to the Eq. 3.2 to show the amount of biodegradation done.

$$\text{Weight loss} = (\text{initial weight-final weight})/\text{initial weight} \times 100 \quad \text{…. (2)}$$

3. Results and Discussion
3.1 Preparation of Biodegradable Film
The biodegradable film sample was prepared using LDPE different composition of corn starch and additives such as glycerol, urea and talc powder. The sample of LDPE is labelled as T_0, sample with 5% corn starch labelled as T_1, sample with 7.5% corn starch labelled as T_2, sample with 10% corn starch labelled as T_3. Table 1 shows the different composition of LDPE, corn starch and additives. The film developed were shown in Fig1, 2 and 3.

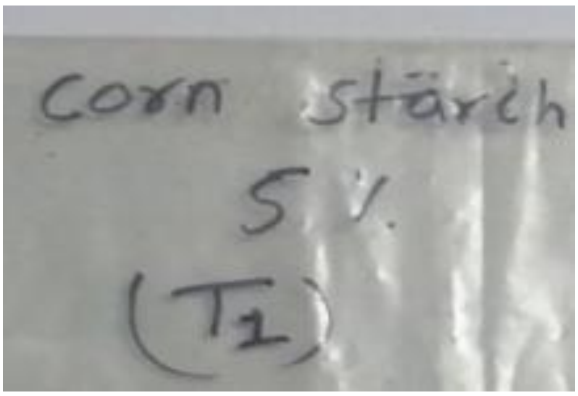

Fig 1: Biodegradable film T1

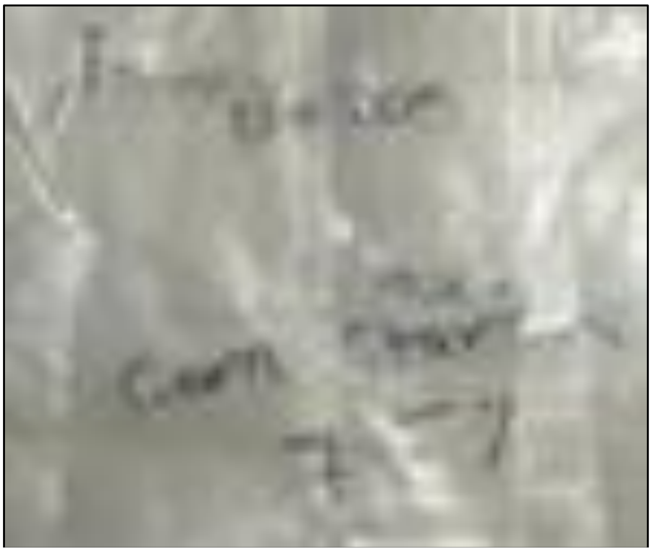

Fig 2: Biodegradable film T2

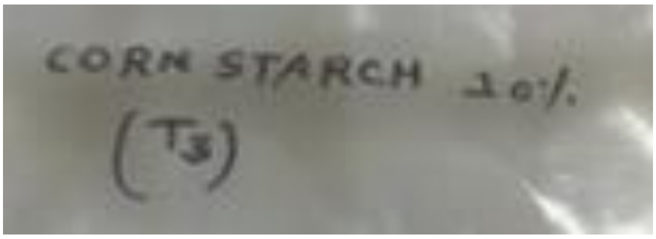

Fig 3: Biodegradable film T3

Table 1: Different composition of biodegradable film

Treatment	LDPE (%)	Corn starch (%)	Glycerol (ml)	Urea (mg)	Talc powder (mg)
T_0	100	…..	…..	…..	…...
T_1	95	5	100	40	40
T_2	92.5	7.5	100	40	40
T_3	90	10	100	40	40

3.2 Physical and Mechanical properties of the biodegradable film

3.2.1 Film Thickness

Thickness is the physical property which is usually defined as the distance between the top and bottom. Thickness of packaging material should be same throughout as it affects the other properties of packaging materials. The film thickness was kept approximately constant and the thickness was measured at four different points of each sample. The mean thickness was then calculated using screw gauge and it was observed that the mean thickness was in the range of 0.75 mm to 0.95 mm. All the readings are shown in the Table 2.

3.2.2 Tensile Strength

Tensile strength is the ability of a material to withstand a pulling (tensile) force. The tensile strength of films T_1, T_2 and T_3 are depicted in Table 3.2. The results showed that the sample T_1 was found to have the maximum strength i.e. 14.80 MPa force and the minimum strength was showed by the sample T_3 i.e. 7.73 MPa force. The result reflect that tensile strength is inversely proportional to starch content. It is seen that there is a gradual decrease in tensile strength with increasing starch content in LDPE/Corn Starch based films.

