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Production and characterization of bioplastic from rambutan (*Nephelium lappaceum*) seeds

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Abstract

In the light of finding solutions to the adversity brought by non-biodegradable wastes, bioplastic a polymer derived from renewable biomass resources such as starch, cellulose and lignin was discovered. Starch from rambutan (*Nephelium lappaceum)* was used as a raw material to determine its potential in bioplastic production. Rambutan seed starch plasticized with sorbitol was developed and characterized. The starch, sorbitol, vinegar and water were prepared in the ratio of 30g: 5ml: 5ml: 60ml. The characteristics of the starch in terms of ash content, moisture content and starch content was determined. From the analysis of rambutan seed starch, the ash content of 1.33%, moisture content of 79.6% and starch content of 22.83% were obtained. Soil burial test was conducted in determining the biodegradability of the film produced. The mass of bioplastic was reduced by more than 50% in the first 6 days and complete degradation occurred on the 15th day. *Nephelium lappaceum* seed is of good quality based on the low ash content but has high moisture content and even with the presence of starch the bioplastic film that was formed needs further investigation.

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Introduction

A world without plastics seems to be impossible. This material has made life easy because of its durability, availability and affordability. However, synthetic plastics have detrimental effect on the environment (Barnes *et al.*, 2009) and are made from non-renewable resources (Reddy *et al.*, 2008). The high demand for plastic has been a major contributor to the increasing garbage problem. According to Geyer *et al.*, (2017) the production of plastics has greatly increased in the year 2017 and yearly increase about 4% for the following years. Due to the increasing concern over environmental problems of these materials, interest has shifted towards the development and promoting the use of bio-plastics (Gadhave *et al.*, 2018).

Bioplastics are derived from natural ingredients such as polysaccharides (e.g. starch, cellulose, chitin and lignin), proteins and lipids (Song *et al.*, 2009). Among these, starch has presented potential for the production of biodegradable materials because it is a low-cost raw material, easily available and renewable (Mbey *et al.*, 2012). In this study, the starch used in the production of bioplastic is a native fruit belonging to the family of Sapindaceae *Nephelium lappaceum* commonly known as rambutan. It is commonly grown and abundant in the province of Surigao Del Norte because most of the people living in the area have rambutan fruit beside their houses. Rambutan seeds are usually discarded because it is considered useless. In order to utilize these raw materials, the researchers conducted a study about the potential use of rambutan seed starch in bioplastic production. This study aimed to produce bioplastic from starch of rambutan seed through starch extraction, starch characterization in terms of ash, moisture and starch content, film preparation and decomposition period of the product.

Materials and methods

Materials

Seeds were collected from the households of the residents of Barangay Cawilan, Tubod, Surigao Del Norte, Philippines and some seeds are recovered from the merchants of Surigao City. The experimental setup was conducted at Surigao Del Norte State University Chemistry Laboratory.

Starch extraction from rambutan seed

The collected seeds were dried, peeled, cleaned and weighed using a digital balance and were ground in a blender with distilled water. Starch slurry was filtered and squeezed using a cotton cloth and liquid filtrate (starch suspension) was obtained. The obtained suspension was allowed to settle for 2 hours. The starch was given enough time to settle at the bottom. Oil that float above the slurry was separated manually using a dropper. Wet starch that obtained from sedimentation procedure was dried in an oven at a temperature of 70°C for 20 minutes.

Characterization of starch

Ash content

The determination of ash content was based on the study of Onitilo *et al.* (2007). The ashing was conducted to determine the amount of residual inorganic substances in samples after ignition. Starch samples, 3 grams each were weighed and placed into previously ignited and cooled crucibles with a known weight. The crucibles containing the samples were placed in a pre-heated furnace at 600°C for 6 hours and was cooled in a desiccator then weighed. The samples were placed back into the furnace for another 4 hours until constant weights of 30.61g, 29.99g, and 28.31g from the three samples were achieved. The differences between the final weights and the crucibles gave the ash contents of the samples that were expressed as percentages of the initial weights. The ash content formula adapted from Association of Official Analytical Chemists AOAC (1990) was calculated as follows:

$$\% \text{ Ash} = (\text{Weight of ash} / \text{Weight of sample}) \times 100$$

Moisture content

The determination of moisture content was based on the study of Onitilo *et al.* (2007). Starch samples, each 3.0 g were weighed by a digital balance into a known weight of evaporating dishes. The weighed samples were placed into the oven at 105°C for 3 hours. The samples were removed and cooled in a desiccator to room temperature and the weights were recorded then returned to the oven at 105°C for 30 min until constant weights of 51.80g, 58.06g, and 53.38g were obtained from the three samples. The differences in weights between each evaporating dish and dried residue samples were recorded as the percentage of the initial sample. The test was carried out in triplicate and the final moisture content for each film was recorded as the mean of the result. The moisture content formula was adapted from AOAC (1990) and calculated as follows:

