

A LOOK INSIDE THE PRODUCT ARCHEOLOGY OF PAPER TOWELS

Freshman Engineering Clinic I Section 13

Professor Mallouk

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ABSTRACT

Product archeology explores the development and life cycle of products. Many different measures are accounted for when analyzing the life cycle of a certain product through all of its phases. There are four main aspects that are studied when considering the process that a product undergoes; global, economic, environmental, and societal (PathFinder). The objective for this study was to compare three brands of paper towels under the product archeology guidelines, giving in depth information on which one was best for different tasks. During the capillarity test, water traveled the most distance on Bounty and the least on Viva. Both absorbency tests demonstrated Viva as the most absorbent; however, Bounty was not far behind when comparing the amount of water held. Bounty had a substantial lead over the other two brands when considering strength and durability in both tests.

INTRODUCTION

Global aspects of product archeology investigate the impact that culture and geography have on the product in question. Many countries around the world have their own practices and beliefs which influence the products and amount of product they use (PathFinder). For instance, less fortunate countries will have less need for products that are high in cost because access to those materials is low in their region (PathFinder). When examining the life cycle of a specific product, this condition is accounted for.

Similarly, economic factors are also important in a product's development. The price of materials and the cost of manufacturing can play a significant role in the overall cost of the product for consumers (PathFinder). When a product requires complex materials and processing techniques, the cost for the consumer rises. When examining the economic aspects of a product, these measures are taken into account and alternative methods are discussed, such as material substitution to lessen the cost of the product.

Environmental impacts of a product discuss the influences made on the planet itself (PathFinder). Sustainability, or avoiding the decrease of the amount of natural resources for future generations, is a topic many scientists and engineers study to implement more environmentally friendly techniques (PathFinder). When products are unable to be recycled or reused, or when their disposal is harmful to the environment, this step in their life cycle is analyzed. The same factors

can be discussed for the opposing outcome; efficient recyclability and proper disposal. All aspects of a product can be considered under this phase.

Societal aspects of a product stem from the overall function and impact the product has on the life of the consumer. Often times, companies guarantee specific functions for their products, and its ability to perform the function efficiently poses an important effect on society. Consumers prefer products that are worth the cost, and when accounting for societal factors, these topics can be discussed.

BACKGROUND AND LITERATURE REVIEW

In modern day society there are an endless amount of choices that one can make when purchasing an item. Whether it may be for the home, office, or outdoors there are many factors to consider in the search. Specifically, paper towels have a plethora of different brand names and special functions that set each individual product apart. Each unique attribute is important when looking at paper towels as a whole and how they can meet the needs of the consumer.

Historical Background

Paper towels, a product so widely utilized and known in households today worldwide, first came to fruition by happenstance. In 1907, it is said the Scott Paper Company had a shipment of toilet paper rolls too long and unsuitable for paper towels. Rather than wasting the shipment, it just so happened that Arthur Scott, the then head of the company, had been researching different product concepts in an effort to help halt the spread of colds in bathrooms and this mistake was the answer he had been searching for. Soon, 'nibroc' towels were being mass produced throughout America. Paper towels were and still are the leading alternative to multi use cloth towels. With cloth towels, the fibers hold on to germs and bacteria that can be next to impossible to ever fully kill. Paper towels are single use so every time one dries their hands or wipes down a surface, they can feel safe knowing every swipe is a clean one. However, this cleanliness comes at a price; because paper towels are single use and made out of paper, they leave a terrible impact on the environment and contribute greatly to waste. Also because of their single use characteristic, paper towels can become costly after buying rolls upon rolls over the course of time. A little over a dollar per roll does not seem like much, but after time, things begin to add up. Bounty brand paper towels are a leading brand in the paper towel industry, coming from Walmart at \$1.36 per

roll. This was the most expensive roll and advertises itself to be made from recycled materials and two times more absorbent. Shoprite's economy towels were the cheapest of the rolls at \$0.79 and were observed to be very thin. Viva brand paper towels had the softest feel and, from Walmart, cost \$1.13. Viva has a WWF logo on its packaging, advertising support of the planet. However, Viva paper towels have been found to not be good for the environment; Viva's soft feel can be owed to the fact that they are manufactured through virgin fibers, or made with 0% recycled materials.

Environmental Impact

A topic that has been discussed most frequently in recent years is the footprint that paper towel production and disposal is leaving behind on the environment. A recurring topic is the way in which companies can market their product in order to have a desired effect on consumers and their onlooking competitors. In 2007 guidelines were created by the Federal Trade Commission that specified "what allows companies to market their product as eco-friendly or "green""(Guides). With these guides in place, consumers have access to the "limitations of modern environmental marketing" and can see the impact the product they are purchasing is having on the environment (Guides). With all of this information available to the general public, studies have been launched to find "the effects ecolabels have on consumers buying paper towels" and have resulted with evidence that shows consumers are not environmentally conscious in their decision making (Srinivasan, A).

Additional problems are the air emissions of factories producing paper towels. Studies have found in Colorado "...improvements in Box Elder on air emission indicator environmental impact scores" when discussing the effects of paper towel production in towns that the factories reside (Ingwersen, W). Paper towel production is seen here as not having a damaging effect on the air quality of towns that already have manufacturing taking place. But even when being reused in the desired manner by environmental agencies, "recycling them a second time after use proves to be harder" to maximize the life of a recycled paper towel (2018, October 5). Overall, production and effect on the environment of paper towels entails much more than the everyday consumer seems to see or care about.

