A Novel, Easy-to-clean Protein Shaker

by

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Abstract

The goal on this thesis project was to develop a novel, easy-clean protein shaker. Protein shakers are used to contain and mix protein supplementation powder and water or liquid of the user's choice. Due to the nature of products within the fitness theme, shakers should be easy to use and low maintenance. Significant problems with current protein shakers are bacteria build-up in hard-to-reach places, low quality seals, mouthpiece caps separating from the shaker, and unsatisfactory mixing. Therefore, the goal of this project was to design and prototype a protein shaker that would be easy to clean, preventing unnecessary bacteria build-up in hard-to-reach locations in the shaker.

In order to identify the needs of shaker users, an investigation into what current shaker users believed important in a product was conducted. A new design that eliminated all corners and crevasses was proposed and a prototype was constructed using rapid prototyping technology. The prototype provided further insight to additional improvements that could be made to the design. The goal of being easy to clean was successfully achieved.

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1 Introduction

In the world of fitness, the protein shake is used for nutritional supplementation not just after workouts, but at any time, in any place. In this fast-paced world, it is a functional requirement for shakers to need less effort to maintain and to keep bacteria-free. Though it is best for protein shakers to be cleaned immediately after the drink is finished, it's not always possible since they are sometimes taken on-the-go. With this in mind, when a shake is finished, there is usually a little bit of protein left over that will sit at the bottom of the shaker or in/on any groove in the bottle. If this sits for more than a couple hours, bacteria will begin to grow, the shaker will smell, and the container will be even harder to clean. If the shaker has grooves that are thin, such as threads, or areas where normal water flow (i.e. from a faucet) is disrupted, as provided by corners or irregular shapes in the bottle, the build-up can be even tougher to clean.

This thesis project aims to design a protein shaker that is easy to clean. The final image of the shaker can be seen in Figure 1.

Fig. 1: 3-D Print of Easy-Clean Shaker. Shown is the assembled prototype.

The structure of this document follows a similar sequence as that of the design process that went into the shown prototype. Beginning with benchmarking present-day protein shakers and understanding the needs of the users, the design is finalized and finally, a prototype is made. Once the prototype is tangible, additional improvements to the design can be noted and made.

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1.1 Background

In order to understand shakers in the current market, an investigation was conducted to benchmark existing shakers and search for any ensuing trends. The shakers chosen for the benchmarking came from a random sample of Zesiger Center patrons. That being said, not all patrons used containers that were designed to be protein shakers. This fact, however, allowed for more design flaws to be highlighted. Some shakers exhibited a focus on the mixing and blending of the drinks. The shaker shown in Fig. 2 even featured a compressible, wire-frame agitator to improve mixing capabilities.