% Moisture content = [(Wt1 – Wt2)/ Wt1] × 100

Where Wt1= Weight of sample before drying

Wt2= Weight of sample after drying

Starch content

Starch content was determined based on the study of Lafont-Mendoza *et al.* (2018). In this procedure, 0.02 grams of starch sample was mixed into 10 ml of distilled water and poured into 100 ml of boiling distilled water as starch solution. The solution was stirred thoroughly and boiled for 1 minute was set aside to cool down. In determining the starch content, three (3) ml of starch solution was placed in a test tube and a drop of iodine-KI reagent was added and the intensity of the blue color was produced. The solution was placed in cuvette and the absorbance was read using the GENESYS 10S UV/VIS Spectrophotometer at 490 nm. The procedure was repeated in triplicate. The starch content formula adapted from the study of Onitilo *et al.* (2007) and calculated as follows:

Starch = [(Absorbance % 0.0044)4]/ (Sample weight × 0.55)

Film preparation

In this study, starch, sorbitol, vinegar, and water are the ingredients for making the bioplastic. The film preparation procedures are described as follows (Arikan and Bilgen, 2019) with some modification of plasticizer (sorbitol). The ingredients were mixed in the following ratio: 30 grams starch: 5 ml plasticizer: 5 ml vinegar: 60 ml distilled water and heated on a medium-low in electric stove. While heating, the mixture was stirred until it thickened. It was then removed from the heat and was placed flat in banana leaves while it is hot. The sample was set to dry for 2 days in room temperature. After drying, the film sample was removed from the banana leaves and was observed.

Soil burial test

The determination of decomposition of the bioplastic film was based on the study of Obasi *et al.* (2013). Soil burial test was carried out on a laboratory scale to examine the biodegradability of the sample film from rambutan seed starch. Wet alluvial soil was placed into plastic containers with tiny holes perforated at the bottom and on the side of the container to increase air and water circulation. The soil was kept moist with water and stored outside the room throughout the test period. Film samples were buried in the soil at a depth of 10 cm from the surface and were subjected to the action of microorganisms which are normally present in the soil. Sample checking took place once in every two days followed by weighing and putting it back again in the soil. Observations were recorded until sample degrades completely in soil. The microbial resistance formula adapted from Wahyuningtyas and Suryanto (2017) was calculated as follows:

Microbial Resistance (%) = Final Mass- Initial Mass × 100

Results and discussion

Starch extraction

Increasing weights of seeds were extracted with different volume of water added with a ratio of 1:1 (w/v) given the same precipitation time which yield increased weight of starch as shown in Table 1.

Table 1. Extraction of starch from rambutan seeds

Weight of seeds	Volume of water added	Weight of starch produced
100 g	100 ml	11.22 g
150 g	150 ml	19.16 g
250 g	250 ml	30.32 g

The starch produced in every trial was increasing. However it was noted during the starch extraction that oil was also produced. The researchers removed the oil manually thus it is possible that there are still remaining impurities present such as fats. Ginting *et al.* (2017) pointed out that the quality and weight of starch produced is affected by the presence of fats.

Characterization of rambutan starch

Characterization of rambutan seeds starch was conducted to determine the percentage of starch produced, ash content and water content and results are presented in Table 2.

Table 2. Chemical composition of rambutan seeds starch

Component	Percentage (%)	SII (%)
Ash content	1.33	max 1.5
Moisture content	79.6	max 14
Starch content	22.83	min 75

SII=Standard Indonesian Industry

Of the three components of the starch analyzed in this study, only the ash content meets the Standard Indonesia Industry (SII) which favors film formation (Santana *et al.*, 2018). Based on Standard Indonesia Industry (SII), ash content was at least 1.5% (Ginting *et al.*, 2018) and rambutan seed ash content has 1.33 %. Hassan *et al.* (2013) stated that the low ash content is a sign of the great quality of the starches because sometimes high mineral content makes decelerate some of the microorganism growth.

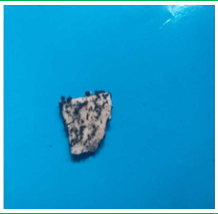
The moisture content of rambutan seed starch was found to be 79.6%. The moisture content was quite high compared to the maximum standard which is 18%. High moisture content makes it prone to colonization of microbes and cause the starch to be discolored (Omotoso *et al.*, 2015). This gives an explanation why molds started to appear after two days of observation.

The starch content is the total amount of starch contained in the dry matter expressed in percent. In this study the starch content was obtained by measuring the absorbance using the GENESYS 10S UV/VIS Spectrophotometer at 490 nm. The starch content of the rambutan seed is 22.83% and was quite lower than the minimum standard which is 75%. It can be possible that the given result was affected by the level of purity during the process of starch extraction. The more impurities in the starch powder results to lower starch content it produced (Ginting *et al.*,2017).