Societal Impact

Consumer have many choices of which paper towel brand suits their needs most effectively. Many considerations must be accounted for, including cost effectiveness, reliability, and most importantly, absorbency. The absorbency test directly relates to the societal impact of paper towels. Absorbency is a large aspect of paper towels that consumers take into consideration when choosing which paper towel to use in the household. The first absorbency test measured the weight of a paper towel before and after soaking in 100 ml of water. The difference in weight would then account for the mass of water absorbed by a single sheet of paper towel. The second test measured the volume of water absorbed over three uses of a single sheet of paper towel. These two tests measure the absorbance of paper towel in different ways to better understand which brand satisfies the consumer needs most effectively.

Economic Impact

As companies and consumers look for paper towels to clean and dry, cost is a very important factor to consider. In the example of restaurant or food companies, cheaper towels are often bought in order to keep bathrooms refilled at a small cost. This makes sense as these towels are mainly used for face and hand drying (Kumar, T). However, with paper towels designed for home use, cost has become one of the only factors used to differentiate between brands as they usually advertise the same information on absorbance or strength. As a result, in order to persuade consumers, paper companies try to advertise the use of recycled materials or state that the production of these towels have minimal impact towards the environment. On the contrary, the price for these paper towels are often higher than those with more environmentally harmful materials, so often enough consumers may ignore the environmental effects in an effort to spend less (Guides). These tests refer to the economic impact towards paper towels because having more uses out of a paper towel will result in less refills needed.

Capillarity

The capillarity of a paper towel relates to how porous the sheet is. If water can move around easily in the paper towel sheet, it means the sheet has a lot of pores, and thus a high capillarity. A high capillarity means the paper towel is unable to hold water in place very well, reducing the

overall absorbency of the sheet as most of the water will drip out of the wet towel when held. Furthermore, the paper towel will easily be soggy and ruined by a spill, meaning it will have to be thrown out more frequently, thus impacting the environmental aspect of paper towels.

Absorption

One of the most important parts of a paper towel is how well it can absorb liquid. The fibrous makeup of a paper towel must be tested in order to see the reaction that it has to large amounts of water. Two primary methods used to test absorption were “liquid dropping onto a paper towel and picking liquid up from the surface” (Abedsoltan, H). Both of these methods address qualities of this product but some would say that a paper towel’s absorbency can be traced back to “a complex heat and mass transfer process” when drying the paper pulps in production (Ajit K Ghosh). From production to testing, the absorbency of a paper towel sheet depends on many factors both fundamentally and experimentally.

Weight and Strength

The ruggedness of a paper towel can be a deciding factor for consumers when it comes to comparing like products. When there is a large mess or gritty stain, budget paper towels will not hold up to the weight and strength tests. These tests include placing a weight on a wet paper towel and sliding it across a horizontal surface and taping a wet paper towel to the top of a beaker and seeing how much mass it takes to rip. Once performed, these tests give a better insight into the brute strength of a paper towel and the amount of stress it can withstand in a real world setting. The weight support and strength of a paper towel is a major factor when faced with difficult messes. Having a stronger paper towel allows for less waste and more efficiency in cleaning.

MATERIALS

Test 1: Displacement Capillarity

- Roll of Bounty® paper towels
- Roll of Viva® paper towels
- Roll of Shoprite® paper towels
- Scissors

- Cup filled halfway with tap water
- Marker or pen
- Ruler

Test 2: Absorbency

- Roll of Bounty® paper towels
- Roll of Viva® paper towels
- Roll of Shoprite® paper towels
- Water
- 100 mL beaker
- 100 ml graduated cylinder
- Large beaker for water collection and weighing purposes
- Digital scale measured to +/- 0.1 g
- Ruler
- Scissors
- Timer

Test 3: Weight and Strength

- Roll of Bounty® paper towels
- Roll of Viva® paper towels
- Roll of Shoprite® paper towels
- Marker or pen
- Coins of the same value (preferably quarters)
- Plastic tub or container
- Beaker (or measuring cup)
- Water
- Rubber bands

EXPERIMENTAL PROCEDURES

Test 1: Displacement Capillarity

In the first part of testing, the porousness or capillarity was compared among different brands of paper towels. First, one sheet of paper towel was ripped from each brand (Viva, Shoprite, and Bounty), and cut into three equal 5 cm by 25.5 cm strips. Then, all the strips were marked by their brand at the top and a line was drawn one inch from the bottom of the strip. After retrieving the cup filled halfway with tap water, each strip of towel was dipped into the tap water up to the one-inch line and then laid down on the table side by side. After five minutes, another line was marked to measure how far up the towel the water reached. Figure 1 shows an example of the experimental setup