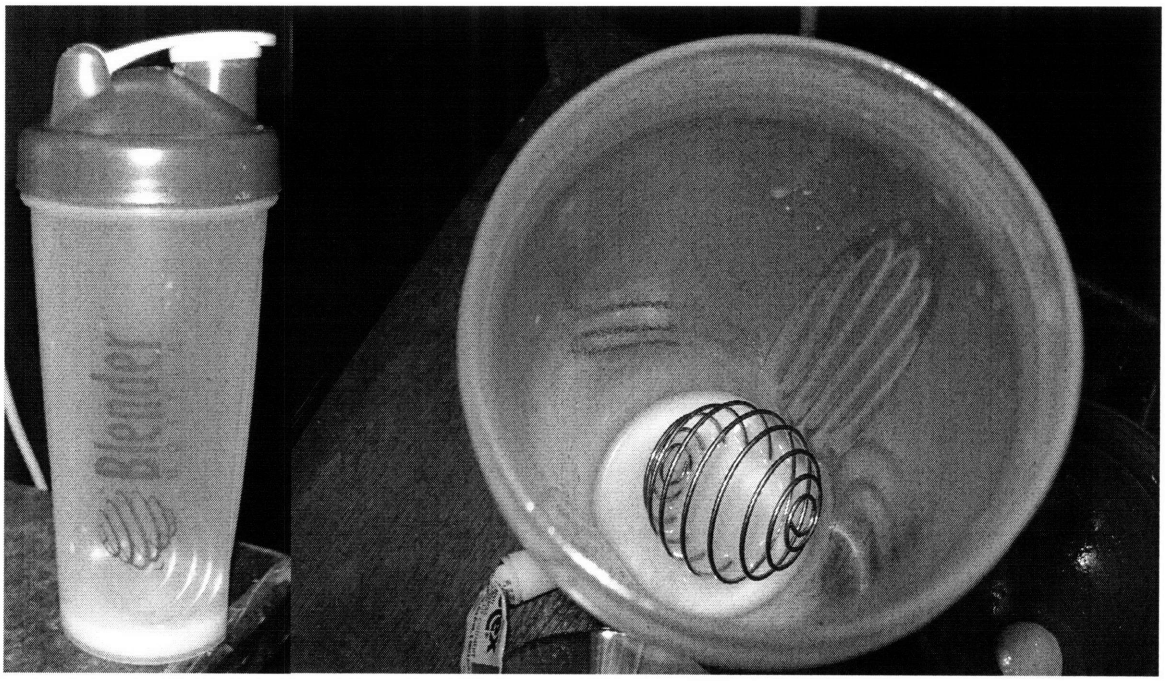

Figure 2: Blender Bottle®. This is a protein shaker with an emphasis on mixing the drink. (The agitator can be seen in bottle on right.)[1]

Although this is a high-quality protein shaker with respect to mixing performance, it was not designed with clean-ability as a top priority. It has sharp corners in the bottom, grooves on the sides of the bottle to give the inside an irregular shape, and the inside of the cap has detailed indentions (shown in Fig. 3, page 9) that provide a "high-traffic" location of the bottle a means of protein and bacteria build-up.

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Fig. 3: Blender Bottle® cap. A cap with protein build-up in the indentions of the cap.[1]

Other shakers in the sample appear to have been designed with little focus other than aesthetics. The shaker shown in Fig. 4 has circumferential indentations for style as well as a detailed cap design for a rugged look.

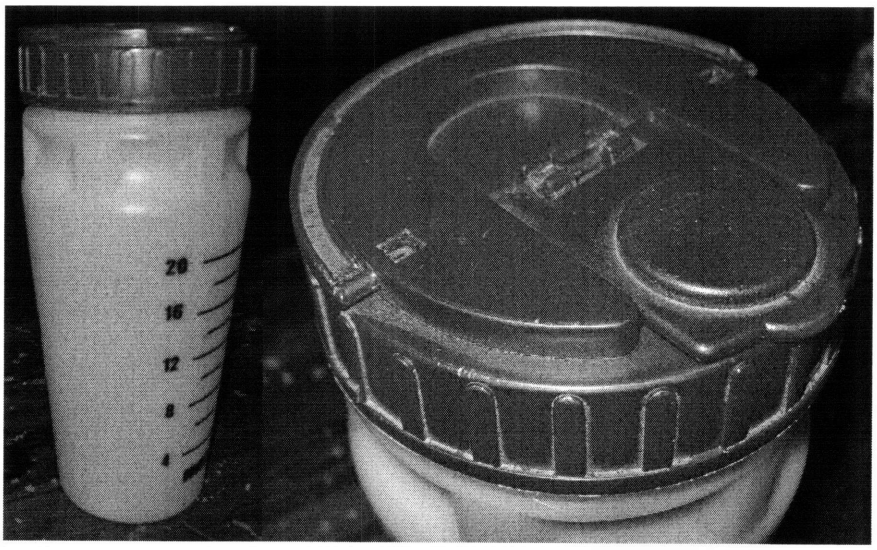

Fig. 4: BSN brand shaker. Shaker pictured above has circumferential indentations and an intricate cap for aesthetics.[2]

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This shaker accomplishes its goal of being aesthetically pleasing; however, it is exceptionally hard to clean, leaving it with build-up in the cap and grooves in the bottle. As seen in Fig. 5, in the shaker cap, nearly everywhere there is detail, there is build-up.

