Asian Journal of Multidisciplinary Studies
Vol. 1, No. 1, (2018)
ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

Fruit and Vegetable Wastes as Potential Component of Biodegradable Plastic

Rency Mecy Orenia, Alejandro Collado III, Mary Grace Magno, Lina T. Cancino
BS Biology, Natural Science Department, Pangasinan State University, Lingayen Campus
Lingayen, Pangasinan, Philippines

Abstract - *Plastic is a material that is very useful to every individual. Commercially plastics that are often used nowadays are petroleum based polymers which take longer years to degrade. These plastics when burned have a negative impact to human and to the environment. They have also detrimental effect to the marine and other aquatic lives when disposed to oceans and other bodies of water. Due to the increasing plastic waste all over the world, researchers are seeking for an alternative that can pass the requirements to be called biodegradable. This study utilized fruit and vegetable wastes as a component in making biodegradable plastic and used additives such as: polyvinyl alcohol as binder, glycerin as plasticizer, soya oil as stabilizer and 5 ml glacial acetic acid. Different formulations were carried out. The products produced were subjected into different tests such as: biodegradability test, chemical solubility test, air test and tensile stress test and were compared to one another. The tests conducted suggest that Formulation 5, which contains 100 g powdered peels, has the largest tensile stress indicating that it has the most tensile strength with considerable biodegradation and chemical solubility..*

Keywords – Biodegradability, Bioplastic, Biopolymer

INTRODUCTION

Plastics are used by most people almost every day, everywhere. It is considered as the most used polymer in our daily lives as it is cheap, readily available, is durable and has flexible material. Plastic polymers are made from building blocks of monomers and are used as packaging, automobile parts, in industries and other things that aid human needs. Due to the robust property of plastic, the production and demand of it is ever increasing [1]. Applications and uses of plastic have many advantages for industrial and human purposes [2]. Although it is proven to have many advantages, environmental impact of plastic is still an issue worldwide. The generation of public waste is expected to continue growing due to the increasing needs and population growth of humans around the globe [3]. As of 2015, approximately 6,300 metric tons of plastic wastes had been generated, around 9% of which had been recycled, 12% was incinerated and 79% was accumulated in the natural environment [4]. Plastic takes hundreds of years to decompose. The production of plastics contributes negatively to our planet's energy problem, since it utilizes nonrenewable resources of petroleum and natural gas. Nowadays, millions of oil barrels are used to manufacture plastics, which are estimated to be 8% of the global petroleum consumption [5]. Because plastic uses limited fossil resources and is non-biodegradable, which make plastic a waste for a very long time and may cause many risks to human health and to the environment [6].

It is in this sense that caught the researchers' deep concern in looking into the safety of human health and in finding some solutions to environmental problems. As cited by Garcia et al. [7] in their study that due to the risks brought by the conventional plastics, it is now becoming mandatory to direct research efforts toward innovative and cost-effective fabrication of environmentally degradable plastics demonstrating performances similar to conventional ones. One of which is the introduction of biodegradable plastics or bio-plastic. Bio-plastic imposes significance in combating the environmental problems brought by conventional plastics. Reducing the dependence on fossil fuels and the related environmental impacts are the contribution of bio-plastics [8]. Bio-based plastics are made with natural based materials. Bio-plastics are type of plastic made perfectly or wholly from natural polymers acquired from renewable biomass that can be degraded through natural process by microorganisms [9]. Thus, this type of plastic can help reduce waste disposal problems. Moreover, bioplastics can be manufactured from easily available cheap materials containing of stored or extracted starch and or cellulose which are naturally occurring polymer [8].

Growing population requires more production of food to sustain life. Most of the foods people eat today are fruits and vegetables which are known to be healthier than meat. Many fruits and vegetable wastes are being left in the market. Hence, fruits and vegetables, being rich in starch and cellulose, have been considered as a potential feedstock for the production of bio-fuels [10]. Cellulose is the most abundant renewable polymer in nature, being the main building component of our planet's vegetation. It is a crystalline unbranched polymer with straight chain conformation, ideal for the formation of strong fibers. Similarly, starch too is a natural polymer that is usually found in some fruits. Starch consists of two types of polysaccharides, amylase and amylopectin. Amylose and amylopectin are considered as a potential for bioplastic production [11].

It is the great desire of the researchers to look into the safety and welfare of the environment. Thus, it is in this aspect that this study had been considered that is - the fruit and vegetable wastes as a potential component of biodegradable plastic.

OBJECTIVES OF THE STUDY

This study was geared to the development of a biodegradable plastic using different combinations of natural occurring polymers from fruit and vegetable wastes. It aimed to make a good, environment-friendly, and toxic-free bioplastic. Also, it aimed to create a biodegradable plastic and a bioplastic that will match the quality in terms of tensile stress and chemical resistance of many conventional plastics being used today.

