BIODEGRADABLE STRAW

USING SUGARCANE

BAGASSE

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ABSTRACT

In this research, industry waste sugarcane bagasse is used to make a biodegradable straw. The bagasse was washed with water repeatedly and dried in the sun for two days. It was then cooked with caustic soda and water, and blended to the finest pieces with starch. Then the bagasse pulp was molded into a straw shape using parchment paper and dried in an oven. The formed straw was dipped in carnauba wax for coating. A weight gain test was conducted with three trials using room temperature water (25°C), hot water (48°C), and carbonated drink (5°C). After the test, it was found out that the p- values are 0.3739, 1, and 0.1161 respectively with significance level 0.05. Since H_o is accepted in all three tests, this means that bagasse straw has equal capabilities when it comes to water resistance compared with the paper straw (control group). A biodegradability test was conducted with one trial and it was found out that the bagasse straw is biodegradable because of the weight loss after one month.

Keywords: bagasse pulp, biodegradability, biodegradable straws, sugarcane bagasse, water resistance, weight gain,

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Introduction

Background of the Study

The use of plastic products has been growing rampant these days and plastic straws are one of them. Plastic straws are considered a modern significant convenience because help those people with mobility issues and people with some conditions from choking. Furthermore, the straw promotes proper hygiene because it keeps the mouth off the opening of a beverage which may have been stored in unhygienic conditions. It keeps our nose out of the drink, act as a stir, and not tipping the beverage towards the mouth makes it much less likely to spill (LVB, 2018). The only problem is that it cannot fully decompose over the course of more than a million years and be of use to the environment after its single usage (Tapan, 2019). Coming up with a solution for proper plastic disposal has also been a great problem in recent years.

The proposed solution for this problem is paper straws. Paper straws are biodegradable straws and are made out of cellulose fibers. Their main source of cellulose are trees. Paper straws are also made out of recycled paper and the paper used also comes from trees meaning a huge amount of trees are to be cut down in order to produce these paper straws. 14% of deforestation is caused by companies that manufacture paper products in order to satisfy the people's needs and this leads to some of Earth's biggest problems such as global warming, depletion of oxygen, and dispersion of biodiversity (paper on the rocks, 2018). As of today, the resources from which these products are made from are being depleted because manufacturers use trees as their main and largest source of cellulose fibers. As a result these slow-to-develop resources are not able to catch with companies' mass production (Butler, 2015).

Sugarcane bagasse was chosen as the material used in this study because it is an industrial waste that is only used for biofuel. Furthermore, the structure and properties of the material is also similar to that of paper commonly used in industries (CNBM, n.d.). Considering the many options that can be used to produce biofuel compared to the limited kinds of material that can be used in creating a biodegradable straw, sugarcane bagasse was chosen as the new material source for the production of the said product.

Sugarcane fibers have been identified as reinforcement fibers that develop its bio composites or polypropylene which is known for its variety of applications for consumer products packaging, this makes sugarcane bagasse suitable for manufacturing (Biermann, 1996).

The focus of this study is to produce a biodegradable straw out of a waste product from a crop that grows abundant here in the Philippines and prove whether sugarcane bagasse is a good alternative for paper since straws made people's lives more convenient and paper straws were proven ineffective in the long run. Biodegradable straws that are made out of bagasse are proposed to answer both problems.

Objectives of the Study

The purpose of this study is to develop a biodegradable bagasse straw using sugarcane bagasse. Specifically, the study aims to:

- Test different procedures in making a biodegradable bagasse straw using sugarcane bagasse.
- Compare the liquid absorption rate of the two different straws to see whether the biodegradable bagasse straw is more liquid resistant using the weight gain test.

- Determine the biodegradable bagasse straws' biodegradability through the biodegradability test.

Significance of the Study

The results of the study can help spread awareness to the people that sugarcane bagasse is a good alternative for paper and it also contributes in decreasing the chances of plastic pollution of both land and water.