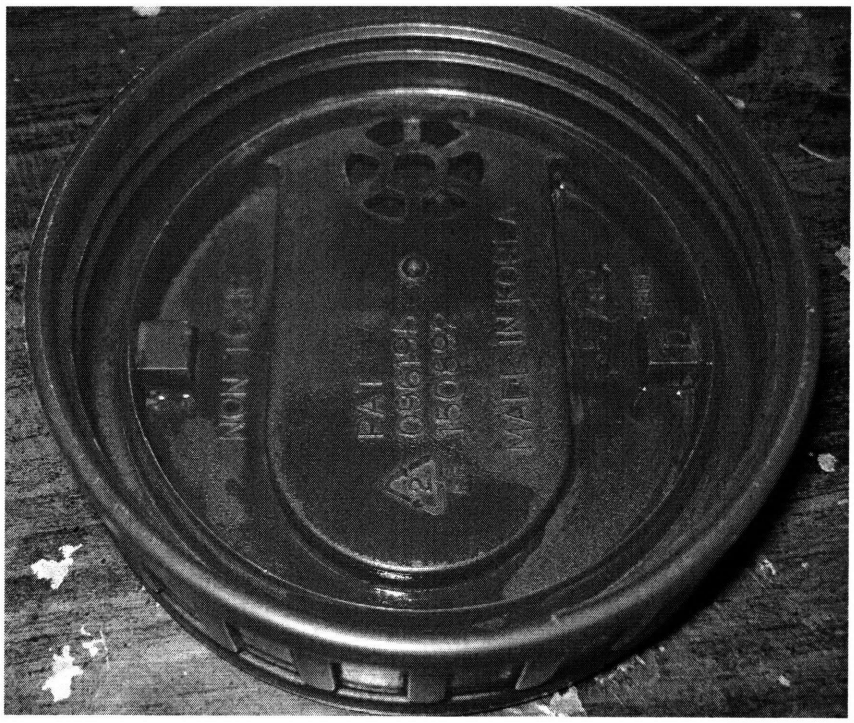

Fig. 5: Inside view of BSN brand cap. As can be seen in the picture, the cap has many details inside. It has corners and grooves that fingers cannot even fit into. To give a sense of scale, the mouthpiece (located at the top of the picture) is approximately the size of a quarter.[2]

Bottles used by patrons that were not designed to be protein shakers gave additional insight to features that are difficult to clean. Some bottle openings were too small to fit a hand in, so the bottom of the bottle could only be cleaned by shaking soapy water in the bottle. This method is not very effective if any amount of protein has been sitting in the container for several hours. In order for the user to clean the bottle properly, he/she must have some cleaning utensil that can fit through the opening and scrub the bottom. As described above, current protein shakers have many focuses; clean-ability is not a strong one.

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2 Considerations of Current Shaker Users

For a product with the end user in mind, an investigation must be conducted to understand the needs of the user. The investigation that was undergone took many suggestions from another group of Zesiger Center patrons that could be broken down to the following categories: shape, dimensions, aesthetics, functionality, and material selection. These suggestions were "what they found important in a protein shaker."

An overwhelming amount of surveyed patrons mentioned the same things. Most suggestions could be categorized as a shape or dimensional attribute. Patrons found it important that the mouth of the bottle portion of the shaker be wide enough to fit any size scoop. It was also found important that the bottle portion of the shaker was short enough to fit under most sinks and to be able to fill up to over 80% capacity with the average water fountain. Some patrons also wanted the shaker to be easy to hold and clean/dry, implying that a hand should be able to fit in it most of the way. One suggestion for the shape of the cap was for it to resemble a funnel so that the shake would be easy to drink fast. A breakdown of the percentage of patrons favoring certain design suggestions is shown in Table 1. The suggestions within the survey came under the premise that easy-clean design parameters would be determined by the author.

Table 1: Support of design suggestions by sampled patrons (based on sample size of 10) that were strongly considered in actual design of prototype.