MATERIALS AND METHOD

Duration and Locale of the Study

The experimentations for the production of bioplastics were conducted at Chemistry Laboratory of Pangasinan State University, Lingayen Campus. Tests for different characteristics were also done in the same laboratory on February to April, 2018.

Collection of Fruit and Vegetable Wastes

Fresh fruit and vegetable wastes were collected from the local market of Lingayen, Pangasinan. The peels were washed with tap water and were sun dried for 24 hours.

Preparation of chemicals

The Polyvinyl alcohol was bought from Tough Stony Scientific Lab, Inc. located in Sta.Cruz, Manila. The glycerin, glacial acetic acid and soya oil were bought in Limpan Merchandise located in Dagupan City. The acetone and distilled water were bought from Mercury Drugstore in Lingayen, Pangasinan. The collected, washed and sun dried fruit and vegetable wastes were used for the production of bioplastic.

Fiftygrams of polyvinylalcohol was diluted in 100 ml distilled cold water to avoid formation of lumps, as it becomes sticky and the tendency to form lumps increases as temperature rises [12]. The soya oil, glacial acetic acid and glycerin were measured using a graduated cylinder.

Production of plastic

The collected peels were washed well with distilled water and drained. They were dried in an oven at 40°C overnight. The peels were further sundried until all the moisture content evaporated. The dried peels were chopped into small pieces and grinded until powdered form. Table 1 presents the different bioplastic formulations. Five beakers were prepared and labeled as F1 for fomulation1 which was served as negative control, F2 for formulation 2, F3 for formulation, F4 for formulation 4 and F5 for formulation 5. For every beaker, a 300 ml of distilled was poured and boiled. While boiling, a desired amount of powdered peels which are : 25 g, 50 g, 75 g and 100 g were added into a beaker no 2 to no.4 respectively , then for beaker no.1 to 5, a solution of 55 ml polyvinyl alcohol diluted with 100ml water was added to the hot mixture and mix thoroughly. While boiling, 2.5 ml soya oil, 5 ml glacial acetic acid and 90 ml glycerin were added in every beaker. The mixture was continuously stirred until a sticky appearance was obtained. The hot sticky mixture was poured into the pan covered with foil. It was then flattened to produce a thin bioplastic film. This was sundried for two to three days. The produced bioplastic were then kept in an open pan for testing.

Table 1.Bioplastic formulations

Component	Formulation 1 (Negative Control)	Formulation 2	Formulation 3	Formulation 4	Formulation 5
Powdered Peels	---	25 grams	50 grams	75 grams	100 grams
Polyvinyl Alcohol (ml)	55 ml	55 ml	55 ml	55 ml	55 ml
Soya Oil (ml)	2.5 ml	2.5 ml	2.5 ml	2.5 ml	2.5 ml
Glacial Acetic Acid (ml)	5 ml	5 ml	5 ml	5 ml	5 ml
Distilled Water (ml)	300 ml	300 ml	300 ml	300 ml	300 ml
Glycerin	90 ml	90 ml	90 ml	90 ml	90 ml

Determination of the Different Characteristics of Biodegradable Plastic

To determine the different characteristics of the produced biodegradable plastics, samples of each of the different bioplastics formulations were cut into strips. Three replicates of the different formulations together with the negative control were subjected for several testing. These were labeled as: F1 for negative control, F2 for 25 gram peels, F3 for 50 gram peels, F4 for 75 gram peels and F5 for 100 gram peels.

Biodegradability Test

The samples of the different formulations together with the negative control with the dimension of 20mm length and 10 mm width were labeled accordingly and were buried in a soil 10 cm. deep [13]. After two weeks, samples were unearthed and the observations were noted and scored as accordingly as to: 1 = not degraded 2 = partially degraded and 3 = completely degraded.

Solubility Test

Test to ascertain their solubility was also conducted by using another set of samples of the different bioplastics formulations with a dimension of 20mm length and 10 mm width. They were immersed individually in various inorganic solvents such as: distilled water, 35% sulfuric acid and 10% ammonia and organic solvents namely: 70% ethyl alcohol, commercial acetone and glacial acetic acid. Five ml of every solvent were poured into a petri dish and the samples of Formulation 1 to Formulation 5 were put into it respectively. The samples were immersed for 2 hours and observe their changes in appearance. They were scored accordingly as to: 1 = insoluble; 2 = partially soluble and 3 = completely soluble.

Air Test

The bioplastic samples with a dimension of 20mm length and 10 mm width were exposed to open air for a week. The changes in the physical appearance were noted and scored as to: 1 = no change and 2 = crinkled.