Scope and Limitations of the Study

The estimated time range of the experiment from the extraction of the bagasse to the final outcome of the product ranges from a minimum period of 5 days to a week depending on the quantity of the bagasse extracted because what hinders the speed of the process is how long the material takes to dry naturally. The general budget for this experiment ranges from a minimum amount of 600 pesos (includes raw materials, ingredients, & equipment) to a maximum amount of 1000 pesos which also depends on the amount one desires to produce. At the minimum amount one could successfully produce a dozen of functional straws. Other equipment not included in the budget can only be accessible in laboratories.

The tools needed for this experiment are a source of flame (stove) & water (for rinsing of the raw material), digital weighing scale, thermometer, stirring rod, beaker, plastic containers for the samples, and the metal mold designed by the researchers themselves.

Techniques involve performing the correct method in order for the laboratory tools and devices to work according to their use and common techniques like measuring,

transferring, manual rinsing, etc. The experiment needs a work force with a minimum number of 2-5 personnel in order to finish in the minimum estimated days of completion.

REVIEW OF RELATED LITERATURE AND STUDIES

Foreign Literature

Plastics around the planet stay for a very long time and not more than 10% of it even gets recycled for other beneficial uses (Parker, 2018). Plastics are derived mostly from crude oil which is a mixture of a lot of different compounds refined in an oil refinery further combined with a bunch of other ingredients (Adkins, 2018). The industrial chemicals used to manufacture the latter are thought to be a great source of the cause for atmospheric pollution since they are able to bond with other elements and form compounds which contribute towards the destruction of the ozone layer according to (Mendez, 2018). Plastic has a few organic ingredients in it but what makes it hard to decompose is because most of these products contain polyethylene terephthalate (PET) which is nearly indestructible (Elkins, 2019). Another problem about this material is that every time it is recycled its polymer chain grows shorter thus its quality also decreases revealing there will be a point wherein it can no longer be of use anymore but to be treated as trash and just stay here for a long time to decompose (Soomro, 2019).

For the price of convenience, the people have harmed the planet Earth far more than what they should have limited themselves to. The current population of the world is around 7 Billion now and it is given that people would resort to cheap plastic manufacturing that makes disposable goods for its efficiency and the convenience it provides the people. One common product is the plastic straw, this one commercial product alone pollutes the Earth's oceans in a whopping 8 billion pieces a year before 2020 because of the poor plastic disposal among many countries (Gibbens, 2019). This issue came to light recently because people have realized that awareness is important

therefore a few countries and localities have done a good job with alternative wares. Paper and its cellulose build which come from trees became one of the most popular alternatives for straws hence companies started to utilize the natural resource for it. However, another problem is that this resource from which the paper straw is made from is continuously being depleted because manufacturers use trees as their main and largest source of cellulose fibers. As a result, these slow-to-develop resources are not able to catch up with companies' mass production of paper wares (Butler, 2015).

The researchers decided to take the initiative of attempting to contribute in a solution to this issue through a research using Sugarcane bagasse, the primary material that will be utilized in order to replicate the commercial straw product. Sugarcane bagasse is the dry pulpy fibrous residue that remains after sugarcane is crushed to extract its juice (Augustyn, 2016). Sugarcane bagasse has 50% cellulose, 25% hemicellulose, & 25% lignin. For paper and pulp production, it is normally stored wet in order to assist in removal of the short pith fibers, which impede the paper making process, as well as to remove any remaining sugar (Rainey, 2009). This plant fiber is an industrial waste which has no economic value after sugarcane juice has been extracted from it making it very convenient as a potential material for other productions. Sugarcane fibers are known for its variety of applications for consumer products packaging making it suitable for manufacturing (Biermann, 1996).

Caustic soda is an important commodity chemical for the pulp and paper industry. Principal uses in pulp and paper production include the cooking/processing of pulps, the extraction of lignin during the pulp bleaching sequences, and the on-site manufacture of sodium hypochlorite (Sheridan, 2006). The general pulp bleaching procedure involves a

bleaching sequence during which impurities and colored matter in the pulp are oxidized and/or converted to alkali-soluble forms, and an extraction sequence happens wherein the impurities are removed. About 10% of the total chemical pulp produced in the world is made using non-wood material such as bagasse and wheat straw (Doherty & Rainey, 2006). Soda process is the preferred method of chemical pulping of non-wood materials, because it is considered to be economically viable on a small scale and for bagasse is compatible with sugarcane processing. So, the blended sugarcane bagasse was cooked in 10% Caustic Soda and water so that the chemicals can extract and enhance the pulp. After then the pulp was washed until excess chemical residue was removed and was blended into the finest pieces with starch. Starch was used as it was still based on the procedure being followed. Starch is used as a flocculant and retention aid, as a bonding agent, as a surface size, a binder for coatings, and as an adhesive in corrugated board, laminated grades, and other products (Maurer, 2009).

