Absorbency of Disposable Diapers

Alyssa Lewis

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Unitas General Science

Abstract

Ever since disposable diapers were created in the 1900s, desperate parents have been on the search for the most absorbent of the diapers. The purpose of this experiment was to determine which of three selected diaper brands can absorb the most liquid. If a certain amount of liquid is poured into a disposable diaper, it will leak or reject the liquid. It was hypothesized that the Pampers brand diaper would absorb the most water. A beaker with milliliter measurements was used to slowly pour water onto each brand of disposable diapers until the diaper would no longer absorb water or began leaking out of the back or sides. The most important variables were reduced or eliminated to ensure accurate results. Some variables that were eliminated were the type of liquid and the size of the diaper. On average, Pampers brand absorbed 982 milliliters of water. The Hello Bello brand absorbed 929 milliliters of water on average. In contrast, the brand Bambo Nature absorbed 1,441 milliliters of water, making it the most absorbent disposable diaper out of the three diapers tested. Determining which diaper absorbs the most liquid may lead to the improvement of the disposable diaper.

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1.0 Question

How much liquid can different brands of diapers hold?

2.0 Purpose

The purpose of this experiment was to determine which brand of diaper can absorb the most liquid out of the three brands tested.

3.0 Variables

3.1 Independent Variables

The diaper brands: Bambo Nature, Pampers, and Hello Bello

3.2 Dependent Variables

The volume of liquid in the diaper.

3.3 Controlled Variables

The diaper size, the type of liquid, how long the liquid is allowed to settle, how the diaper is laying, whether the diaper is a nighttime or daytime diaper, how quickly the liquid is poured in, the water temperature.

4.0 Hypothesis

Each diaper will only hold a certain amount of liquid before it will become saturated and start to leak. It was hypothesized that the Pampers diaper would absorb the most liquid.

5.0 Background

No one wants a wet diaper. Because of a cotton shortage, Marian Donovan developed disposable diapers after World War II. (Spurrier, 2018). "'Diaper' was originally the term for an overall pattern of small repeated geometric shapes, and then a white cotton or linen fabric with such a pattern" (Reinhardt and Beck, 2019). Diapers have developed over the years, resulting in the disposable diaper we have today. The question is, how much liquid are different diapers able to absorb? Understanding how the disposable diaper has developed, how it is designed, and how superabsorbent polymers work will provide parents with information they need to choose the best diaper for their child.

The way diapers have developed over the years is truly amazing. In ancient times, diapers were extremely different from the diapers we have today. Diapers were packed with any resource available, but the most common were moss, grass, and wood shavings (Catcher, 2019). Animal skins and milkweed leaves were also used (Reinhardt and Beck, 2019). Depending on what country the babies lived in, the material with which the diaper was packed could vary. In China, the baby's diaper could be filled with sand to absorb the urine (Tobin, 2020). Early diapers in Europe and North America were made of a rectangular or square piece of linen (Reinhardt and Beck, 2019). Cotton was also used, if linen was not. Everybody tended to use safety pins to hold the diaper in place, even if they were not the safest option (Reinhardt and Beck, 2019). However, cotton and linen have to be washed, so a disposable alternative was sought. The first signs of disposable diapers started to shine through in the 1940s, when a British man crafted the first disposable diaper insert (Catcher, 2019). The diapers developed over the years, beginning to become more complex and efficient. People first started trying the new rage in the mid 1900s. It is no secret that most parents find disposable diapers to be more convenient. However, there were many problems with the disposable diaper. Many diapers nowadays are scented. However, that is not the preferred option, as the fragrances are chemical-laden (Spurrier, 2018). Modern diapers also use dyes, which can cause skin rashes (Spurrier, 2018). However, most parents feel that the most important quality they seek is convenience. Thus, today, the majority use the disposable diapers that have been evolving since ancient times.