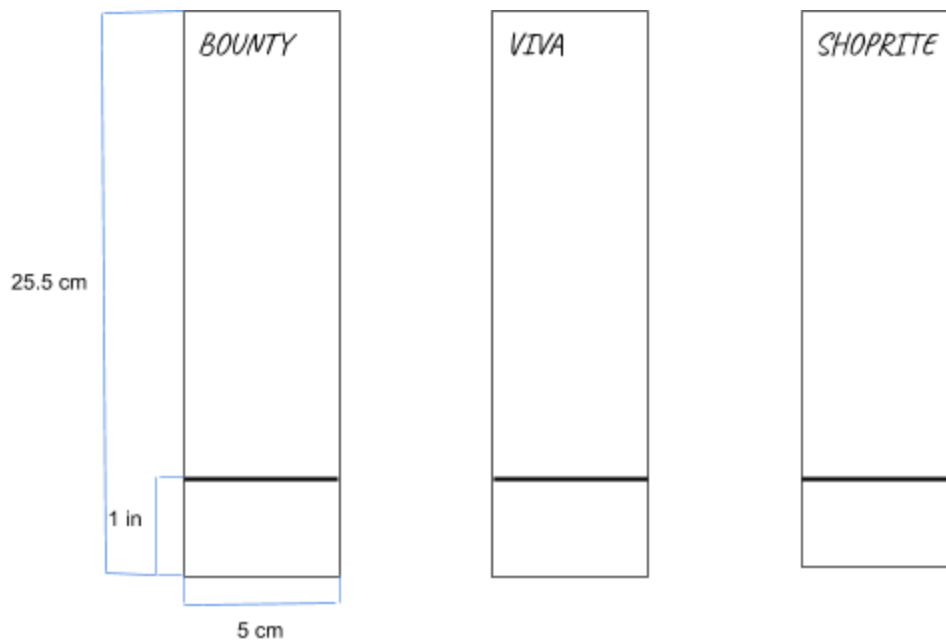


Figure 1: Diagram of capillarity test

Test 2: Absorbency

Part A:

In the second test, the first section focused on how much water the sheet could hold. After first cutting each sheet to the same size, (27.9 cm x 15.2 cm) the mass of each dry sheet was taken. Then, all the sheets were placed on a dry surface and had fifty milliliters of water poured on top. After allowing ten to twenty seconds for the sheets to absorb all the water, the towels were picked up for another ten to fifteen seconds to allow any excess drips to fall off the paper. Then, each sheet was massed again.

Part B:

In the second test, the second section focused on how much water the sheet could absorb on its own. On a dry flat surface, a series of controlled spills were simulated containing 100 mL of tap water. Then using an equally sized sheet of paper towel from each brand (27.9 cm x 15.2 cm), the motions of cleaning said spill were simulated by rubbing the paper towel over the spill to soak up as much of the water as possible. After the paper towel reached its capacity of holding water, it was wrung out into a large beaker and the procedure repeated to clean as much of the spill as we could two more times. Then, the volume of water left in the beaker was measured and recorded. This experiment was performed with a sheet from each brand.

Test 3: Weight and Strength

Part A:

In the third test, the first section focused on how much weight could be placed on top of the towel. First, a sheet of paper towel was detached from each brand and wet thoroughly in approximately 100 mL of water. Then, each sheet was stretched over the mouth of a large beaker and secured with a rubber band. Then weights were added one by one until the sheet ripped. The highest amount of weight was recorded and the experiment repeated another two times with each brand.

Part B:

In the third test, the second section focused on how much weight could be carried while dragging the towel. First, a sheet of paper towel was detached from each brand and wet thoroughly in approximately 100 mL of water. Then, each sheet was placed on a dry flat surface and weights

were added one by one. In between adding each weight, the towel would be dragged about 5-10 cm until the friction from being pulled and the forces of the table and weight caused the paper towel to rip. Then, the highest amount of weight held was recorded and repeated so that each brand was tested three times total.

RESULTS AND DISCUSSION

All raw data and equations can be found in Appendix B-1 through B-6

Qualitative Data: When doing an initial observation, we noticed that Bounty was a lot thicker than the other two competing brands, Viva and Shoprite. Furthermore, Bounty advertised its towels to be 2 times more absorbent, and the one we had only came in full sheets, rather than the “choose your size” towels the other brands came in. We also found that Viva was the softest to touch, and it advertised to be recycled and environmentally friendly, Lastly, the Shoprite brand was the cheapest per roll, whereas Viva was the next cheapest and Bounty was the most expensive.

Test 1) Displacement Capillarity

After testing the Capillarity of each paper towel brand, it was found that water traveled along the Bounty brand easiest, closely followed by Shoprite, as indicated in Figure 2. Shoprite was the thinnest towel and expanded the farthest, meanwhile Viva, the thickest and least perforated, didn't climb very far at all. Bounty climbed somewhere in the middle. This means that both these brands cannot hold in place as much as the Viva brand, as the water is able to move around the towel easier in the other brands.