Suggestion of Patron	**Percent of patrons with this suggestion**
Wide top to bottle	80%
Height limit	40%
Transparent bottle	60%
Quality seal	40%
Measurement lines	60%
Funnel-shaped cap	10%

Though no patrons mentioned exactly what the shaker should look, they mentioned that it should be transparent so that the liquid level can be observed easily. A few also mentioned that a dark-colored cap would be appealing. One specified attribute that can be considered both aesthetic and functional is a set of measurement lines on the outside of the

bottle. Patrons also mentioned some attributes and features of importance to them that were purely functional. Many wanted a cap that didn't leak or detach while in the shaking process. One patron mentioned the possibility of a handle on the side of the bottle to aid the user in shaking because mixing well is a definite requirement.

Transparency of the bottle deals not only with aesthetics, but material selection as well. Along those lines, some patrons thought it would be enticing for the inside of the bottle to have non-stick sides and to be smell resistant. Moreover, with the non-stick feature still in mind, it was important to be able to write one's name on the outside with a permanent marker.

3 Design of Easy-Clean Protein Shaker

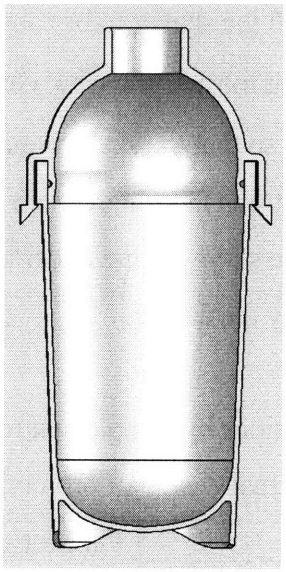

Fig. 6: Prototype Cross-section. A cross-section of assembled prototype's solid model.

Respecting the suggestions of the surveyed patrons, the design of the prototype, shown in Figure 6, began. To design the bottle portion of the shaker, the dimensional constraints should be considered. It was suggested that it should be short enough to both fit under most sinks and be able to fill up with an average water fountain. It was found that most kitchen sinks have very high clearances, so they would not be the limiting factor here; it would be bathroom sinks. An average clearance height in bathroom sinks, by measuring both MIT residences and MIT public bathroom sinks, was found to be approximately 8-9". The next

check would be the average height of water fountain streams. Measuring fountain streams from around the Zesiger Center and MIT's Infinite Corridor, the peak heights varied from 6-8". When filling up a bottle of any sort, the bottle doesn't need to be stood up, but rather held at an angle. This means that the bottle being filled can be taller than the stream height and still be filled most of the way. Another factor affecting how much the fountain can fill the bottle is where the stream lands with respect to the edge of the fountain basin. Most streams landed within 3-4" from the side of the basin, allowing the bottom of the bottle to be held off the edge when being filled. It also needed to be easy to reach the bottom of the inside portion of the bottle with one's hand, so it needed to be wide at the top. These were the factors that determined the width of the mouth as well as the height of the bottle portion of the shaker. To determine how the profile of the bottle would look, more specifically the width of the base of the bottle, a bottle of similar size was considered. As a base for how big a bottle could be before being too hard to hold, a 32 oz. Gatorade™ bottle[3] was benchmarked. The final width of the shaker bottle's base was held to 3 ¼", about a 3/8" smaller diameter than the Gatorade™ bottle for safe measure. Finally, in order for the bottle portion of the shaker to be easy to clean, it must have no corners, meaning that the bottom must be somewhat hemispherical. However, the shaker must also be able to stand, so to have the round bottom it must also have a skirt around it to be the standing base. To provide additional clearance from the round bottom to the ground, the skirt was extended about ¼" past the plane of the round bottom for stability purposes.