The disposable diaper is made up of three main components: the inner layer, also known as the absorbent core, the outer layer, and the closure. Most of the diaper is composed of the absorbent core(Spurrier, 2018). The absorbent core keeps the baby's skin dry, even if the diaper

is sat on when wet (Beraho, 2017). The core can absorb many times its own weight. The components that are needed to produce the absorbent pad are put into a machine which combines them and spits them out on the other side (How It's Made, 2015). The core comes out of the machine in strips ready to be cut into diaper sized pieces (How It's Made, 2015). The first absorbent pad was made of unbleached creped cellulose tissue (Reinhardt and Beck, 2019). Now, part of the disposable diaper's core is made of pine, wood, and cotton wool, combined with a pine fluff (How It's Made, 2015). The fluff in the absorbent core spreads the liquid over the surface of the diaper and superabsorbent polymers absorb it (Spurrier, 2018). These two agents work together to make the inner layer as absorbent as possible. The diaper's absorbent core is secured by sheets of fabric. The outside of the diaper is made of a waterproof fabric to prevent seepage (How It's Made, 2015). This layer of the diaper is also referred to as the backsheet (Beraho, 2017). The backsheet is structured to allow water vapor and air, not liquids, to pass through the outer cover (Beraho, 2017). The outer layer is made from the same material as plastic wrap (Woolston, 2019). The plastic is petroleum based. If the material is not plastic, it is material that has been treated with plastic (Spurrier, 2018). Chlorine can be used to bleach diapers even though has been known to be carcinogenic, which means it has the potential to cause cancer (Spurrier, 2018). Nonwoven loop landing zone material or mechanical hook tape can be used to close diapers (Driessche and Geensen, 2015). Different brands have differently sized closure tabs. Cuffs are used to prevent leakage out the leg holes and the waist (Beraho, 2017). These three components, the absorbent core, the outer layer, and the closure, are essential to the production of the diaper in order for the diaper to hold the maximum amount of liquid waste.

One of the most necessary materials, found in the absorbent core, is SAP, which stands for superabsorbent polymers. This material is critical to the absorbance factor of the diaper. Using SAP in diapers is more effective and useful because of how much more liquid the superabsorbent polymers can absorb than fluff pulp. Cotton and fluff pulp only have the ability to hold up to 20 times their own weight (Layton, 2017). However, superabsorbent polymers can absorb hundreds of times their own weight. SAP is a granulated chemical which swells to retain urine (How It's Made, 2015). The superabsorbent polymers appear differently under differnt circumstnces. These small crystals are a white powder when dry and transparent when wet. Sometimes the SAP can leak out of diapers, leaving the crystals behind (Woolston, 2019). Thus, it is extremely important for the superabsorbent polymers to be extremely safe if they are going to make contact with the babies' skin. Because most SAP existing now is derived from petroleum, there are concerns about the chemical nature of the SAP (Spurrier, 2018). To begin with, the crystals have been known to kill children after consuming as little as 5 grams of it (Gifford, 2019). Inhaling particles may cause irritation to airways (Woolston, 2019). In addition, SAP can cause skin irritation, fever, vomiting, oozing blood from perineum and scrotal tissues, and staph infections (Gifford, 2018). Ties to Toxic Shock Syndrome have also aroused speculation and suspicion (Spurrier, 2018). Thankfully, some diaper companies have concluded that the SAP they use is non-toxic and safe for babies' sensitive skin (Spurrier, 2018). They use SAP that has not been derived from petroleum, but is plant-based. Some of the companies stating this claim are gdiaper, the Honest Company, Seventh Generation, and Bambo Nature, one of the diapers used in theis experiment (Spurrier, 2018). Unfortunately, Pampers does not disclose the kind of SAP they use (Spurrier, 2018). Hello Bello uses traditional petroleum based SAP.

Unfortunately, it is not clear if testing has been sufficiently done concerning the SAP (Spurrier, 2018). Therefore, the word of these companies cannot be completely trusted. All in all, even if superabsorbent polymers may be dangerous, they are useful, and therefore used to great extent.

The purpose of this experiment was to explore which disposable diaper holds the most liquid. Although diapers are used to absorb liquid waste from the wearer of the diaper, water was used in this experiment with the intent that the results can be extrapolated to determine which disposable diaper would hold the most liquid waste. Understanding the history of the diaper, the design of the disposable diaper, and the superabsorbent polymers are essential to designing and carrying out an experiment that will provide an answer to this question. It was hypothesized that the brand Pampers would absorb the largest volume of liquid. Thanks to Marion Donovan's innovative mind, today's world now has an effective disposable diaper that many people choose to use today.