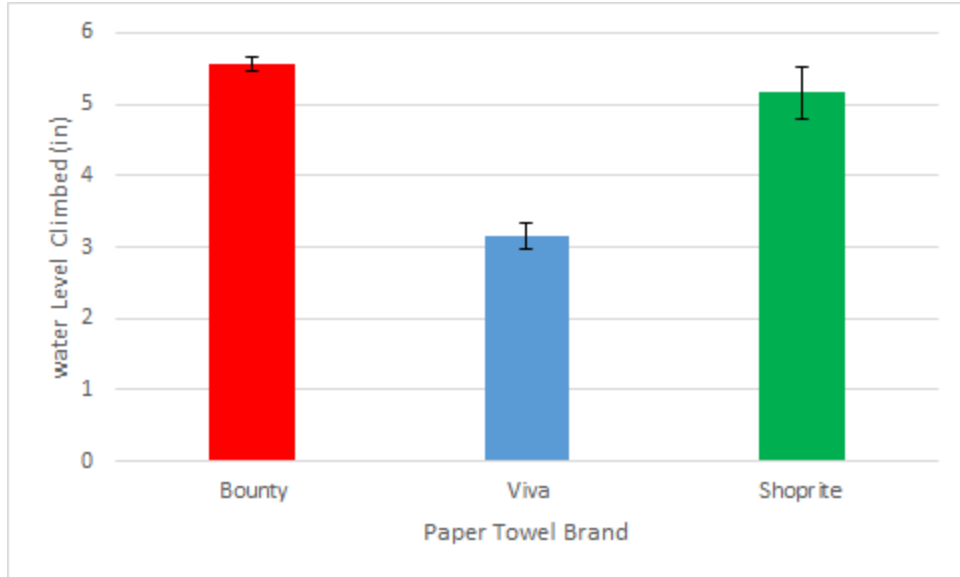


Figure 2: Water distance traveled in each brand of paper towel (error bars represent +/- 1 standard deviation)

Test 2) Absorbency

In the first part of the absorbency test, Viva held the most water, followed by Bounty and then Shoprite. This can be seen on Figure 3, which displays the average mass of water absorbed in each paper towel. No error bars were included because only two trials were performed. Figure 2 also indicates the minor difference between Bounty and Viva's absorbance results.

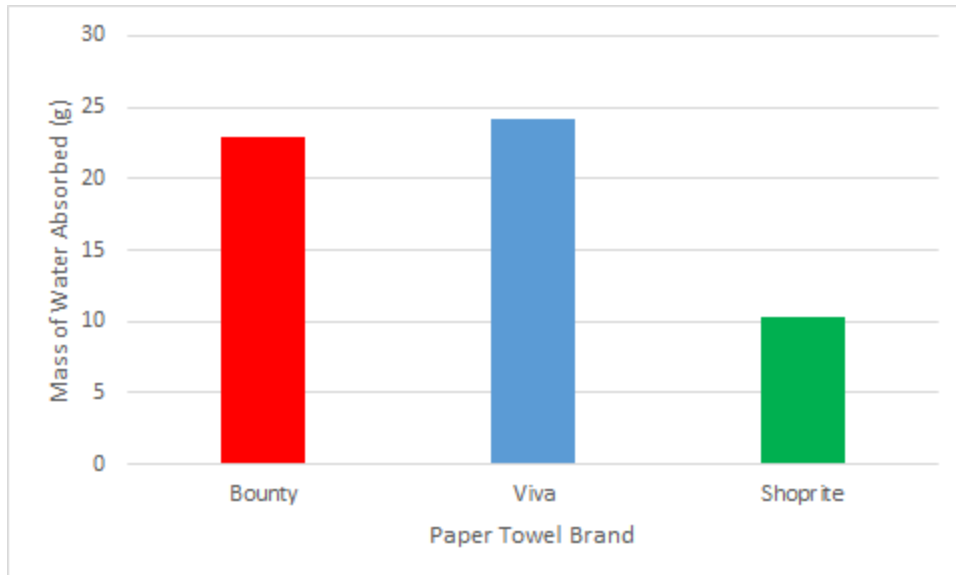


Figure 3: Water absorbed by each brand determined by mass

In the second part of the Absorbency test, the result standings were the same (Figure 4). Again, the performance from Viva and Bounty were similar. To not much suprise, Viva, the thickest towel, held the most water, while Shoprite, the thinnest, held the least. Bounty fell in the middle, closer to the results of Viva.

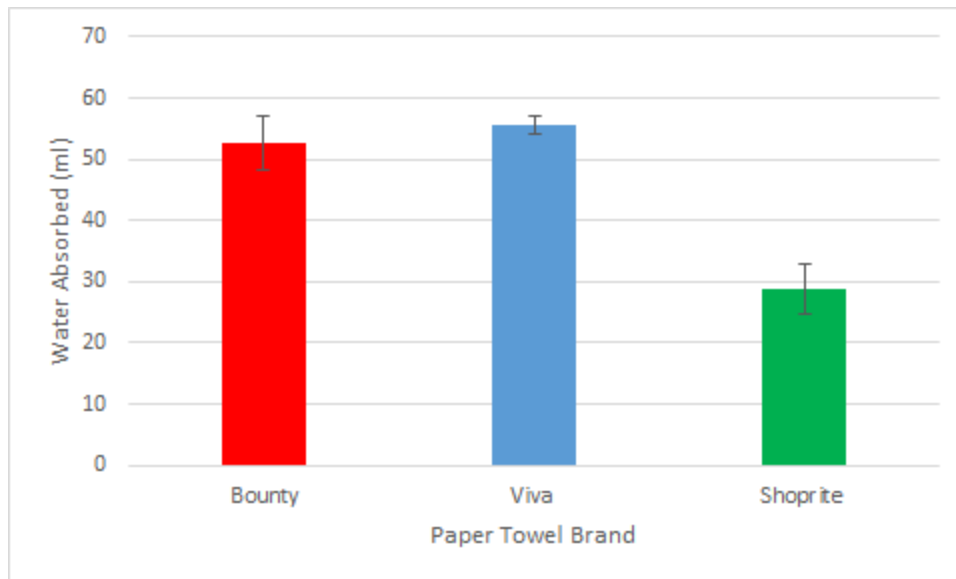


Figure 4: Water absorbed over three consecutive uses by each brand (error bars represent +/- 1 standard deviation)