Tensile Stress

Samples of each of the bioplastics of different formulations were taken and cut with the dimension of 100mm for height, 19 mm for length and 0.1 mm thick each. Three replicates of the different formulations were used and a 200 g load was hanged into each sample. The initial length and the final length after loading were recorded and solved for the Strain; The Hook's Law for determining the stress was used:

Tensile Stress = E (Strain) in N/mm^2

$$\text{And } E = \frac{F\,(L_o)}{A\,(\Delta L)}$$

Where:

E is the modulus of elasticity or Young's modulus, a material property that describes its stiffness in N/mm^2

A is the area perpendicular to the tensile stress in mm^2

Lo is the initial length in mm

Lf is the final length in mm

Strain is computed as (Lf-Lo) / Lo

Data Analysis

After all the tests were done, the recorded results and data were analyzed by Analysis of Variance (ANOVA). ANOVA is a statistical technique that assesses potential differences in a scale-level dependent variable by a nominal-level variable having 2 or more categories. A Scheffe Test was also used for one-way test comparison; it is a statistical test that is used to make unplanned comparisons, rather than pre-planned comparisons, among group means in an analysis of variance (ANOVA) experiment. These tests also showed which formulation is the best in terms of the various tests conducted.

RESULTS AND DISCUSSION

Biodegradability Test

The products used for testing were coded and labeled with Formulation 1 to Formulation 5. Formulation 1 as the negative control, Formulation 2 for 25 gram peels, Formulation 3 for 50 gram peels, Formulation 4 for 75 gram peels, Formulation 5 for 100 gram peels.

As stated by the American Society for Testing Materials (ASTM) in 2011 [14], a bioplastic to be considered biodegradable should degrade naturally in a short period of time. Therefore, the first test done was the biodegradability. After 2 weeks of being buried, the exhumed plastic strips were graded and scored accordingly. They were graded as 1 = not degraded, 2 = partially degraded and 3 = completely degraded as used by [15].

In Table 3, a quantitative result of biodegradability test based on the descriptive interpretation of the different bioplastic formulations are shown. The table shows that the Formulation 1 which is the negative control was partially degraded after two weeks of being buried. The negative control is a mixture of chemicals which are polyvinyl alcohol, soya oil, glacial acetic acid, glycerin and distilled water.

Asian Journal of Multidisciplinary Studies
Vol. 1, No. 1, (2018)
ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

Table 3. Results of the biodegradability test of the different formulations

Formulation	Replicate	Biodegradability Result
1 (Negative control)	1	2
	2	2
	3	3
2 (25 g peels)	1	3
	2	3
	3	3
3 (50 g peels)	1	3
	2	3
	3	3
4 (75 g peels)	1	3
	2	3
	3	3
5 (100 g peels)	1	3

Table 3 shows that the formulation 2 to formulation 5 was completely degraded. The presence of peels attributed to the complete degradation of the samples because the peels have a property to be easily degraded [16]. It can also be supported by another study conducted that the presence of Polyvinyl alcohol (PVA) also helps in the degradation of the samples because it can be completely mineralized by microorganisms [17].

A similar study was done where there is also a rapid degradation in their product [13]. The rapid degradation is due to the composting process, which occurred in two stages: an active composting stage and a curing period. In the first stage, the temperature rose and remained elevated as long as there was available oxygen, which resulted in strong microbial activity, while on the second stage, the temperature decreased but the plastic strips continued to compost at a slower rate [18].

It can be noted from Table 4 that the p value between the different formulations is 1.00 which is greater than .05 level of significance. This simply means that they are not statistically significant so, the null hypothesis that there is no significant difference among the different formulations is thereby .accepted. Thus, the bioplastics made from peels of different formulation together with the negative control are comparable in terms of biodegradability.

Another statistical tool was used to further analyze the significant differences of different formulations as compared to negative control in terms of biodegradability which is the Scheffe test.

Table 5, presents the significant difference for biodegradability test of the different formulations using Scheffe .The tabulated result of the negative control and the result of every formulation in triplicate form were also included. P values as well as their interpretations whether significant or not are also indicated.

Asian Journal of Multidisciplinary Studies
Vol. 1, No. 1, (2018)
ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

Table 4. Significant difference for biodegradability test of the different formulations.

	F	P value	Significance
Between Groups	4.000	1.000	Not significant
Total		1.000	

**The mean difference is significant at the 0.05 level.*

Table 5. Significant difference for biodegradability test of the different formulations using Scheffe

(I) TRT	(J) TRT	Mean Difference (I-J)	P value	Significance
1.00	2.00	-.66667	.109	Not significant
	3.00	-.66667	.109	Not significant
	4.00	-.66667	.109	Not significant
	5.00	-.66667	.109	Not Significant
2.00	1.00	.66667	.109	Not significant
	3.00	.00000	1.000	Not significant
	4.00	.00000	1.000	Not significant
	5.00	.00000	1.000	Not significant
3.00	1.00	.66667	.109	Not significant
	2.00	.00000	1.000	Not significant
	4.00	.00000	1.000	Not significant
	5.00	.00000	1.000	Not significant
4.00	1.00	.66667	.109	Not significant
	2.00	.00000	1.000	Not significant
	3.00	.00000	1.000	Not significant
	5.00	.00000	1.000	Not significant
5.00	1.00	.66667	.109	Not significant
	2.00	.00000	1.000	Not significant
	3.00	.00000	1.000	Not significant
	4.00	.00000	1.000	Not significant