6.0 Procedure

The equipment and materials used in this experiment were as follows:

- Pampers diaper 14-33 lbs.(3)
- Hello Bello diaper 16-28 lbs.(3)
- Bambo Nature diaper 15-40 lbs.(3)
- Paper towels
- Water
- A clean beaker with milliliter measurements
- Pair of disposable gloves (3)
- Waterproof permanent marker

1. The Pampers were laid out and numbered as follows:

#1 Pampers
#2 Pampers
#3 Pampers
Each diaper was used for a different trial in this experiment.

2. The Hello Bellos were laid out and numbered as follows:

#1 Hello Bellos
#2 Hello Bellos
#3 Hello Bellos
Each diaper was used for a different trial in this experiment.

3. The Bambo Natures were laid out and numbered as follows:

#1 Bambo Nature
#2 Bambo Nature
#3 Bambo Nature
Each diaper was used for a different trial in this experiment.

4. The beaker was filled with water.
5. Paper towels were laid on the counter.
6. The #1 Pamper was laid flat on the paper towels.
7. The beaker was filled with water until the 250 milliliter mark.
8. The water was poured into the diaper.
9. The diaper was observed in order to find water resting on top or leaking out of the diaper.
10. Steps 7-9 were repeated until the diaper began rejecting or leaking water.
11. The volume of water needed for the diaper to show signs of wetness were recorded.
12. The #1 Pampers diaper was removed from the counter.
13. Steps 4-12 were repeated using the #1 Hello Bello diaper.
14. Steps 4-12 were repeated using the #1 Bambo Nature diaper.

15. Steps 4-14 were repeated using the diapers labeled #2.
16. Steps 4-14 were repeated using the diapers labeled #3.

6.1 Photographs of Procedure

Figure 1. Initial set up of materials.

Figure 2. Numbering the diapers.

Figure 3. Laying the diaper on paper towels.

Figure 4. Using the beaker to pour water.

Figure 5. The diaper increasing in size.

7.0 Results

Table 1. Volume of liquid held by each diaper at capacity.

Diaper Brand	Trial #1 mL	Trial #2 mL	Trial #3 mL	Average mL
Pampers	628	1160	1159	982
Bambo Nature	1228	1665	1430	1441
Hello Bello	794	1000	992	929

Figure 6. Graph to show volume of liquid held by each diaper at capacity.

Figure 7. Photograph of Results

8.0 Data Analysis

Bambo Nature exhibited the greatest amount of absorbency, absorbing an average of 1441 mL of water. Pampers absorbed the next greatest amount of water with an average of 982 mL of water. Lastly, Hello Bello exhibited the least amount of absorbency with a mean of 929 mL of water. In Trial #1, Bambo Nature absorbed 1228 mL of water, Pampers absorbed 628 mL of water, and Hello Bello absorbed 794 mL of water. In Trial #2, Bambo Nature absorbed 1665 mL of water, Pampers absorbed 1160 mL of water, and Hello Bello absorbed 1000 mL of water. In Trial #3, Bambo Nature absorbed 1430 mL of water, Pampers absorbed 1159 mL of water, and Hello Bello absorbed 992 mL of water. The Bambo Nature diapers exhibited a noticeably greater absorbency than the other two diaper brands tested. Pampers held around 32% less water than Bambo Nature. Likewise, Hello Bello held around 36% less water than Bambo Nature. The Hello Bello and Pampers diapers held varying amounts of water in each trial. In Trial 1, Hello Bello held more water than Pampers. However, Pampers held more water in both Trials #2 and #3, causing Pampers to be a more absorbent diaper than Hello Bello. The different kinds and quantities of superabsorbent polymers used have an effect on how absorbent and effective the diaper will be. Bambo Nature, with plant-based SAP, absorbed the most. Hello Bello, with a petroleum-based SAP, absorbed the least. Because Pampers does not disclose their kind of SAP, it is unclear if the kind of SAP affected the absorbency. In Trial #1, the results were uniformly lower in all three diaper brands. The results were conclusive but did not support the hypothesis, as the Pampers brand was the second most absorbent on average.

9.0 Conclusion

Bambo Nature absorbed the most liquid, and Hello Bellos absorbed the least amount of liquid, with Pampers absorbing the second least amount of liquid. The results did not support the hypothesis. It was learned that the amount and kind of superabsorbent polymer affects how absorbent the diaper will be. The diapers with plant-based SAP are able to absorb more liquid. The fact that the first trial's results were lower may be due to miscalculations or other technical difficulties. Further research could include experimenting with different sizes of the three brands tested.

10.0 Acknowledgements

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