Test 3) Weight and Strength

In both parts of the strength tests, Bounty held a lot more weight than the other two brands. Figure 54 shows the averages of weight each paper towel brand during the experiment, while Figure 65 shows the average weight each towel was able to pull before ripping. Both figures show that Bounty led this test with the greatest durability by holding an average of double that of Viva, and Shoprite held almost half of what was held by Viva. As Bounty was the thickest towel and Shoprite was the thinnest, there could be a positive correlation between thickness and strength of paper towel. Furthermore, because of the massive amount of weight Bounty can hold, it can be inferred that it's made with a mix of materials other than paper. This would make sense as Bounty did not have any environmental labels on it.

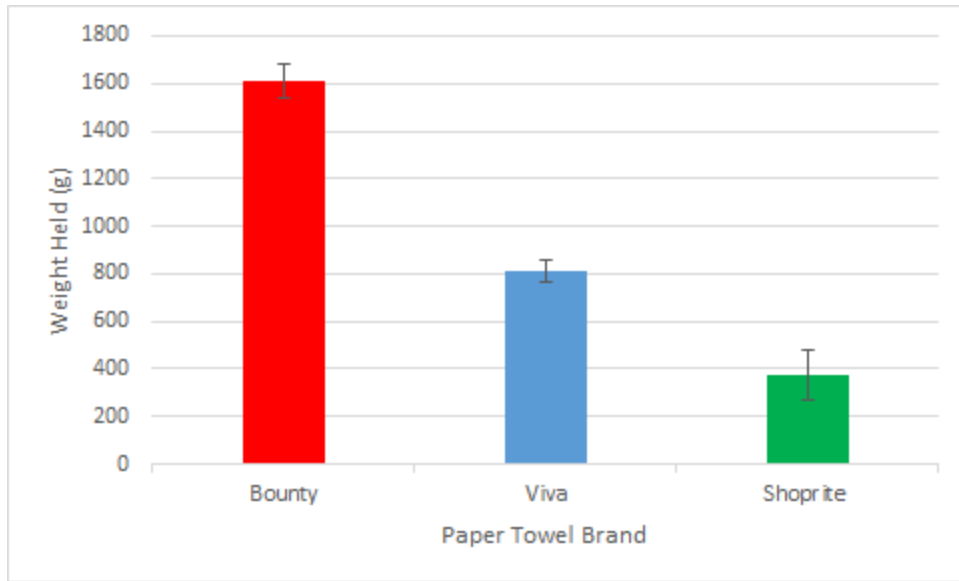


Figure 5: Weight held by each brand of paper towel when weight was placed on top (error bars represent +/- 1 standard deviation)

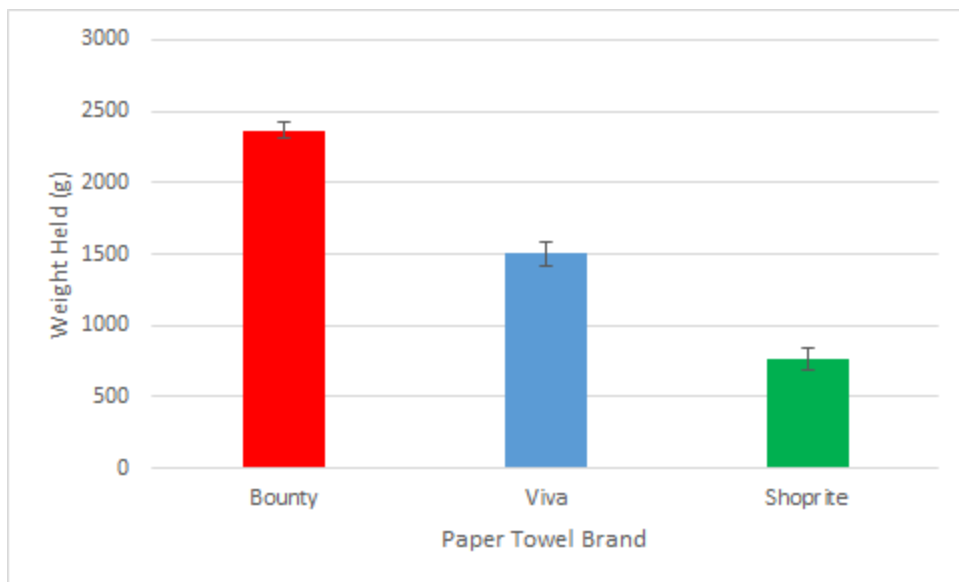


Figure 6: Weight held by each brand of paper towel when weight was dragged (error bars represent +/- 1 standard deviation)

Overall Results

Viva was the softest to touch and has the best price ratio for what it accomplished in the tests. Upon further research, Viva was found to use virgin fibers as mentioned in the background history, which only derive from newly cut trees, making it not as eco friendly as it advertised (Ament, P). However, Viva was able to absorb and clean without soaking up and ruining the entire paper towel. This is important towards the environmental and global aspect of paper towels, as the more uses a paper towel can get ultimately means it isn't thrown away as often. Even though Bounty can hold enormous amounts of weight, the amount of weight it held is not necessary for normal paper towel use in the societal aspect. Bounty ended up being the most environmentally friendly option, as it is made up of recycled paper, and absorbs a lot more than Shoprite and almost as much as Viva. Shoprite was the overall worst paper towel, as it held the least weight and water. However, this made sense as Shoprite was the cheapest roll. As Shoprite will have to be thrown out more than Bounty and Viva, it shows the relationship between the economical and environmental aspects of paper towels.