It can be gleaned from Table 5, that all formulations are not statistically significant having the p values greater than the level of significance which is 0.05 leading to the acceptance of the null hypotheses. This simply means that the different formulations and the negative control have almost the same results in terms of biodegradability, as it was proven during the experimentation that all of different formulations with powdered peels degraded.

Chemical Solubility

Chemical solubility is the property of solid, liquid, or gaseous chemical substance called solute to dissolve in a solid, liquid, or gaseous solvent. This test investigates the capacity of the formulated plastic to remain robust after exposing to different kinds of organic and inorganic chemicals. The different bioplastic formulations including the negative control were properly labeled and immersed in the various solvents at the same time. Solubility is another important characteristic feature, where it is essential to have bioplastic material which is less soluble in water than any other solvents [15].

The bioplastics were immersed in ethyl alcohol, acetone, ammonia, distilled water, glacial acetic acid and sulfuric acid. The changes in the physical appearance were recorded and scored as to: 1 = insoluble, 2 = partially soluble and 3 = completely soluble.

Asian Journal of Multidisciplinary Studies
Vol. 1, No. 1, (2018)
ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

Table 6. Results in the chemical solubility of the different formulations

Formulation	Replicate	Ethyl Alcohol (70 %)	Acetone	Glacial Acetic Acid	Ammonia (10%)	Sulfuric Acid	Water
1 (negative control)	1	1	1	2	3	3	3
	2	1	1	2	3	3	3
	3	1	1	2	3	3	3
2 (25 g peels)	1	1	1	1	2	3	2
	2	1	1	1	2	2	2
	3	1	1	1	2	2	2
3 (50 g peels)	1	1	1	1	1	2	2
	2	1	1	1	2	2	2
	3	1	1	1	2	1	1
4 (75 g peels)	1	1	1	1	2	1	1
	2	1	1	1	1	1	1
	3	1	1	1	1	1	1
5 (100g peels)	1	1	1	1	1	1	1
	2	1	1	1	1	1	1
	3	1	1	1	1	1	1

It can be perceived from Table 5, that all the samples and negative control when immersed in 70% ethyl alcohol and acetone have similar quantitative value of 1 which means that no reaction was observed during the test which indicates that they are insoluble. According to [19], binder such as polyvinyl alcohol is insoluble in organic solvents. This is the reason why all the formulations of the produced bioplastic are insoluble in ethyl alcohol, acetone and glacial acetic acid. The reaction of negative control from the different formulations varies when the samples were immersed in glacial acetic acid. The negative control is partially soluble while the different formulations are all insoluble. For the reaction of different samples into ammonia, it was noted that the formulation 1 which is the negative control and contains purely the chemicals was soluble, while formulation 2 to formulation 3 had an average quantitative value of 2 with a qualitative description as partially soluble. Formulation 4 is insoluble to ammonia. Similarly, the effect of sulfuric acid differs for every formulation. In Formulation 1,all the replicates became completely soluble; formulation 2 and formulation 3 became partially soluble. The different formulation also showed physical changes in appearance when immersed in water and sulfuric acid. Discrepancies of results in every formulation were noted because physical properties of the polymer have an effect in its solubility, particularly for liquids that cause appreciable swelling. In order to be absorbed into a polymer, there must be a sufficient space so that the polymer will have a chain flexibility to accommodate a liquid molecule [20].

Asian Journal of Multidisciplinary Studies
Vol. 1, No. 1, (2018)
ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

Table 7. Significant difference for solubility test of the different formulations using one way ANOVA.

		F	P value	Sig.
AMMONIA	Between Groups	.66667	.351	Not significant
SULFURIC	Between Groups	23.500	.000	Significant
WATER	Between Groups	17.000	.000	Significant

Table 8. Significant difference solubility of the different formulations when immersed to ammonia using Scheffe Test.