3.2.3 Elongation at Break

The elongation at break of LDPE/TPS composite films is inversely proportional with starch content due to its embrittlement properties. The elongation at break decreases from 333.49% down to 181.86% with increase in starch content from 0 to 10%. This is due to (i) physical incorporation of starch in the matrix of LDPE that weakens the London forces between LDPE layers and (ii) the fact that starch, a low molecular weight polymer, has lower elongation compared to LDPE. Incorporation of starch causes discontinuity in the film matrix, leading to lower elongation due to lack of chemical interaction between starch and LDPE. An indication of the elongation at break results achieved is depicted in Table 3.2

3.2.4 Water Absorption of the film

The water absorption of composite films is directly proportional to starch amount incorporated into polymer matrix. In other word, the water absorption would increase by increasing the starch content in LDPE. The starch is responsible for water absorption due to hydrophilic nature of starch and ionic character of hydroxyl groups of starch. Composites with more water absorption have lower mechanical properties. Regarding the starch content, the water absorption of pure PE, composites and pure starch is varied from 0.005 up to 0.065%. Table 2 shows reasonable water absorption.

Table 2: Physical and mechanical properties of various composition of bio-based film.

Treatment	Thickness (mm)	Tensile strength (MPa)	Elongation at break (%)	Water absorption (%)
T0	0.95	11.97	333.49	0.005
T1	0.70	14.80	253.50	0.031
T2	0.95	14.08	225.53	0.045
T3	1.15	7.73	181.86	0.065

3.2.5 Biodegradability of the Film

The effect of starch contents of 0%, 5%, 7.5%, and 10% on biodegradability of the composites films for 60 days was observed. The results showed that the biodegradability of composites increased by increasing the starch content. It was because hydrophilicity of composite due to higher water absorption and micro-organisms attack. This is evidence that the consumption of starch and the holes that are created increase the surface of the LDPE, and as a result, the microorganisms can attack the LDPE matrix more easily, creating favourable conditions for the consumption of polyethylene oligomers.

The biodegradability of the films was analysed by buring the films in wet soil and measuring the weight loss during the monthly intervals. The weight loss of the films after 60 days confirmed the obtained results shows biodegradation of the film.

4. Conclusion

Corn starch incorporated LDPE bio-plastics film was prepared in three proportion T_1, T_2 and T_3 using blown film extrusion method. Mechanical properties of T_2 sample was found reasonably better as compared with other sample. Corn starch incorporated LDPE film can be used for food packaging application. It could be concluded that the starch has direct effect on biodegradation because micro-organisms would attack to starch leading to biodegradability of the composite films. From this result it can be concluded that corn starch can be a good polymer with LDPE and can be used as a packaging materials. It can be regarded as a boon for our society in controlling pollution.

5. References

1. Kuorwel KK, Cran MJ, Miltz J *et al.* Antimicrobial activity of natural agent coated on starch based film. Journal of food science. 2011; 76:531-53.
2. Gacitua F, Voilley A. Methylcellulose-based edible films and coatings and Mechanical and thermal properties as a function of plasticizer content. Journal of Agricultural and Food Chemistry. 2005, 45:685-689.
3. Central pollution control board. Overview of plastics waste management. Annual report on plastics waste management, Delhi, India, 2017.
4. Azahari NA, Othman N, Ismall H *et al.* Biodegradable studies of polyvinyl alcohol/corn starh blend films. Journal of physical science. 2011; 22:15-31.
5. Torabi A, Mahmood, Hamid R *et al.* Preparation of biodegradable low density polyethylene by starch-urea composition. Journal of chemical and chemical engineering. 2004; 23:7-11.
6. Manikantam RN, Vardharaju, Sharma R *et al.* Storage Stability of Banana Chips in Polypropylene based Nanocomposite Packaging Film, Journal of food science and technology. 2012; 48:43-45.
7. Oromiehie AR, Taherzadeh L, Rabiee A *et al.* Physical and thermal properties of corn starch/LDPE composits. Journal of applied polymer science. 2013; 127:1128-1134.
8. Jane J. Carbhohydrates: Basic concepts. *In*: “Food chemistry: Principles and applications” (G.L. Christen and J.S. Smith, eds.) California: Science. 2000; 43-45.
9. Marsh K, Bugusu B. Food packaging role, materials and environmental issues. Journal of Food Science. 2007; 72:39-55.
10. Keziah VS, Priya V. Biodegradable plastics film from corn starch. Journal of biochemistry. 2018; 10:7.