Study on Biodegradation of Cassava Starch Film By Soil Burial Test

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Abstract

Plastics are made of petroleum based materials that are not readily biodegradable.To overcome these problems, the biodegradable film was prepared from cassava by cassava starch in this research. Extraction of starch was carried out by distilled water. So yield percentages of cassava starch were found 11.16 % and 33.69 % from fresh and dried samples. Extracted starch was preliminary identified by iodine solution test and FT IR spectroscopic method. And then some physical properties of cassava starch such as pH (6.55), moisture content (11.22 %), bulk density (0.65 g/cm^3), water absorption capacity (1.64 g/g) and swelling power (7.4 g/g) were determined respectively. Then biodegradable cassava starch film was prepared by casting method. After the preparation of biodegradable cassava film, physicomechanical measurements of this prepared film such as thickness (0.34 mm), tensile strength (1.0 M Pa) elongation at break(59.0 %) and tear strength (6.5 k N/m) were measured. Moreover the biodegradability of cassava starch film was determined by the soil burial test.

Keywords: Biodegradable film, starch, physicomechanical properties, burial test

Introduction

The problem of plastic contamination in the terrestrial environment has remained widely unexplored. Plastic pollution may be dramatically seen in the ocean; however, more than 80 percent of the plastics found in marine environments has been produced, consumed and disposed of on land. Therefore, plastic pollution on land is a problem both of contamination and damage to terrestrial environments and of transfer to aquatic environments (marine and freshwater). High levels of microplastics contamination on land have been observed, estimated 4 to 23 times larger than in the oceans (Adhikari*et al*., 2016).

Botanical Aspects of Cassava

Botanical Name	:	*Manihotesculenta*Crantz
Family	:	Euphorbiaceae
Genus	:	*Manihot*
Species	:	*esculenta*
Myanmar name	:	Palaw-pinan-u-pin
English name	:	Cassava
Common names	:	Tapioca, manioc
Part used	:	Root

Figure 1.Photo of Cassava

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Materials and Methods

Sample Collection and Preparation

For the present work, the main constituent, cassava sample was purchased from Mingalardon Township at Yangon Region. Required chemicals such as glycerol, and polyvinyl alcohol were bought from Chemical Store, Pabedan Township at Yangon Region. Then the sample was washed with water and removed the peels. The cleaned and fresh cassava were cut into small pieces. They were divided into two portions such as fresh and dried samples.So fresh and dried cassavasamples were used to extract cassava starch.

Extraction of cassava starch with distilled water from fresh and dried cassava samples

10 g of fresh cassava paste was prepared by using a blender. 100 mL of distilled water was added to the fresh sample in a blender. It was blended manually for 15 min and allowed to settle about 30 min. The supernatant was decanted off and filtered through a double-layered cotton cloth. The former procedure was repeated again and again. Then extracted cassava starch was dried in air for 48 hr at room temperature. The starch lumps were powdered by placing in an Oven at 60℃ for 8hr before it was stored in polyethylene bag and then yield percent of cassava starch was calculated. The results are shown in Table 1.

Identification of extracted starch with iodine solution test

0.25 g of extracted starch was poured in a test tube to a depth of about 1 cm. It was then added small amount of distilled water, stirred with a glass rod and allowed to stand for few minute. A drop of iodine solution was added to the milky solution and looked for a colour change. A blue-black colour indicated the presence of starch in the test solution (Gin SuanMang, 2016).

Identification of extracted starch with standard starch by FT IRspectroscopy

The FT IR spectra of extracted starch and standard starch were obtained by using Shimadzu Perkin Elmer Spectrum GX system FT IR spectrometer at Department of Chemistry, Monywa University.

Some Physicomechanical Analysis of Extracted Cassava Starch

Some physicochemical properties of cassava sample were carried out by determination of pH value (pH meter), moisture content (moisture analyzer), bulk density (tapping box), water absorption capacity (centrifuge method) and swelling power (centrifuge method) respectively.