The coating that was used is the Natural Carnauba Wax which comes from the leaves of the *Copernicia prunifera* palm grown only in Brazil. What makes it convenient as a coating for the straw is that it has a very high melting point of 82-86 °C and is non-toxic and hypoallergenic (Helmenstine, 2018). Furthermore, purified carnauba wax is food safe and a little ingestion won't do so much harm on the body (Wallace, 2004).

METHODOLOGY

Materials

The following materials were used: sugarcane bagasse, sodium hydroxide (caustic soda), starch, and carnauba wax.

Sugarcane bagasse was obtained from local plantations located in the province of Bukidnon.

Procedure

The procedure on getting bagasse pulp was based on the methodology of the study by Al-Sulaimani, and Dwivedi (2017). The agricultural residue of bagasse fibers was collected and dried under the sun for two days and washed by water repeatedly. Then, the bagasse was cooked with 10% of caustic soda for 30 minutes (see Appendix A Fig.1) and washed with hot water and tap water repeatedly. Then, the pulp was mixed in the blender for 5 minutes using little water. And finally, the additive Starch was added to the pulp to enhance the properties of paper.

The first straw-making procedure was based on the methodology by Natasha (2014). The bagasse pulp was wrapped around a mold using non-stick paper while keeping the pulp together so it formed a straw and it was dried in a drying oven at 30°C overnight (see Appendix A Fig.2). Then, the formed straw was dipped into the Carnauba wax. And finally, the formed straw was dried for a few minutes to harden the layer of wax.

The second straw-making procedure was based on the methodology of Green Box Eco Packaging (2016). The pulp was poured into a form and pressed into the desired

shape using the metal molder and it is dried at an oven at 30°C overnight (see Appendix B Fig. 1).

Data Analysis

The data analysis was based on the study of Joseph N. Gutierrez, Aidan W. Royals, Hasan Jameel, Richard A. Venditti, and Lokendra Pal (2019). The evaluation was done after the production of biodegradable straws.

I. Weight Gain for different Straws in different liquids with varied temperatures

This test measured how much liquid the straws in the test conditions absorbed as a function of time in the different kinds of liquids (drinks). One of the downside factors with the biodegradable straw made from cellulose is that it partially absorbed the liquid it was submerged in because of the material's cellulose properties (Chaplin, 2002), with this the researchers evaluated how the bagasse straw did in the test with the help of a scatter plot to present the data and a one way ANOVA test.

II. Biodegradability Test

Biodegradability testing addresses the eco-friendly physical property of a product or material in a specific environmental condition. For this study the researchers performed the said test by burying the biodegradable bagasse straw under soil and left it for a definite number of days and checked its weight every time between periods. After every period of time burying it, the new weight was compared to its initial in the data collected consistently and then followed the interpretation.

RESULTS AND DISCUSSIONS

The data analysis continued with the successful bagasse straws produced from the first procedure (see Appendix A Fig. 3). The outcome of the second straw-making procedure was a failure because after the cover was removed, the bagasse straw would disintegrate and was broken into small parts thus concluding the second procedure a failed plan (see Appendix A Fig. 4).

According to the visual representation the scatter plots have shown below, it has been determined that the bagasse straw absorbed most liquid from the hot water and least from the carbonated drink whereas that the paper straw absorbed the most liquid in the room temperature water and the least in the carbonated drink.