Dependent Variable		(I) TRT	(J) TRT	Mean Difference (I-J)	P value	Significant
AMMONIA	Scf	1	2	.66667	.351	Not significant
			3	1.000	.084	Not significant
			4	.66667	.351	Not significant
			5	1.00000	.084	Not significant
		2	1	-.66667	.351	Not significant
			3	33333	.883	Not significant
			4	.0000	1.0000	Not significant
			5	.33333	.883	Not significant
		3	1	-1.000	.084	Not significant
			2	-.33333	.863	Not significant
			4	-.33333	.863	Not significant
			5	.0000	1.000	Not significant
		4	1	-.66667	.351	Not significant
			2	.0000	1.000	Not significant
			3	.3333	.863	Not significant
			5	.3333	.883	Not significant
		5	1	-1.00000	.084	Not significant
			2	-.3333	.863	Not significant
			3	.00000	1.000	Not significant
			4	-.33333	.883	Not significant

Asian Journal of Multidisciplinary Studies
Vol. 1, No. 1, (2018)
ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

Table 9. Significant difference for solubility test result of the different in sulfuric using the Scheffe test.

Dependent Variable	(I) TRT		(J) TRT	Mean Difference (I-J)	Sig.	Significance
Sulfuric	Scheffe	1	2	.66667	.109	Not significance
			3	1.000*	.012	Significant
			4	1.000*	.012	Significant
			5	2.000*	.000	Significant
		2	1	-.66667	.109	Not significant
			3	.33333	.655	Not significant
			4	.33333	.655	Not significant
			5	1.333*	.002	Significant
		3	1	-1.000*	.012	Significant
			2	-.333	.655	Not significant
			4	.000	1.000	Not significant
			5	1.000*	.012	Significant
		4	1	-1.000*	.012	Significant
			2	-.333	.655	Not significant
			3	.000	1.000	Not significant
			5	1.000*	.012	Significant
		5	1	-2.000*	.000	Significant
			2	-1.333*	.002	Significant
			3	-1.000*	.012	Significant
			4	-1.000*	.012	Significant

The table shows that all of the formulations has a pvalue greater than 0.05 level of significance which means that they are not statistically significant. Since all formulations except formulation 1contain peels, thus they have the same effect in terms of solubility when immersed in ammonia.

The result to the ammonia test indicates that no change was happened to the bioplastic. The ammonia test describes the ability of the formulations that contain peels to remain intact even when exposed to ammonia. Ammonia is one of the materials for cleaning products. Another similar study, made by [15] which focused on banana peels to produce plastic films, their study proves that peels used in the formulation are stable and intact.

Table 9 shows the p value of the different formulations. It can be noticed that the Formulation 1 (negative control) when compared to Formulation, 3, 4 and 5 showed a significant value lesser than 0.05. However, Formulation 2 have a p value greater than 0.05 indicating that the Formulation 2 has almost the same reaction with that of negative control in maybe because of the least amount of peels contained in it.

When comparing formulation 2 to some other formulations, only the Formulation 5 shows the significant difference. Thus, Formulation 1,3 and 4 are not statistically significant.

In Formulation 3 compared to other formulations, Formulation 1 and 5 have a p value lesser than 0.05 and are statistically significant. Formulation 2 and Formulation 4 are not statistically significant when compared to Formulation 3.

Formulation 4 compared to some other formulations, Formulation 1 and 5 have a p value lesser than 0.05 and are statistically significant. Formulation 2 and Formulation 3 are not statistically significant when compared to Formulation 4.

However, the comparison of Formulation 5 to other formulations shows a significant difference thereby rejecting the null hypothesis. This may be due to the large amount of peels content that makes them

ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

intact as confirmed by [15] in their study using banana peels.

Table 10. Significant difference for the solubility of the different formulations in water using the Scheffe test.

Dependent Variable	(I) TRT		(J) TRT	Mean Difference (I-J)	P Value	Significance
WATER	Scheffe	1	2	.66667	.351	Not significant
			3	1.333*	.018	Significant
			4	2.000*	.001	Significant
			5	2.000*	.001	Significant
		2	1	-.66667	.351	Not significant
			3	.66667	.351	Not significant
			4	1.333*	.018	Significant
			5	1.333*	.018	Significant
		3	1	-1.333*	.018	Significant
			2	-.66667	.351	Not significant
			4	.66667	.351	Not significant
			5	.66667	.351	Not significant
		4	1	-2.000*	.001	Significant
			2	-1.333*	.018	Significant
			3	-.66667	.351	Not significant
			5	.000	1.000	Not significant
		5	1	-2.000*	.001	Significant
			2	-1.333*	.018	Significant
			3	-.66667	.351	Not significant
			4	.000	1.000	Not significant

In Table 10, when Formulation 1 was compared to Formulation 2, 3, 4 and 5, only the formulation 2 has a p value greater than 0.05 and shows no significant difference. All other formulations are significant. Similarly, in comparing Formulation 2 to others, the Formulation 1 and 3 shows no significant difference while Formulation 4 and Formulation 5 are highly significant.

For formulation 3 comparison with respect to others, only the Formulation 1 shows a significant difference. When Formulation 4 was compared to Formulation1, 2, 3 and 5, Formulation 1 and 2 obtained a p value lesser than 0.05 which means that Formulation 4 has a significant difference to these two formulations. In comparing Formulation 5 to others, Formulation 1 and Formulation 2 show a significant difference while Formulation 3 and Formulation 4 are not significant, which means that the solubility in water of Formulation3,4 and 5 are almost similar.

