ENGS 21. Introduction to Engineering

Engineering Improved Quality of Life

Final Report

Almond Press

Group Number: 8

Group Members:
Amanda Bak
Maya Clarke-Brunetto
Shinar Jain
Himadri Narasimhamurthy
Daniel Phan
Robert Wang

TA: Sarah Rote

Tech Adviser: Dan Denauw

Executive Summary

A 2015 survey reports that U.S. customers purchase plant-based milks for taste and health value. Almond milk is in high demand for vegans (~3.2% of the U.S. population) and the lactose intolerant (~12.5% of the U.S. population). With a lack of effective technology, the target population does not have an easy and clean way to make additive-free almond milk.

Therefore, we propose the Almond Press: a unique product inspired by can crushing and juice press technologies. After blending almonds and water in a high-speed blender, the user will pour the mixture into a strainer lined with nylon mesh. The top presser, attached to a user controlled lever arm, will crush and squeeze the almond pulp, filtering the milk into a cup below. State-of-the-art (SOA) almond milk products are lacking: store bought milk is either expensive or contains additives, handmade milk is messy and time intensive, and automated milk makers produce low quality milk. Our analysis of the SOA products includes documenting population surveys of the commercial offerings for consistency, taste, creaminess, and nuttiness.

We also compared the process time, volume of produced milk, and mass of leftover pulp for the handmade process, the Almond Cow Milk Maker, and our Almond Press prototype. With a manual press, replaceable strainer, and easy-to-wash assembly, our Almond Press will trump market alternatives. We intend to produce our Almond Press in a factory and distribute through organic food retailers and e-commerce outlets. Based on our profit forecast and a market size of approximately 1.25 million users, we will break even before our third year.

Throughout our design process, we will constantly incorporate user feedback of Petra Taylor, frequent almond milk consumers, and college students. Our team encompasses many strengths including engineering and machine shop knowledge and design thinking and economics experience.

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1. Introduction and Problem Statement

The lack of healthy and additive-free dairy alternatives is a significant issue for many Americans with dietary restrictions and preferences. Almond milk is a low calorie and vegan option for these consumers. However, pre-packaged options often have additives and the handmade process is time intensive and laborious.[1] Almond milk is a mixture of ground almonds and water. The mixture typically contains naturally occurring vitamins and minerals, along with brand-dependent additives. One cup of almond milk typically contains 30 calories, 2.5 grams of monounsaturated and polyunsaturated fats, 160 milligrams of sodium, and 1 gram of protein.[2]

1.1 Demographics/Problem Scope

Between vegan consumers and the dairy intolerant, the consumer base for almond milk is around 18% of the U.S., about 60 million people.[3] Approximately 12.5% of the U.S. population has a heavily reduced ability to digest lactose and is medically diagnosed as lactose-intolerant.[4] In addition, 3% are unable to digest casein, a protein in dairy milk.[5]

1.2 Problem Statement

Current technology to make homemade, additive-free almond milk is time-intensive, messy, and inefficient for those who need to drink almond milk but wish to avoid potentially harmful additives in pre-packaged options.

2. Customer Profile

2.1 Description of User, Demographics, and User Preferences

U.S. consumers buy plant-based milk, including almond milk, for its taste (68%), health benefits (65%), and dietary restrictions (24%).[3] In 2015, U.S. almond milk sales yielded approximately $1.2 billion in revenue and are projected to increase to $1.8 billion by 2020.[6] Our target market will include individuals who a) produce homemade almond milk, and b) currently drink almond milk but prefer the added health benefits of homemade almond milk. Therefore, our product has the potential to benefit from the large and growing market.

Petra Taylor, a Dartmouth engineering professor, stated, “I drink almond milk daily for taste and health reasons. I have to make my own almond milk every few days, since commercial almond milk has a ton of additives, but it's a messy process.” She has expressed great interest in a solution that creates high quality almond milk and is user friendly.

2.2 Survey Results

To better understand our target market, we surveyed 80 individuals at various local dining locations, including King Arthur Flour, Dirt Cowboy Café, the Class of 1953 Commons, and House Center B. We found that 53 participants drank or made almond milk on a monthly basis at the least. One student mentioned, “I don’t like some brands that have a lot of additives. I can tell by taste and I’ve had an allergic reaction to Silk.”