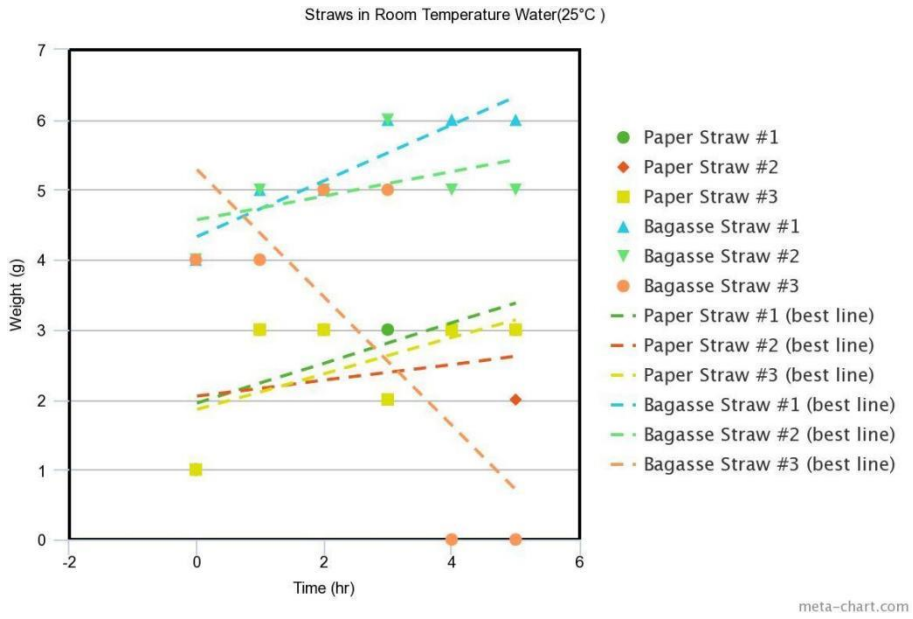

Fig.I.1. Weight gained by the bagasse straw & paper straw at room temperature water (25°C). Horizontal line x = time in hours (hr); vertical line y = weight in grams (g).

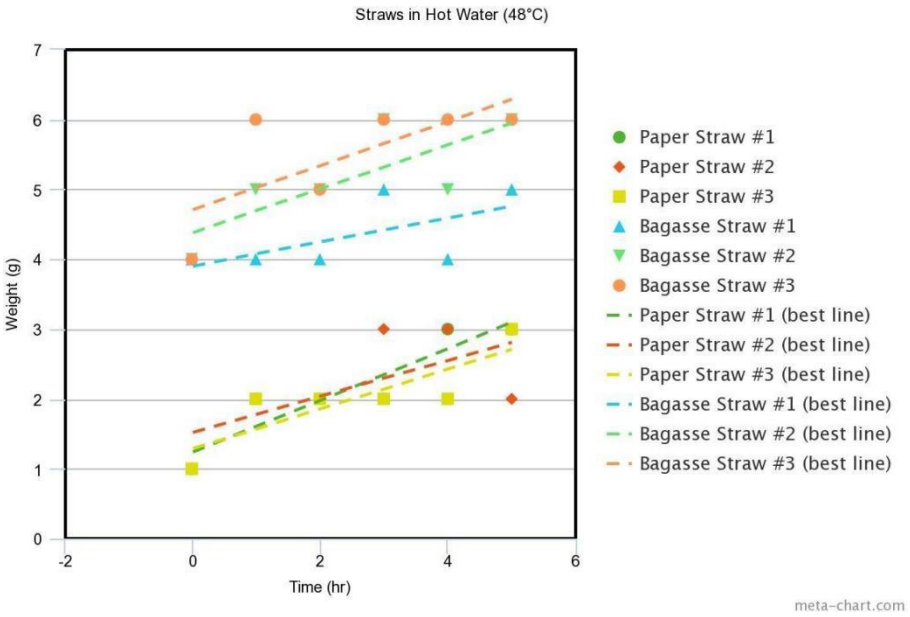

Fig.I.2. Weight gained by the bagasse straw & paper straw in hot water (48°C).

Horizontal line x = time in hours (hr); vertical line y = weight in grams (g).