Air Test

The air test is subjected to test the ability of the plastic to stay intact when left in an open space for 7 days. The table below shows the result visual assessment for the air test.

Table 11, presents the results of the different formulations when exposed to air. The results gathered were acquired through visual assessment. They obtained data were scored accordingly as to 1 = no change and 2 = crinkled.

Table 11. Results in the air test of the different formulations and products

Formulation	Replicates	Change in appearance
1	1	1
	2	1
	3	1
2	1	2
	2	2
	3	2
3	1	2
	2	1
	3	1
4	1	2
	2	1
	3	1
5	1	1
	2	1
	3	1

Table 12. Significant difference for the air test of the different formulations using the One-way ANOVA.

	Mean Square	P value	Significance
Between Groups	.190	.002	Significant

Table 11 provides the recorded data for air test. They are scored according to change in their physical appearance. All of the replicates of Formulation 2 showed a crinkled appearance, while some replicates of Formulation 3 and 4 also showed a crinkled appearance after 7 days of exposure, while the rest of the formulations do not have a change in physical appearance.

The table shows the p value of the air test of 0.002 which indicates that there is a significant difference between groups meaning that the reaction of the different formulations in terms of exposure to air are comparable and almost the same. Thus, the null hypothesis is hereby rejected.

The results for the air test shows that even after exposing to the open space, the formulated bioplastic is still intact. A similar study was conducted that the bioplastic made from agricultural wastes had the same result where no change was observed due to the presence of the organic material [19].

In Table 13, it can be noted that Formulation 2 has a p value lesser than .05 when compared to Formulation 1, 4 and 5, indicating that in terms of the air test, these formulations are significantly different from each other. The rest of the compared formulations are not significantly different.

ISSN 2651-6691 (Print)
ISSN 2651-6705 (Online)

Table 13. Significant Difference for the air test of the different formulations using Scheffe Test.

(I) TRT	(J) TRT	Mean Difference (I-J)	P value	Significance
1.00	2.00	-1.00000*	.012	Significance
	3.00	-.66667	.109	Not significant
	4.00	.00000	1.000	Not significant
	5.00	.00000	1.000	Not significant
2.00	1.00	1.00000*	.012	Significant
	3.00	.33333	.655	Not significant
	4.00	1.00000*	.012	Significant
	5.00	1.00000*	.012	Significant
3.00	1.00	.66667	.109	Not significant
	2.00	-.33333	.655	Not significant
	4.00	.66667	.109	Not significant
	5.00	.66667	.109	Not significant
4.00	1.00	.00000	1.000	Not significant
	2.00	-1.00000*	.012	Significant
	3.00	-.66667	.109	Not significant
	5.00	.00000	1.000	Not significant
5.00	1.00	.00000	1.000	Not significant
	2.00	-1.00000*	.012	Significant
	3.00	-.66667	.109	Not significant
	4.00	.00000	1.000	Not significant

Table 14. Tensile Strain and Tensile Stress of the different formulations of produced bioplastics.

Formulation	Tensile Strain, $\frac{\Delta L}{L_{\circ}}$	Young's Modulus, $\frac{F\,(L_{\circ})}{A\,(\Delta L)}$, N/$mm^2$	Tensile Stress N/mm^2
1	0.13	7.94 N/mm^2	1.0322N/mm^2
	0.13	7.94 N/mm^2	1.0322N/mm^2
	0.13	7.94 N/mm^2	1.0322N/mm^2
2	0.29	3.56 N/mm^2	1.0325N/mm^2
	0.29	3.56 N/mm^2	1.0325N/mm^2
	0.29	3.56 N/mm^2	1.0322N/mm^2
3	0.25	4.13N/mm^2	1.0322N/mm^2
	0.25	4.13 N/mm^2	1.0322N/mm^2
	0.25	4.13 N/mm^2	1.0322N/mm^2
4	0.20	6.18N/mm^2	1.0324N/mm^2
	0.10	11.35 N/mm^2	1.135N/mm^2
	0.23	5.52 N/mm^2	1.0326N/mm^2
5	0.8	13.93 N/mm^2	11.14 N/mm^2
	0.8	13.93 N/mm^2	11.14 N/mm^2
	0.8	13.93 N/mm^2	11.14 N/mm^2

Table 15. Significant difference for tesnsile stress of the different using the one way ANOVA.