CONCLUSION

Through performing multiple trials of each test, conclusions can be made about the capillarity, absorbency, and strength of paper towels. During the capillarity test, Shoprite proved to be the most porous out of the three brands tested, while Viva was the least porous. Similarly, relating to the capillarity test and amount of water held in the paper towel, Viva resulted in the highest absorbency volume for both parts A and B of test 2. Expectedly, Shoprite absorbs the least amount of liquid. While Bounty fell in the middle for both capillarity and absorbance, it performed the best in the strength and durability test. Bounty held weight that was much higher from that of Viva and Shoprite. All results were consistent with team expectations.

Accurate and useful results were determined in all three tests; however, improvements to the experiments can be applied. In many tests, the amount of water expected to use was too much in relation to the size of the paper towel being used. Multiple practice trials were needed to find the most effective amount of water. In addition, the method used to test strength while stacking

weights on the paper towel was tedious and time consuming. Although the method was efficient, a better understanding of the maximum weight the paper towel can hold would have been helpful before the test began. These suggestions for improvements would be advantageous if tests were completed again.

The results found by the experiments carried out can be applied for a variety of future work. On an environmental level, the strength test can be used to compare the durability of the current paper towel materials with ones more suitable to the planet. In this way, paper towels can be strong, which appeals to society, and less harmful on nature, which is beneficial to the environment. For example, even though Viva advertised to be eco-friendly, further research found that it was actually made of virgin paper, which is made of only newly cut trees (Growing a green family). Similarly, the absorbency test is directly related to economic values. By applying the results of the most absorbent paper towel brands, consumers can decrease their spending on paper towels by using less sheets. Future applications of these findings are significant in many aspects of product archeology.

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APPENDIX A

Abedsoltan, H. (2017). Meso-Scale Wetting of Paper Towels (Master dissertation). Retrieved from Rowan University Libraries ProQuest. (10645415)

This study analyzes the absorption of paper towels through multiple experiments. These experiments include different types of absorbance strategies such as liquid dropping onto a paper towel and picking liquid up from a surface. In addition the study addresses absorbency rate and absorbance capacity. The studies also include different types of liquid to maximize results. Liquids were tested on varying paper towel brands and results were presented in graphs and tables. Many types of Bounty paper towels were tested against other brands and results demonstrated a number of brands that performed better than Bounty during absorbency tests. This study focuses on the societal concern of absorbency among different brands of paper towel available for consumers. The source establishes a respected amount of credibility upon first glance. The study was conducted through Miami University for a masters in science degree, and reviewed under the departments of chemical, paper, and biomedical engineering. The source continues to hold credibility throughout, including diagrams and figures of results concerning different topics of absorbency.

Ajit K Ghosh (2011). Fundamentals of Paper Drying – Theory and Application from Industrial Perspective, Evaporation, Condensation and Heat transfer, Dr. Amimul Ahsan (Ed.), ISBN: 978-953-307-583-9, InTech, Available from:

<http://www.intechopen.com/books/evaporation-condensation-and-heat-transfer/fundamentals-of-paper-drying-theory-and-application-from-industrial-perspective>

This source dives deep into the ins and outs of how paper absorbs liquid. Referencing paper products in industry as a whole, Ghosh looks at how the fibrous paper-pulps consumers use everyday get sourced, pressed, and finished in order to optimize their potential. The processes in which those paper pulps can be dried can be found in this article. Overall, these various methods of drying paper, described as a complex heat and mass transfer process. These processes heavily rely on evaporation of water using steam

and heat transfer by conduction. In the Fundamentals of Paper Drying, multiple methods of creating paper can be found along with their disadvantages and benefits. These are helpful topics to look into when discussing the optimal paper towel product for a specific experiment. This source demonstrates how global paper machines can operate with more efficiency and precision in order to optimize the functionality of the paper product being created. This source is fairly credible as it was written by a senior lecturer of the department of Civil Engineering in Universiti Putra Malaysia. It has also been published on the reputable Intechopen.

Guides for the Use of Environmental Marketing Claims - ACTION: Proposed revisions to guidelines. (2010, October 15). Federal Register (USA). Retrieved from NewsBank: https://infoweb.newsbank.com/apps/news/document-view?p=AWNB&t=&sort=_rank_%3AD&maxresults=20&f=advanced&val-base-0=Paper%20towels&fld-base-0=alltext&bln-base-1=and&val-base-1=materials&fld-base-1=alltext&bln-base-2=and&val-base-2=accessability&fld-base-2=alltext&docref=news/132E4CE734B9F490

The article is a review conducted by the Federal Trade Commission on new environmental claims made by consumer products. The conducted review found that the Environmental guides should be updated and strengthened to ensure the sustainability of products that claim to use “natural products” or “green energy”. The new guidelines, released in 2007, are more strict and specific towards what allows companies to market their product as eco-friendly or “green”. The article is helpful towards the topic of paper towels because it describes the new rules enforced towards paper towel manufacturers who claim to use biodegradable materials. Furthermore, the article goes deeper in the problems and limitations of modern environmental marketing. For example, the article discusses how, due to the new rules, some companies will struggle as they’ll be unpopular because they have to list their harmful materials. The paper towel industry, if affected by this change, may need to change their material usage, in order sell under the “eco-friendly” label. The article is fairly credible as it is an official review written by the US Federal Trade Commission.