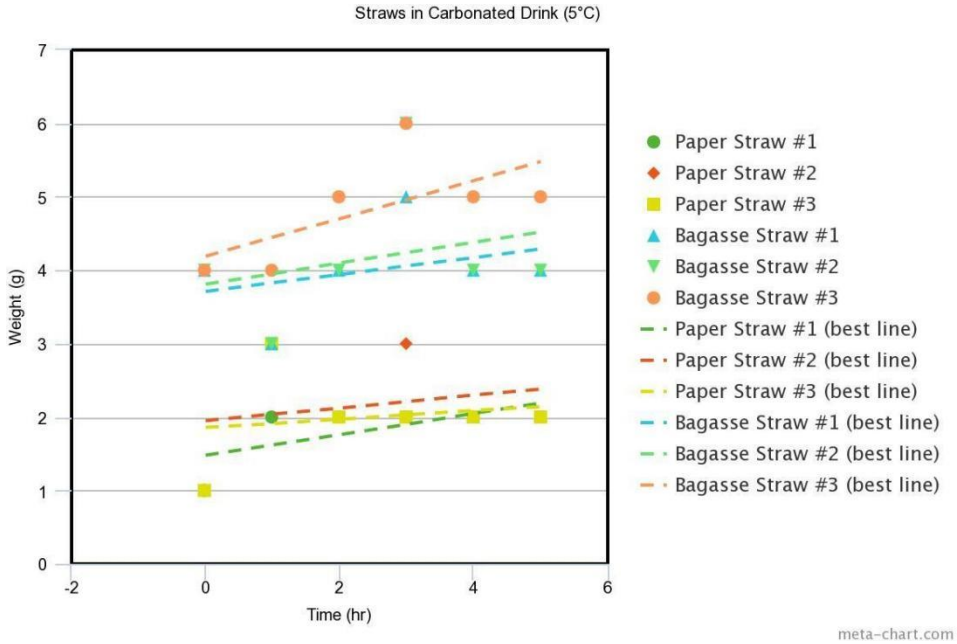

Fig.I.3. Weight gained by the bagasse straw & paper straw in a carbonated drink (5°C).

Horizontal line x = time in hours (hr); vertical line y = weight in grams (g).

A one-way ANOVA test was used on the three different treatments to determine whether there is a significant difference in the amount the bagasse straw and paper straw each absorbed. The p-values are 0.3739, 1.0000, and 0.1161 with significance level 0.05 and in all three tests H_o is accepted which means there is no significant difference among the samples and this indicates that the paper straw and bagasse straw are of equal capabilities when it comes to water resistance.

Table.I.1. One-way ANOVA table comparing the results of the Bagasse Straws and Paper Straws in room temperature water (25°C).

Source of Variation	**Sum of Squares SS**	**Degrees of Freedom DF**	**Mean Squares MS**	**F**	***p*-value**
Between Samples	SSB = 0.6667	$k - 1 = 1$	MSB = 0.6667	1	0.3739
Within Samples	SSW = 2.6667	$n - k = 4$	MSW = 0.6667		
Total	SST = 3.3333	$n - 1 = 5$			

H_0: There is no significant differentiating between samples.

H_1: There is a significant differentiating between samples.

$F(1,4)$ at 0.05 level of significance

=7.7086

As calculated $F = 1 < 7.7086$

Table.I.2. One-way ANOVA table comparing the results of the Bagasse Straws and Paper Straws in hot water (48°C).

Source of Variation	Sum of Squares SS	Degrees of Freedom DF	Mean Squares MS	F	*p*-value
Between Samples	SSB = 0	$k - 1 = 1$	MSB = 0	0	1
Within Samples	SSW = 1.3333	$n - k = 4$	MSW = 0.3333		
Total	SST = 1.3333	$n - 1 = 5$			

H_0: There is no significant differentiating between samples.

H_1: There is a significant differentiating between samples.

$F(1,4)$ at 0.05 level of significance

=7.7086

As calculated $F = 0 < 7.7086$

Table.I.3. One-way ANOVA table comparing the results of the Bagasse Straws and Paper Straws in carbonated drink (5°C).

Source of Variation	Sum of Squares SS	Degrees of Freedom DF	Mean Squares MS	F	*p*-value
Between Samples	SSB = 0.6667	$k - 1 = 1$	MSB = 0.6667	4	0.1161
Within Samples	SSW = 0.6667	$n - k = 4$	MSW = 0.1667		
Total	SST = 1.3333	$n - 1 = 5$			

H_0: There is no significant differentiating between samples.