To begin the design of the cap, some sort of base for the layout needed to be chosen. Since it too should have no concave corners, the cap was to be hemispherical in nature as well. Thinking back to the suggestions of the surveyed patrons, it is necessary to have a seal that will not leak. Due to the small radius of the threading grooves in most caps, other sealing methods were investigated and a snap fit with an o-ring was chosen for its clean-ability. The type of snap that worked best with the design of the shaker was a cantilever snap.[4] In this type of scheme, the outside of the bottle deflects the cantilevered snap until it reaches the ledge on the bottle where it snaps back to zero deflection and is

secure to up and down motion (the removal of the cap). The amount of allowable deflection, y, was determined using Equation 1.

$$y = \frac{2\varepsilon L^2}{3h} \quad [5] \qquad \text{(Eq. 1)}$$

The model used for determining the dimensions of the snap can be seen in Figure 7.

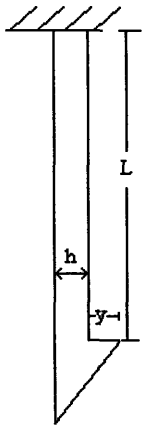

Fig. 7: Cantilever beam model. The model shown was used for the calculations that determined the size of the snap feature.

For sealing purposes, the o-ring is located between the outside of the cap and the inside of the bottle.

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Determining the size of the mouthpiece for the cap required the making of a mock-up, as shown in Figure 8.

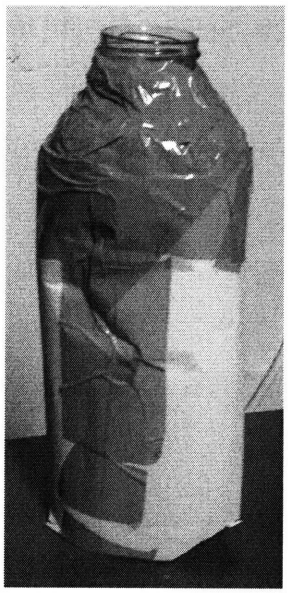

Fig. 8: Shaker Mock-up. The mock-up shown above was made of paper, tape, half of a tennis ball, and the mouthpiece of a Vitamin Water™ bottle. The mock-up helped determine if the dimensions of the bottle were plausible and how high the mouthpiece should come out of the cap to avoid collisions with the user's nose while drinking.[6]

Although the majority of protein shakers have the mouthpiece positioned off to one side of the cap, the one for this shaker is placed in the center. Taking into account on patron's desire for a funnel shape top for speed drinking, there are additional advantages with this particular shape. The centered mouthpiece also gives it a symmetrical, streamline look. The symmetry isn't purely aesthetic, however; it adds ease of use because the shaker can be drunk from any orientation. A functional advantage is that it takes advantage of the hemispherical shape of the cap. The mouthpiece utilizes the shape since the flow of liquid is naturally directed to the center, when in a drinking position, extracting more protein from the container than usual.

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4 The Prototype

From a solid-model of the design described in the previous section, a rapid-prototype was 3-D printed, as seen in Figure 9.