Ingwersen, W., Gausman, M., Weisbrod, A., Sengupta, D., Lee, S., Bare, J., . . . Ceja, M. (2016). Detailed life cycle assessment of Bounty® paper towel operations in the United States. *Journal of Cleaner Production*, 131, 509-522. Retrieved October 7, 2018, from <https://www.sciencedirect.com/science/article/pii/S0959652616304383>.

This article reports, with great detail, the life cycle of Bounty® brand paper towels in the two controlled areas of Albany, Georgia and Box Elder, Utah. The journal installment reports its findings within the confines of a Life Cycle Assessment (LCA), an official and highly renowned form of comprehending the environmental influences deriving from consumer products. The main purpose of the article was in finding just how much the manufacturing of paper towels impacts the environment, and if humanity's influence on nature has minimized. The study finds improvements in Box Elder on air emission indicator environmental impact scores, and in Albany, lower water use. These results help to prove that in the manufacturing of paper towels, there remains continuous strive to improve maltreatment to the earth. With many credible and distinguished authors and having been published in the noteworthy journal, *Journal of Cleaner Production*, the article holds great integrity.

Ingwersen, W. W., Ceja, M., Weisbrod, A. V., Cabezas, H., Demeke, B., Eason, T., . . . Gonzalez, M. A. (2016, February 22). Evaluating Consumer Product Life Cycle Sustainability with Integrated Metrics: A Paper Towel Case Study. *Ind. Eng. Chem. Res.*, 2016, 55 (12), pp 3433–3441 DOI: 10.1021/acs.iecr.5b03743. Retrieved October 7, 2018, from <https://pubs.acs.org/doi/10.1021/acs.iecr.5b03743>

This article delves into environmental protection behind paper towels in efforts to influence decision making. The four factors of land, resources, value added, and stability highlight, with focus on the industrial process, the effects of paper towels' impact on the environment. One thing helpful about this article came from its strong variety of graphs and illustrations of data to help display a better picture regarding impact. The results show that newer state-of-the-art manufacturing facilities produce much more

sustainability in supply chains. Integrated metrics for the study point to the direction of air pollution, greenhouse gases, fossil fuels, and land deforestation as the most important resources or methods to control in order to ensure the sustainability of paper towel production preservation. This article derives from the organization of Industrial and Engineering Chemistry Research and its research was conducted by many qualified authors.

Joseph, T., Baah, K., Jahanfar, A., & Dubey, B. (2015, May 15). A comparative life cycle assessment of conventional hand dryer and roll paper towel as hand drying methods. *Science of The Total Environment* Volumes 515–516, 15 May 2015, Pages 109-117 October 7, 2018, from

<https://www.sciencedirect.com/science/article/pii/S0048969715001424>

Concerning this article two methods of hand-drying were studied, particularly warm-air hand dryers and paper towels. This sources comes from the journal *Science of The Total Environment* making it very credible. These two methods were assessed by studying the towel material and manufacturing processes and juxtaposing it against dryer electricity use and manufacturing methods. The study was aided by the deconstruction of an electronic warm-air hand dryer and a conventional paper towel dispenser. Researchers found that per functional unit, in order to achieve a pair of dry hands, the dispenser product system had a greater life cycle impact than the electronic hand dryer across three to four endpoint impact categories. Results conclude that the use of a conventional hand dryer has a lesser environmental impact than with using two paper towels issued from a roll dispenser. This journal entry has been published on the highly renowned Science Direct. However some bias could be included in the journal in order to support the personal views of the writers and editors.

Kumar, T. (2018, October). Sanitary Paper Product Manufacturing in the US. Retrieved from <https://clients1.ibisworld.com/reports/us/industry/default.aspx?entid=425>

The article includes describes the manufacturing process of paper towels and other paper-based hygiene products. This article name the key contributors to the economic and material supplies used by paper towel companies, such as Procter & Gamble, Kimberly-Clark corporation, and Georgia-Pacific LLC. Furthermore, it covers of marketing, demand, and quality control of these paper towels. The article references and explains certain business practices, such as barriers preventing entry to the market, risk assessment, uniform prices, and employment effects. Because it goes over the distribution and manufacturing of paper towels, this article would be perfect towards figuring out the technical and economical aspects of paper towels. The article does reference environmental organizations, however, it never mentions the environmental impacts of paper towels. The industry report tries to display little to no bias as it strictly describes the manufacturing and distribution of paper towels with figures and references.

Olson, S. R., Hoadley, D. A., & Daul, T. A. (n.d.) (2015, 26 May). U.S. Patent No. 20160345786A1. Washington, DC: U.S. Patent and Trademark Office. Retrieved from <https://patents.google.com/patent/US20160345786>.