H_1: There is a significant differentiating between samples.

$F(1,4)$ at 0.05 level of significance

=7.7086

As calculated $F = 4 < 7.7086$

Table.II.1. Table for the Biodegradability Test.

Sample	Burial Period (days)	Initial Weight (grams)	New Weight (grams)	Weight Loss (grams)
Bagasse Straw	7	4	2	2
	14	2	2	0
	21	N/A	N/A	N/A
	28	N/A	N/A	N/A
	35	2	1	1

It is evident on the table that the bagasse straw showed biodegradation because of the weight loss that occurred over the course of one month.

CONCLUSION

The production of biodegradable straw using sugarcane bagasse was successful by using one of the procedures proposed. The tests results showed that the bagasse straw and the paper straw have equal capabilities in liquid absorption. It was also proven that the bagasse straw is biodegradable because of the weight loss which was evident over the course of one month indicating biodegradation. Therefore, the bagasse straw can be used as a biodegradable straw.

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APPENDIX A

PHOTOS OF SAMPLE PRODUCTION

Fig 1. Cooking of bagasse in caustic soda to achieve pulp.

Fig 2. Straw-molded bagasse pulp in the drying oven.

Fig 3. The Final Biodegradable Straw Product.

Fig 4. Failed 2nd procedure for straw-molding.

APPENDIX B

FIGURES AND SCATTERPLOTS

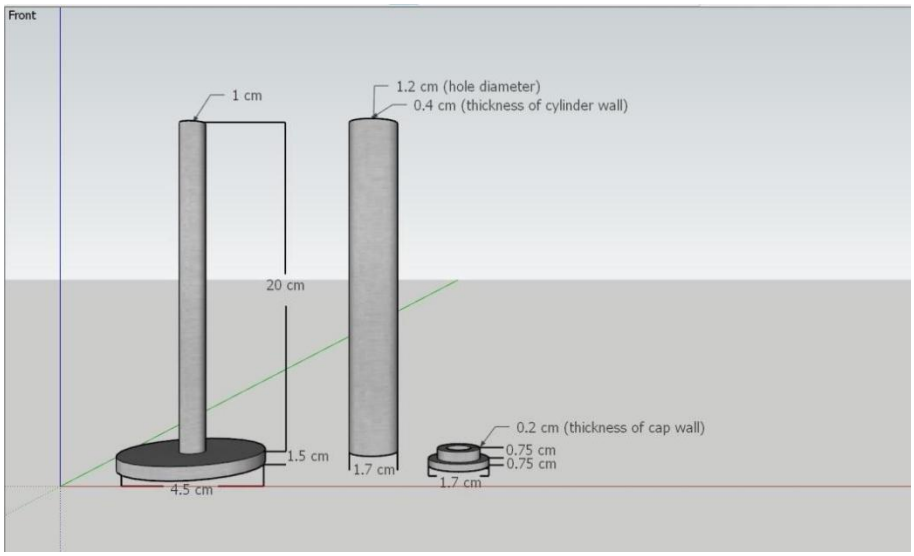

Fig 1. Metal Mold with measurements designed with the program SketchUp (2018).