Film preparation

For the film preparation, four trials have been made. The ratio of starch, plasticizer, water and acid was followed based on the procedure presented in the methodology. The bioplastic film formed cracks after 2 days of observation and molds are starting to appear. It can be possible that the fat from the sample was not fully retrieved using manual fat extraction in which it forms complexes with the starch and affects the film formation and gives rise to brittleness of the film.

Table 3. Reduction of the bioplastic from rambutan seeds

Degradation of bioplastics from rambutan seeds				
3 days	6 days	9 days	12 days	15 days
				Completely degraded

According to Shamekh (2002), the desired fat content in a starch is as small as possible because the presence of fat in the starch also form complexes with the amylose thus it hinders the release of amylose from the granules during the gelatinization. In addition, Singh and Nath (2013) stated that lipids may negatively influence the swelling of the starch granule, change the gelatinization temperature, and limit amylose retrogradation, giving rise to brittle bioplastics. In the study of Nauli *et al.* (2012), the fat content in the rambutan seed was 38.9% which is considered to be quite high resulting to affect the gelatinization process.

It can also be possible that the moisture content of the starch also affects the bioplastic formation. High moisture content affects the quality, durability and freshness of starch (Ginting *et al.*, 2018). Since rambutan seed starch contained considerably high moisture content, it favors microbial development and prone to colonization by organism (Wembabazi *et al.*, 2014) which caused the molds to appear on the film in the first two days of observation.

Determining the decomposition period

Biodegradability of bioplastics was determined using soil burial degradation test. Bioplastics were buried in the soil with controlled heat and moisture. Prior to burial, the initial mass (mass before degradation) was determined. The final mass (mass after degradation) of the bioplastics was measured afterwards (Wahyuningtyas *et al.*, 2017).

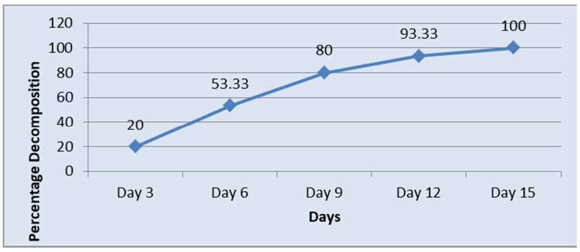


Fig. 1. Results of bioplastics degradation testing

As shown in Table 3, samples broke down into small pieces in 3 days. There are visible changes in the film after 6 days of observation but the complete degradation occurred on the fifteenth day. The mass reduction in bioplastics took place after 3, 6, 9, 12 days. The mass of bioplastics buried for 6 days was reduced by more than 50% (as shown in Fig. 1). This mass loss in bioplastics happened because it is made from natural materials which were easily digested by microbes. After the bioplastic absorbs water from the soil, hydroxyl group in the starch initiated the hydrolysis reaction; due to this reaction, the film was decomposed into small pieces and quickly disappeared (Wahyuningtyas *et al.*, 2017).

Conclusion

This study concluded that starch from rambutan seeds can be a potential material for bio plastics production. It is found out in this study that the more seeds sample the more starch was produced. Although the starch content of rambutan seed obtained was 22.83% but its low ash content favors bioplastic film formation. The complete degradation of the bioplastic film formed from rambutan seed is fast making it a potential bioplastic material. It is recommended that further investigation will be conducted on the possible factors that will be considered to produce bioplastic film that is of good quality. With the knowledge gained in this study, proper fat extraction of the sample could possibly increase the content of starch. Additionally, proper defatting of starch is highly recommended to effectively remove fat from the starch that may hinder the release of amylose for a favorable film formation and removal of water to lessen the moisture is a must to improve its quality and will not favor microbial growth of the bioplastic.

References

AOAC. 1990. Official Methods of Analysis of the Association of Official's Analytical Chemists, 14th Ed. Association of Official Analytical Chemist, Washington D.C., 223-225.