This author states that the intentions of this patent are about a “paper towel product that will capably separate from the paper towel roll as a full sheet, half sheet, or quarter sheet.” While the article states that consumer demand for environmentally friendly disposable products remains high, “many consumers remain concerned about the level of resources that are required to produce” these disposable products and this article addresses these concerns head on by demonstrating the means of accomplishing this goal with a new style of perforated paper towel. The disposability of this paper towel product has been tested with two examples along with the collected data. The data comes accompanied by tables that show what percentage of consumers will be willing to choose the product in the open market. This article shows the desirable nature of the paper towel product in question to everyday consumers based off the features it has.

Paper Towels - How It's Made | Science. (n.d.). Retrieved from

<https://www.sciencechannel.com/tv-shows/how-its-made/videos/paper-towels>

This video from the popular Science Channel TV show, goes through the process from start to finish of recycled office paper becoming consumer product paper towels.

Highlighting especially in the manufacturing stage in a North American paper towel factory, viewers watch the little bits of recycled paper become pulp into dry sheets of paper into perforated sheets wrapped around a cardboard roll. By observing this entire process, viewers are able to fathom just how much work goes into a daily used product that may sometimes be taken for granted. Along with showing the technical side of manufacturing the product, the video also targets society to encourage awareness toward knowing what goes into what one buys. "How It's Made," an acclaimed show on The Science Channel for years now, takes place in real, functioning factories, thus proving it to be a credible source.

Richard, M. (2012, 12 July). U.S patent No. 8,783,600. Washington, DC: U.S. Patent and Trademark Office.

The patent describes an invention proposed by Myron Richard. The invention, called the center spreader, allows paper towel rolls to still be usable without the cardboard tubing in the center. By using a device that creates ridges within the paper towel roll, the inside of the roll separates, allowing a place for paper towels to be inserted. In the patent, Richard claims his product is meant to help the environment by preventing over pollution due to throwing away the paper towel rolls. Furthermore, he describes how the product works as well as its dimensions and reliability. This article is a U.S approved patent, found on WIPO (World Intellectual Property Organization). However, the patent could possess some bias as it is written by the inventor himself.

Srinivasan, A. (2004). Value of ecolabels and expenditure analysis for paper towels (Doctoral dissertation). Retrieved from Rowan University Libraries ProQuest. (3123822)

This study addresses the effectiveness of ecolabels on paper towels. Ecolabels appear on products that boast the use of recycled materials in the products, such as paper towel made from post consumer materials. The study focuses on the effects ecolabels have on consumers buying paper towels. The research examines the amount of consumers that actually notice the eco labels on the paper towel packaging, and the influence they have on consumers willing to pay extra for recycled products. Motivation for this study lies in the environmental impact of the large amounts of waste created from the disposal of paper products. If consumers buy eco labeled paper towels, many societal, economic, and environmental applications can be examined. This source holds credibility in many ways. Conducted through the School of Business and economics at the University of Kentucky, this dissertation includes respected language and countless figures, charts, and data to support the findings discussed.

(2018, October 5). Wait paper towels really come from trees? Retrieved from

<http://www.growingagreenfamily.com/wait-paper-towels-really-come-from-trees/>

The author of this eco-friendly website addresses many questions regarding paper towel and their impact on the environment. The author states that recycled paper towels do not benefit the environment, as recycling them a second time after use proves to be harder. In addition, the author establishes her viewpoint against the use of paper towels and more towards cloth alternatives for environmental purposes; however, she does include opposing viewpoints to provide reasoning for the motivation of her writing. The author writes to explain the importance of being eco-friendly by focusing on location of paper manufacturing, the making process, and environmental impacts. This webpage does not hold high credibility; however, the author does research everything she publishes and does provide answers to many questions.

APPENDIX B

Raw data (Tables B-1 through B-5) and calculated results / sample calculations (Equation B-6)

Table B-1: Resulting data from Test 1

Trial	Bounty (in)	Viva (in)	Shoprite (in)
1	5.62	3.04	5.52
2	5.60	3.38	5.16
3	5.44	3.07	4.79
Mean	5.55	3.16	5.16
Standard deviation	0.0987	0.188	0.365

Table B-2: Resulting data from Test 2, part A

Trial	Bounty (g)			Viva (g)			Shoprite (g)		
1	Start	Final	Actual	Start	Final	Actual	Start	Final	Actual
	2.6	25.4	22.8	3.1	26	23.9	1.7	12.7	11
2	Start	Final	Actual	Start	Final	Actual	Start	Final	Actual
	2.6	25.7	23.1	3.1	27.5	24.4	1.7	11.3	9.6
Mean	22.95			24.15			10.3		

Table B-3: Resulting data from Test 2, part B

Trial	Bounty (ml)	Viva (ml)	Shoprite (ml)
1	48	57	31
2	53	54	24
3	57	56	31
Mean	53	56	29
Standard deviation	4.5	1.5	4.0

Table B-4: Resulting data from Test 3, part A

Trial	Bounty (g)	Viva (g)	Shoprite (g)
1	1600	810	490
2	1550	860	300
3	1690	770	330
Mean	1613	813.3	373.3
Standard deviation	71	45	100

Table B-5: Resulting data from Test 3, part B

Trial	Bounty (g)	Viva (g)	Shoprite (g)
1	2300	1400	700
2	2400	1550	750
3	2400	1550	850
Mean	2366.3	1500	766.3
Standard deviation	58	87	80

Equation B-6: Standard deviation

$$\sigma = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$

X = Measurement

\bar{X} = Average of all measurements

n = Number of measurements

σ = Standard deviation