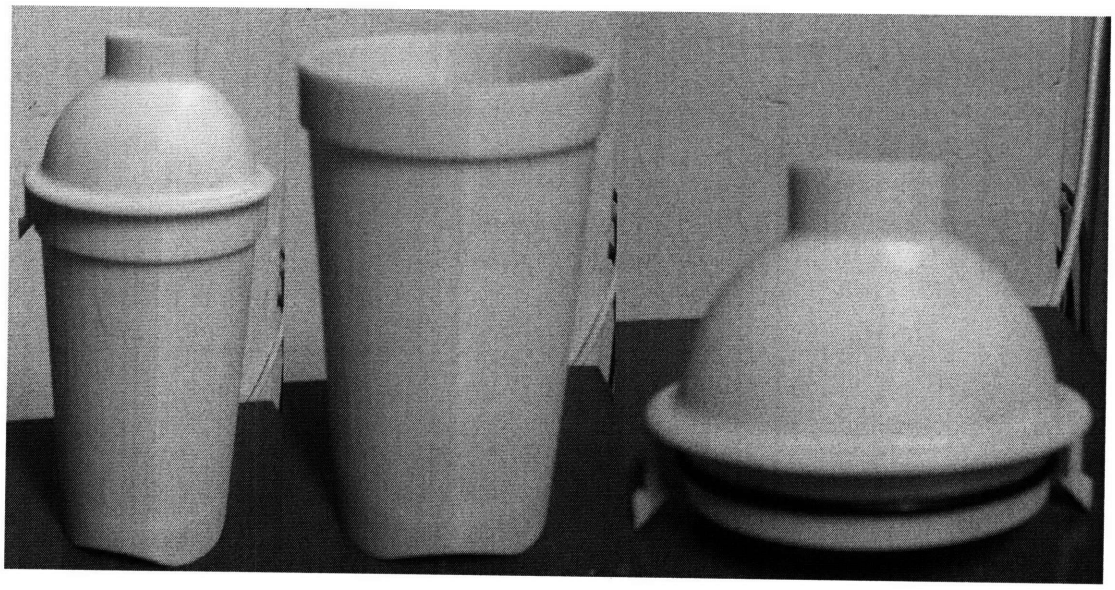

Fig. 9: Components of Easy-Clean Shaker. From left to right is the fully assembled shaker, bottle, and cap. Seen on the cap is the o-ring.

Since the round bottom of the bottle portion of the shaker cannot be seen from the prototype, a cross-section of the solid model can be seen in Figure 10.

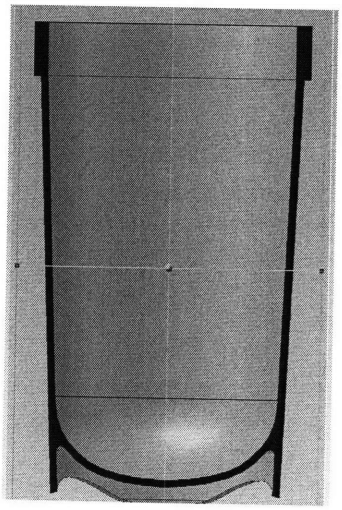

Fig. 10: Cross-section of Bottle. The picture shows a cross-section taken from solid model of prototype.

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As can be seen from Fig. 8, the bottle portion contains no corners to allow the build-up of protein and bacteria, accomplishing the goal of being easy to clean. Although it appears that there is a lip near the top of the bottle, it is merely a line that the solid modeling software includes to indicate the interface of two walls of two different slopes. It is extremely difficult to remove this line due to the vertical plane constraint of the bottle-cap interface. Though the cap interface and the sloping wall of the bottle are of differing slopes, the actual change is so minute that the slope-change line is undetectable to the eye. Also shown in the picture is a wavy, radial cut around the skirt for aesthetics and stability purposes.

5 Conclusions and Future Work

Details for aesthetics that affected the functionality or goals of this shaker were avoided during the design process. The prototype produced is a protein shaker that has no corners, ledges, indentations, or crevasses that cannot be reached by a hand or finger for cleaning purposes where protein would be stored. Therefore, the prototype has proven that the design would be easy to clean.

The final form of the prototype came with many suggestions as well as questions for the future of this project. Currently, with the o-ring that is on the cap, the top and bottom of the shaker cannot be fully attached. The main cause for this is a clearance/spacing issue between the outside of the cap and the inside of the bottle. This issue can be resolved by both decreasing the outer diameter of the cap wall facing the bottle and making sure the o-ring is perfectly fit for the groove in the cap. Furthermore, with the new clearance, it will become obvious that the tabs that open the snaps need to be wider and more comfortable to engage. The current prototype has some sharp edges and corners that were overlooked, including the current tabs and the bottom circular edge of the cap. In the future, a stopper for the mouthpiece would be used to start testing its seal strength. Then to fully test the prototype, it would either need to be made out of clear plastic, or if it were 3-D printed again, it could be sprayed with a clear lacquer, for water-proofing. Hopefully, it would be made out of clear plastic so that it can have measurement lines on

the outside to monitor the containing liquid's volume. Optimization of parameters governed by the easy-clean form factors were a goal clearly met in this project, and making the aforementioned minor changes will launch this prototype to market.

6 References

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