Determination of pH fromextracted cassava starch

1 g of cassava starch was put into the beaker. 100 mL of distilled water was added into the beaker and stirred with the magnetic stirrer for 30 minutes at room temperature at a rate of 1500 rpm. It was allowed to stand for 30 min and filtered. The obtained filtrate was used for the determination of pH.The resultis shown in Table 3.

Determination of moisture content of extracted cassava starch

Moisture content of extracted cassava starchwas determined by moisture analyser(Sartorious, Germany, Ospicious Co., Ltd).

Extracted cassava starch (1 g) was firstly prepared to place in a pre-weighed evaporating dish and was kept on the moisture analyser at 105 ˚C for about 12 min

and 18 sec. The procedure was done by the catalogue. The data reading was measured at three times. Then it was cooled in a desiccator and then weighed again. The process of heating, cooling and weighing was repeated until a constant weight was achieved. The amount of water in theextracted cassava starch was then calculated.The result isshown in Table 3.

Determination of bulk density of extracted cassava starch

The bulk density of extractedcassava starch was determined by tapping box, gravimetric method (A.O.A.C, 2000).

The cleaned and dried measuring cylinder (10 mL) was pre-weighed. The cylinder was filled with extracted cassava starch to reach the mark of 10mL from the measuring cylinder and weighed. The cylinder from the tapping box was slowly knocked until there was no more reduction in volume. Bulk density of extracted cassava starch was calculated.The above procedure was done for three times and the result was shown in Table 3.

Determination of water absorption capacity of extractedcassava starch

Extracted cassava starch (1g) was placed in a pre-weighted centrifuge tube and added 10 mL of distilled water. The tube was shaken with shaker at 70℃ for about 2 hours and allowed to stand for 30min at room temperature. The tube was placed in the centrifuge at 1100 rpm for 10min. The supernatant was decanted. The centrifuge tube was weighed. The above procedure was done for three times. The gained in weights were calculated and described in Table 3.

Determination of swelling power of extracted cassava starch

1 g of cassava starch was dissolved in 10 mL of distilled water into 50 mL of the beaker and performed vortexes thoroughly by using the shaker and heated in a water bath at 65, 75, 85, 95ºC respectively for 15 minutes. During heating, the slurry was stirred gently to prevent clumping of the starch. The tubes containing the paste were immediately cooled down and centrifuged at a rate of 3000 rpm for 15 minutes. After centrifuging, the supernatant was carefully decanted. The weight of the sediment was recorded(Gin SuanMang, 2016). Swelling power of cassava starch was calculated and the results are shown in Table 3.

Preparation of Biodegradable Cassava Starch Film

Biodegradable cassava starch film was prepared from extracted starch, distilled water, glycerol and polyvinyl alcohol by casting method.

15 g of preheated starch powder and (12 mL) of glycerol were mixed into the 300mL of the beaker. Then, 150 mL of distilled water was added to the mixture. It was stirred at 70˚Cfor 5 min. And then 5 g of polyvinyl alcohol was added and stirred on the magnetic stirrer at 70˚C for 15 min. And then clear and homogenous mixture solution was quickly casted on the aluminium foil (7″ x 7″) and dried at room temperature in air for two days. After drying, the films were peeled off and were kept in plastic bags away from the moisture (Cagri, *et al*., 2004).The photograph of preparation of colorless film is shown in Figure 7(a).

Some physicomechanicalmeasurements of prepared biodegradable cassavastarch film

Some physicomechanical measurements of prepared biodegradable cassava starch film were determined such as thickness, tensile strength, elongation at break

and tear strength by Rubber Research and Development Centre, Department of Agriculture, Ministry of Agriculture.

Determination of thickness

Thickness of the prepared biodegradable cassava starch film was measured by using NKS micrometer. The thickness of the film was measured at 5 locations (centre and four corners) using digital micrometer. The resulting data was presented in Table 4.

Determination of tensile strength and percent elongation at break

The prepared biodegradable film was cut off according to NKS micrometer. The shape and dimension of the test pieces were shown in Table 4 and Figure 7. Both ends of the test piece (1″×1″) were firmed clamped in the jaws of a testing machine. One jaw was fixed and the other was movable. The movable jaw moved at a rate of 100 mm/min. The recorder of the machine showed the tensile strength in MPa. The percent elongation at break was calculated by supporting Rubber Research and Development Centre. The procedure was repeated three times for each resultas shown in Table 4.