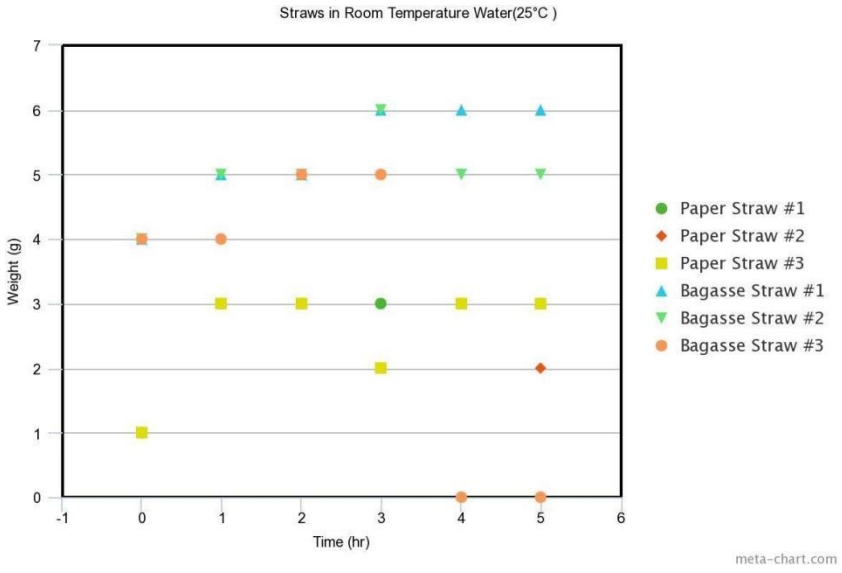

Fig. 2. Raw Scatter Plot of Straws in Room Temperature water (25°C).

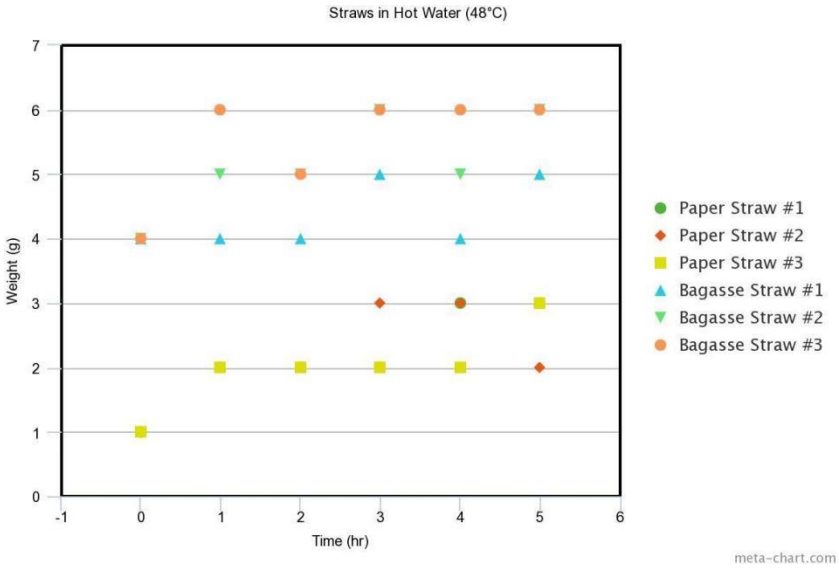

Fig. 3. Raw Scatter Plot of Straws in Hot water (48°C).

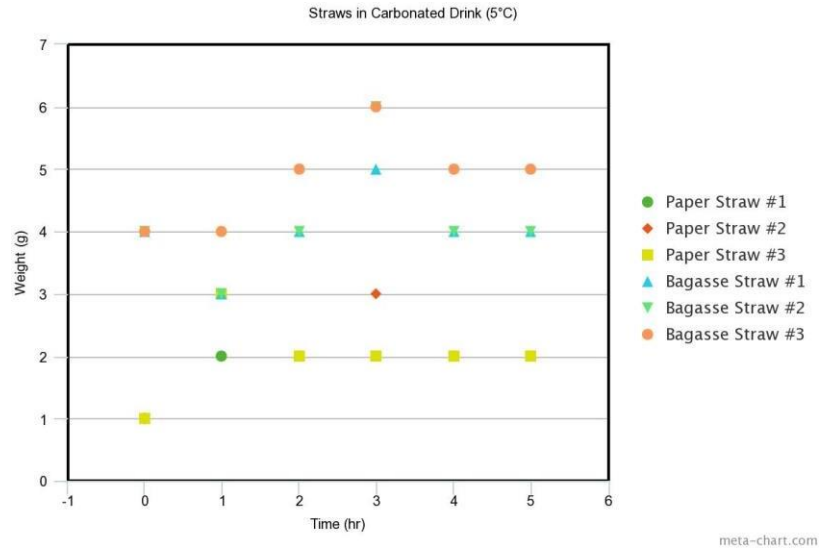

Fig. 4. Raw Scatter Plot of Straws in a Carbonated Drink (5°C).