	Mean Square	P value	Significance
Between Groups	60.783	.000	Significant

Table 16. Significant difference for the tensile stress of the different formulations using Scheffe

(I) TRT	(J) TRT	Mean Difference (I-J)	P value	Significance
1.00	2.00	.00003	1.000	Not significant
	3.00	.00083	1.000	Not significant
	4.00	-.18383*	.001	Significant
	5.00	-10.10917*	.000	Significant
2.00	1.00	-.00003	1.000	Not significant
	3.00	.00080	1.000	Not significant
	4.00	-.18387*	.001	Significant
	5.00	-10.10920*	.000	Significant
3.00	1.00	-.00083	1.000	Not significant
	2.00	-.00080	1.000	Not significant
	4.00	-.18467*	.001	Significant
	5.00	-10.11000*	.000	Significant
4.00	1.00	.18383*	.001	Significant
	2.00	.18387*	.001	Significant
	3.00	.18467*	.001	Significant
	5.00	-9.92533*	.000	Significant
5.00	1.00	10.10917*	.000	Significant
	2.00	10.10920*	.000	Significant
	3.00	10.11000*	.000	Significant
	4.00	9.92533*	.000	Significant

Tensile Stress

Tensile stress refers to a force that attempts to pull apart or stretch a material It was calculated using the formula of tensile strain, by Young;s Modulus. It shows the ability of the plastic to remain intact after carrying a specific amount of load.

Samples of each of the bioplastics of different formulations were taken and cut with the dimension of 100mm for height, 19 mm for length and 0.1 mm thick each. Three replicates of the different formulations were used and a 200 g load was hanged into each sample.

It can be noted from Table 14 that Formulation 5 which is the biodegradable plastics made from 100 g powdered peels has the highest tensile stress. Formulation 5 that had the highest tensile stress could be due to the quantity of glycerine combined to the large amount of powdered peels used which improve its mechanical strength. The stress of formulation 5 was also higher than that of the negative control and the rest of the formulations which really indicates that it has the greatest tensile strength.

It can be noted from Table 14 that Formulation 5 which is the biodegradable plastics made from 100 g powdered peels has the highest tensile stress. Formulation 5 that had the highest tensile stress could be due to the quantity of glycerine combined to the large amount of powdered peels used which improve its mechanical strength. The stress of formulation 5 was also higher than that of the negative control and the rest of the formulations which really indicates that it has the greatest tensile strength.

The result of the significant difference may be due to the big discrepancy of result obtained in the tensile stress test because Formulation 5 with highest peel content which is 100 g, obtained the highest tensile stress, followed by Formulation 2 . The other formulations with the lesser content of peels had a low tensile stress. The tensile stress of the object is directly proportional to its tensile strength, which means that the Formulation 5 which has the greatest tensile stress has the most tensile strength. Thus, the null hypothesis that there is a significant difference between and among the different formulations is hereby rejected. This confirms the result obtained using one-way ANOVA.

CONCLUSION AND RECOMMENDATION

After all the tests and observation done, it is then concluded that in terms of biodegradability, the different formulations are not significantly different from each other because they degraded naturally. The formulations of 100g peels have an incomparable solubility compared to other formulations. Air test also showed that 100g peels can still be intact after 7 days of exposure into open space. The 100g peels formulation also showed the best result in tensile stress indicating that it has the highest tensile strength. It is therefore concluded that Formulation 5, which contain 100g peels is the best among the different bioplastics formulations.

The bioplastic produced through this method is a preliminary study only and could be substantial and the biodegradable tractability is one of the main challenges in developing bioplastic material. Thus, the following recommendations are hereby considered: (1) To purchase necessary and appropriate equipment, materials and supplies to be used in the several tests of physical and chemical characteristics of bioplastics to attain accurate results. (2) The researchers also recommend the use of an aromatic yet useful component to remove the unpleasant smell of the plastic caused by glycerin and glacial acetic acid.

REFERRENCES

[1] Fathanah, U., Lubis, M.R., Rosnelly, C.M., Moulana, R., 2013, "Making and Characterizing Bioplastic from Cassava (Manihot utilissina)" International Conference of Chemical Engineering on Social Science and Applications. Retrieved on February 2018 from: https://aip.scitation.org/doi/abs/10.1063/1.4965761

[2] Kaewphan, N., Gheewala, S., 2013, "Greenhouse Gas Evaluation and Market Oppurtunity of Bioplastic Bags from Cassava in Thailand", Journal of Sustainable Energy & Environment 4 15-19. Retrieved from: https://pdfs.semanticscholar.org/acc1/63bb395a131016ca1622850fa08cd1863897.pdf

[3] European Commission, 2011. Plastic Waste in the Environment, Final Report.

[4] Geyer, R., Jambeck, K., Law, L., 2017. Production, use and fate of all the plastics ever made.Sci. Adv. 3,e1700782.

[5] Bayer, I.S., Guzman-Puyol, S., Heredia-Guerrero, J.A., Ceseracciu, L., Pignatelli, F., Cingolani, R.R., Athanassiou, A. 2014. Direct Transformation of Edible Vegetable Waste into Bioplastics.