Determination of tear strength

Testing specimen was cut out by a die from prepared starch film. Specimen was cut with a single nick (0.05 mm) at the centre of the inner concave edge by a special cutting device using a razor blade. The clamping of the specimen in the jaws of a testing machine was aligned with travel direction of the grip. The speed of the moving grip is 100 mm/min. The recorder of the machine showed the highest force to tear from a specimen nicked (Sandar Win, 2009). Tear strength was obtained by Rubber Research and Development Centre, Department of Agriculture, Ministry of Agriculture at Yangon Region.

Observation of biodegradability of prepared cassava starch film

The biodegradability of the prepared cassava starch film (colourless) was determined by soil burial test.The prepared biodegradable film wascut into (1″ x 1″) dimension. The film was then accurately weighed and buried in the soil (humus collected from HtaukKyant) of flowerpots at a depth of about 9″. Firstly soil was filled a depth of about 1.5 inches from the bottom of the flowerpot. Secondly, the prepared film was placed on the soil and recorded. Andthen the soil was covered on the prepared biodegradable film to reach about 7″. Biodegradation of the prepared film was determined by taking out the films from the soil (humus) at an interval of one tofour weeks respectively (Sandar Win, 2009).Geometry of prepared biodegradable film was also recorded with photos in Figure 8.

Results And Discussion

Preliminary Preparation of Cassava Samples

For the research, cassava sample was purchased from Mingalardon Market, Mingalardon Township at Yangon Region.Cassava sample was prepared into two types such as fresh cassavapaste and dried cassava powder. Dried cassava powder was stored in air-tight container. Then cassava starch was extracted with distilled water from fresh and dried cassava samples. They were shown inFigure 2.

(a) (b) (c)

Figure 2.(a) Fresh cassavapaste

(b) Dried cassava powder

(c) Starch from fresh and dried samples

Determination of Yield Percentages of Extracted Cassava Starch

Cassava starch was extracted with distilled water from fresh and dried samples. The yield percentages of extracted cassava starch aredescribed in Table 1 and Figures 2 and3. From these results, 11.16 % of cassava starch was found from the fresh sample and 33.69 % of cassava starch was produced from the dried sample.So extracted starch of dried sample was more obtained than the fresh sample.

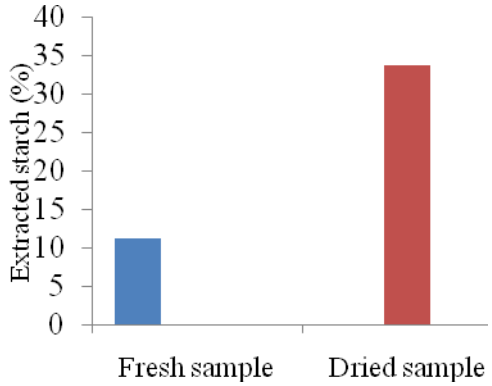


Table 1.Results for Yield Percent of Extracted Starch

Samples	Extracted starch (%)
Fresh cassava paste	11.16
Dried cassava powder	33.69

Figure 3. Histogram for yield percent of extracted cassava starch

Identification of extracted cassava starch by iodine solution test

The extracted cassava starch was preliminary identified by iodine solution. The color of iodine solution was changed from brown to blue-black. The blue-black color indicates the presence of starch. When the iodine ion comes in contact with amylose, it gets stuck in the coil of starch, forcing the ion to become linear and changing the electron arrangement. The new electron arrangement alters how the molecule absorbs light and changes the solution from orange-red to blue black. Amylopectin has a relatively small area available for building, so it absorbs less iodine and turns a pale purple-red.

Identification of extracted starch by FT IRspectrophotometric analysis

The functional groups of extracted cassava starch and standard starch were investigated by FT IR spectrophotometric analysis. Figure 4 represented for standard starch and figure 5 showed the FT IR spectra of extracted cassava starch. The band assignments were described in Table 2.According to these results, it can be seen that the extracted starch contains –OH group, sp^3 carbon and ether group respectively.