Arikan EB, Bilgen HD. 2019. Production of bioplastic from potato peel waste and investigation of its biodegradability. International Advanced Researches and Engineering Journal **03(02)**, 093-097. https://doi.org/10.35860/iarej.420633

Barnes DKA, Galgani F, Thompson RC, Barlaz M. 2009. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B: Biological Sciences **364(1526)**, 1985-1998. https://doi.org/10.1098/rstb.2008.0205

Gadhave RV, Das A, Mahanwar PA, Gadekar PT. 2018. Starch Based Bio-Plastics: The Future of Sustainable Packaging. Open Journal of Polymer Chemistry **08(02)**, 21-33. https://doi.org/10.4236/ojpchem.2018.82003

Geyer R, Jambeck JR, Law KL. 2017. Production, use, and fate of all plastics ever made - Supplementary Information. Science Advances **3(7)**, 19-24. https://doi.org/10.1126/sciadv.1700782

Ginting MHS, Hasibuan R, Lubis R, Tanjung DS, Iqbal N. 2017. Effect of Hydrochloric Acid Concentration as Chitosan Solvent on Mechanical Properties of Bioplastics from Durian Seed Starch (*Durio zibethinus*) with Filler Chitosan and Plasticizer Sorbitol. IOP Conference Series: Materials Science and Engineering **180**. https://doi.org/10.1088/1757-899X/180/1/012126

Ginting MHS, Hasibuan R, Lubis M, Alanjani F, Winoto FA, Siregar RC. 2018. Supply of avocado starch (*Persea americana* Mill) as bioplastic material. IOP Conference Series: Materials Science and Engineering **309(1)**. https://doi.org/10.1088/1757-899X/309/1/012098

Hassan LGH. 2013. Extraction and Characterisation of Starches from Four Varieties of *Mangifera indica* Seeds. IOSR Journal of Applied Chemistry **3(6)**, 16-23. https://doi.org/10.9790/5736-0361623

Lafont-Mendoza JJ, Severiche-Sierra CA, Jaimes-Morales J. 2018. Evaluation of the Starch Quantification Methods of *Musa paradisiaca, Manihot esculenta,* and *Dioscorea trifida* Using Factorial Experiments. International Journal of Food Science **2018**, 7. https://doi.org/10.1155/2018/5901930

Mbey JA, Hoppe S, Thomas F. 2012. Cassava starch-kaolinite composite film. Effect of clay content and clay modification on film properties. Carbohydrate Polymers **88(1)**, 213-222. https://doi.org/10.1016/j.carbpol.2011.11.091

Nauli HS, Nazaruddin R, Nazanin V, Mamot S. 2012. Physicochemical and Nutritional Composition of Rambutan Anak Sekolah (*Nephellium lappaceum* L.) Seed and Seed Oil. Pakistan Journal of Nutrition **11(11)**, 1073-1077.

Obasi HC, Igwe IO, Madufor IC. 2013. Effect of soil burial on tensile properties of polypropylene/plasticized cassava starch blends. Advances in Materials Science and Engineering **2013**, https://doi.org/10.1155/2013/326538

Omotoso MA, Ayorinde GO, Akinsanoye OA. 2015. Preparation of Biodegradable Plastic Films from Tuber and Root Starches. IOSR Journal of Applied Chemistry (IOSR-JAC) **8(4)**, 10-20.

Onitilo MO, Sanni LO, Daniel I, Maziya-Dixon B, Dixon A. 2007. Physicochemical and functional properties of native starches from cassava varieties in Southwest Nigeria. Journal of Food, Agriculture and Environment **5(3-4)**, 108-114.

Reddy RL, Reddy VS, Gupta GA. 2008. Study of Bio-plastics As Green & Sustainable Alternative to Plastics. International Journal of Emerging Technology and Advanced Engineering **9001(5).**

Santana RF, Bonomo RCF, Gandolfi ORR, Rodrigues LB, Santos LS, dos Santos Pires AC, de Oliveira CP, da Costa Ilhéu Fontan R, Veloso CM. 2018. Characterization of starch-based bioplastics from jackfruit seed plasticized with glycerol. Journal of Food Science and Technology **55(1)**, 278-286. https://doi.org/10.1007/s13197-017-2936-6

Shamekh SS. 2002. Effects of lipids, heating and enzymatic treatment on starches. VTT Publications **460**, 3-43.

Singh AV, Nath LK. 2013. Evaluation of chemically modified hydrophobic sago starch as a carrier for controlled drug delivery. Saudi Pharmaceutical Journal **21(2)**, 193-200. https://doi.org/10.1016/j.jsps.2012.05.005

Song JH, Murphy RJ, Narayan R, Davies GBH. 2009. Biodegradable and compostable alternatives to conventional plastics. Philosophical Transactions of the Royal Society B: Biological Sciences **364(1526)**, 2127-2139. https://doi.org/10.1098/rstb.2008.0289

Wahyuningtyas N, Suryanto H. 2017. Analysis of Biodegradation of Bioplastics Made of Cassava Starch. Journal of Mechanical Engineering Science and Technology **1(1)**, 24-31. https://doi.org/10.17977/um016v1i12017p024

Wembabazi E, Nuwamanya E, Baguma Y, Wembabazi E, Rubaihayo P. 2014. A Comparative study of the physicochemical properties of starches from root, tuber and cereal crops. African Journal of Biotechnology **10(56)**, 12018-12030. https://doi.org/10.5897/AJB10.2310