[6] European Commission, 2011. Plastic Waste in the Environment, Final Report.

[7] Garcia, H., Rui Ferreira, R., Celso Martins, C., Andrea, F., Sousa, A.F., Carmen, S.R.,Freire, C.S.R., Silvestre, A.J.D., Kunz, W., Rebelo, L.P.N., Pereira, C.S. 2014. Ex Situ Reconstitution of the Plant Biopolyester Suberin as a Film. Biomacromolecules. DOI: 10.1021/bm500201s. Retrieved from https://vdocuments.site/downloadex-situ-reconstitution-of-the-plant-biopolyester-suberin-as-a-film

[8] Kaewphan, N., Gheewala, S., 2013, "Greenhouse Gas Evaluation and Market Oppurtunity of Bioplastic Bags from Cassava in Thailand", Journal of

Sustainable Energy & Environment 4 15-19. Retrieved from: https://pdfs.semanticscholar.org/acc1/63bb395a131016ca1622850fa08cd1863897.pdf

[9] Goodall C, 2011, Bioplastics: an important component of global sustainability. Retreived on March 2018, from: http://www.biomebioplastics.com/uploads/files/white_paper_doc.pdf.

[10] Singh, A.; Kuila, A.; Adak, S.; Bishai, M.; Barnejee, R., 2012, Utilization of vegetable wastes for bioenergy generation. Agr. Res., 1, 213−222. Retrived on March 2018 from: http://www.academia.edu/8212836/Utilization_of_Vegetable_Wastes_for_Bioenergy_Generation

[11] Mali, S., Grossmann, M.V.E., Garcia, M.A., Martino, M.N. and Zaritzky, N.E., (2002), Microstrucural characterization of yam starch films. Carbohydrate Polymers, 50, 379-386. Retrived from: catalogo.latu.org.uy/opac_css/doc_num.php?explnum_id=946

[12] Silverson Machine, Inc. 2016. Preparation of polyvinyl Alcohol (PVA) Solutions. Retrieved on March 2018 from: http://www.silverson.com/us/resource-library/application-reports/preparation-of-polyvinyl-alcohol-pva-solutions/

[13] Azahari, N.A., Othman, N., Ishmail, H., 2011. Biodegradation Studies of Polyvinyl/Corn Starch Blend Films in Solid and Solution Media. Retrieved on March 2018 from: http://jps.usm.my/studies-of-polyvinyl-alcohol-corn-starch-blend/

[14] ASTM Standards 2011. Standard terminology relating to plastics. Annual Book of ASTM Standards, Vol 8(1), American Society for Testing and Materials, West Conshohocken, PA. D883-96

[15] Yaradoddi, J., Patil, V., Ganachari, S., Banapurmath, N., Hunashyal, A., Shettar, A., 2016 "Biodegradable Plastic Production from Fruit Waste Material and its Sustainable Use for Green Applications" International Journal of Pharmaceutical Research & Allied Sciences. Retrieved on March 2018 from: https://www.researchgate.net/publication/309923037BIODEGRADABLE_PLASTIC_PRODUCTION_FROM_FRUIT_WASTE_MATERIAL_AND_ITS_SUSTAINABLE_USE_FOR_GREEN_APPLICATIONS.

[16] Ghamande, M., Kulkarni, A., Shah. N., Kothari, S., Bhosale, S., 2018. Bio-Plastic (Generating Plastic from Banana Peels). Retrieved on March 2018 from: http://data.conferenceworld.in/25FebEMSSH/9.pdf

[17] Shimao, M., 2001. Biodegradation of plastics. Retrieved from: https://www.googlw.com/url?sa=t&source=web&rct=j&urenvismadrasuniv.org/Biodegradation/pdf/Biodegradation%2520of%2520plastics.pdf&ved=ahUKEwjRn6TjpjbAhVKvbwKHRtBDOgQFjAAegQIBhAB&uusg=AOvVaw0wolqR0q6gIZF16PFhjxt

[18] Kale, G., Kijchavengkul, T., Auras, R., Rubino, M., Selk, S. E. & Singh, S. P. (2007). Compostability of bioplastic packaging materials: An overview. Macromol. Biosci., 7(3), 255–277. Retrieved on November 2017 from: https://onlinelibrary.wiley.com/doi/full/10.1002/mabi.200600168

[19] Jack, I.R., Ngah, S.A., Osagie O.F., Emenike, I.G., 2017. Biodegradable Plastic from Renewable Sources. Retrieved on November 2017 from: https://link.springer.com/article/10.1007/BF02931273

[20] Arnold, J.C., 2003. Environmental Effects on Crack Growthin Polymers. Swansea University. https://www.sciencediect.com/topics/materials-science/solubility-of-polymer