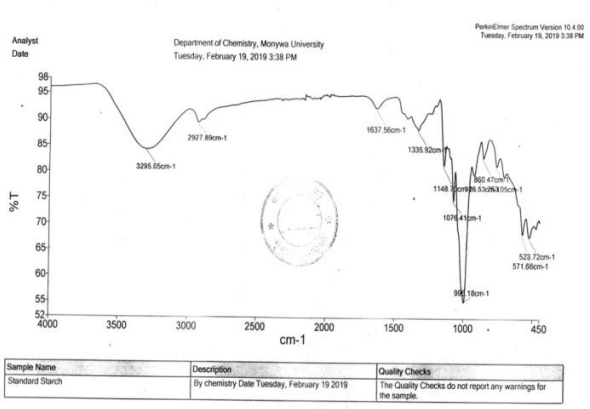


Figure 4.FT IR spectrum of standard starch

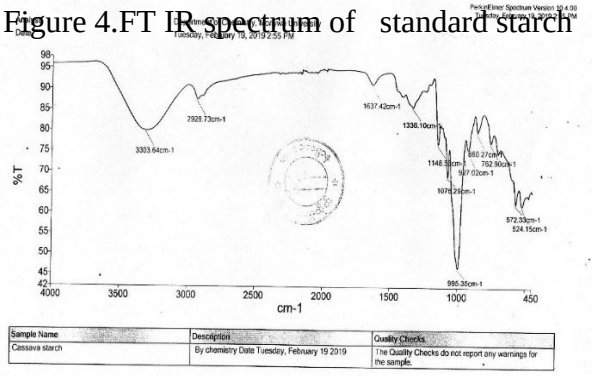


Figure 5. FT IR spectrum of cassava starch

Table 2. FT IR Spectral Data Assignments of Standard Starchand Extracted Cassava Starch

Observed frequency (cm^{-1})		*Literature frequency (cm^{-1})	
Standard starch	Cassava starch	Brasoveanu (2013)	Assignments
3295	3303	3000 - 3600	O – H stretching
2927	2928	2850 - 3000	C – H stretching
1637	1637	1300 - 1650	C – O,C – H,C = C stretching
1335	1336	1200 - 1450	O – H in plane bending
1148	1147	970 - 1250	C – O stretching

Determination of Some Physical Properties of Extracted Cassava Starch

Some physicomechanical properties of extracted cassava starch were also determined such as pH, moisture content, bulk density, water absorption capacity and swelling power respectively. These results are present in Table 3 and Figure 6.

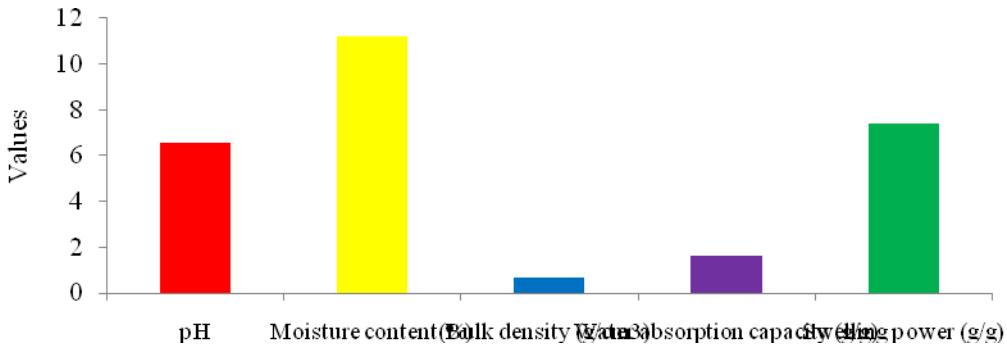


Figure 6.Result values for some physical parameters of extracted cassava starch

Table 3. Some Physicomechanical Properties of Extracted CassavaStarch

Physicochemical Properties	Extracted Starch
pH	6.55
Moisture content (%)	11.22
Bulk density (g/cm^3)	0.65
Water absorption capacity (g/g)	1.64
Swelling power (g/g)	7.4

Some Physicomechanical Properties of Prepared Biodegradable Film

Biodegradable film (colourless) was prepared by casting technique using cassava starch, glycerol and polyvinyl alcohol. The determination of physicomechanical properties such as thickness, tensile strength and elongation at break and shearing strength of prepared biodegradable film were carried outby Rubber Research and Development Centre, Department of Agriculture, Ministry of Agriculture at Yangon Region.

According to the determination, 0.34 mm of thickness, 1.0 MPa of tensile strength,59.0 % of elongation at break and 6.5k Nm^{-1} of tear strength were observed in Table 4 and Figure 7. Therefore this prepared film can be used as wrapping film for foods.

(a) (b) (c) (d)

Figure 7. (a) Prepared biodegradable cassava starch film (colourless)

(b) Measurement of thickness

(c) Test pieces for measuring of tensile strength and elongation at break tear strength

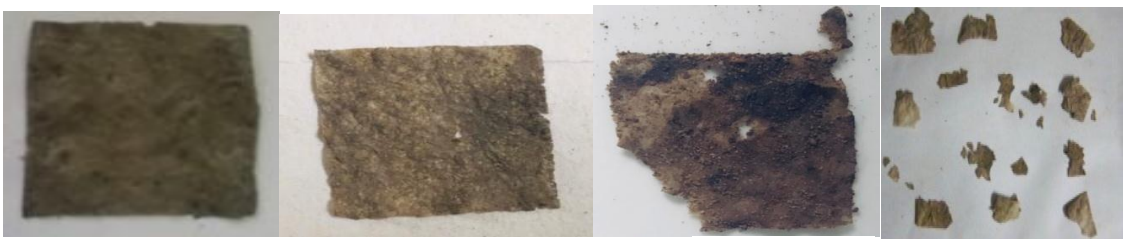
(d) Test pieces fortear strength

Table 4.Characteristics of Prepared Biodegradable Cassava Starch Film

Characteristics of biodegradable film	Thickness (mm)	Tensile strength (MPa)	Elongation at break (%)	Tear strength (kN/m)
Cassava starch film	0.34	1.0	59.0	6.5

Biodegradability of Prepared Biodegradable Film

Biodegradability of cassava starch film (colourless) was investigated by soil burial methods. The degradation ofcolourless film after buried in the soil (humus)was determined by geometrical photographs at time intervals of one to four weeks are shown in Figure 8. It was clearly seen that this film was more and more degradable by soil burial test.



1 week 2 weeks 3 weeks 4 weeks

Figure 8.Geometry of biodegradable colourlessfilm by soil (humus) burial tests

Conclusion

From the research, yield percentages of extracted starch were found 11.16 % from fresh cassavasample and 33.69 % from dried cassavasample. So starch was more produced from dried sample than the fresh. From extracted starch, physical properties were measured such as pH (6.55), moisture content (11.22 %), bulk density (0.65 gcm^{-3}), water absorption capacity (1.64 g/g)and swelling power (7.4 g/g) respectively. Then identification of extracted starch was carried out by iodine solution test and FT IR spectroscopic method. In iodine solution test,a blue-black colour indicated the presence of starch. Moreover FT IR spectral data of extracted starch and standard starch were similar to the literature values of starch.Biodegradable film was prepared from extracted starch, distilled water, glycerol and polyvinyl alcohol.After the preparation of biodegradable film, some physicomechanical measurements of prepared film were determined which indicated 0.34 mm of thickness, 1.0 M Pa of tensile strength, 59.0 % of elongation at breakand6.5 k $Nm^{-1}$of tear strength. Finally the biodegradability of the preparedcolourless film was observed in humus by the soil burial test within four weeks. According to the geometrical photos of soil burial tests, significant degradation of the colourless biodegradable film was occurredin the soil.

So the colourless biodegradable film can be disposed easily after using it, without environmental impact. This biodegradation of colourless cassava starch film may be saved from the dangerous of plastic pollution.

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