Our participants were willing to pay $20-$50 for an almond milk production device, but because college students tend to be more price-senstive, we believe our target market would consider puchasing a device up to $100. The remaining survey data can be found in Appendix A.

Of the survey participants, 10 have also volunteered to assist us with user testing and feedback in the future. In addition to these participants, we are in regular contact with Professor Taylor.

3. State-of-the-Art

3.1 Products

As displayed in Table 1, we explored three state-of-the-art means of obtaining almond milk: pre-packaged almond milk, the handmade almond milk process, and existing technologies, such as automated almond milk makers. Enlarged state-of-the-art images and our full SOA table can be found in Appendix B.

Table 1: State-of-the-Art Product Analysis

Product Name	Description	Strengths	Weaknesses
 Almond Cow Milk Machine[16]	• All-in-one machine • Designed specifically to make almond milk • Can be used for any other nut based milk at home	• Automatic - less laborious for the user • Results in less mess than handmade process • Eliminates need for nut bag	• Expensive (cost around $175) • No high speed blender • Produces diluted milk • Has poor extraction (pulp after process still contains liquid)
 Handmade Process[17]	• 4 steps: 1) soak almonds in water overnight 2) blend soaked almonds with water in high-speed blender 3) strain mixture in a nut bag 4) squeeze pulp	• Healthy • Additive free • Consumer control over the ingredients	• Labor intensive • Messy • Time-intensive (60 minutes) • Does not last long (lack of preservatives)
 Silk Almond Milk (Commercial Offering)[15]	• Second Market Leader at 33.4% Market Share of brands of U.S. refrigerated almond milk in 2017	• Convenient • No carrageenan • Comes in a variety of flavors, such as Vanilla and Dark Chocolate	• Contains many potentially harmful additives and significant sugar levels • Does not foam well (hard to make lattés and other barista drinks)

3.2. Handmade Almond Milk

The handmade almond milk process allows the consumer to control the ingredients in their almond milk. However, the process is messy, laborious, and time-intensive. After conversing with Professor Taylor, we concluded that making almond milk at home is a four-step process (see Table 1). The handmade process specifies one part almond milk to four cups of water, so the final product is about 20% almonds by volume.

3.3. Pre-packaged Almond Milk

Pre-packaged almond milk options typically contain potentially harmful additives, such as sugar and thickeners. Notably, several brands contain carrageenan, a food additive that may be linked to gastrointestinal problems.[8] Many of these brands also do not list almond composition; those that do display an extremely low percentage of almonds. For example, Almond Breeze only contains 2% almonds in their milk by volume, less than the handmade process.[9]

3.4. Existing Technology: Automated Almond Milk Maker

The Almond Cow Milk Machine, a bestselling device, costs $175 (in comparison to typically $100). After assessing other devices, we concluded that Almond Cow is the highest-ranked machine, and we chose to test this device. In Professor Taylor's experience, this device is hard to use, fails to blend almonds, and produces diluted almond milk. Details can be found in Table 1.

3.5 Patents

Among current patents (see Table 2), we identified one regarding the chemical preparation process for almond milk. We did not find patents on designs of the device itself, and therefore decided to explore an alternative soymilk maker and juicer.

Table 2: Patent Analysis

Patent Number and Name	Description	Strengths	Weaknesses
US5656321[10] Almond milk preparation process and products obtained	A chemical process for preparing almond milk	Claims to be a healthy alternative to dairy milk	Contains chemicals and powders instead of whole natural almonds.
WO2012153238 A1[11] Soymilk maker	An motor driven soymilk maker	separates the milk and residue without a separate filter	May not work for almonds due to their harder shells compared to soybeans
US20100058940[12] Automatic juicer (See Appendix C)	An automatic juicer that pushes a juicing cone upward into a fruit to release juice	An automatic process and easy to use	Uses a a squeezing operation instead of a grinding one, not applicable for almond milk making

Existing patents fail to address the problem we identified about the difficulty of making almond milk at home, and were more sparse than anticipated and lacked detailed diagrams. We gained inspiration from other juicing mechanisms by studying these patents.

4. Key Specifications

Our key specifications were developed by examining problems with current alternatives. While current state-of-the-art alternatives meet some of these specifications, none meet all of them. Table 3 shows our key specifications, but all of our specifications are in Appendix D. Quality and taste of milk are extremely important; current options produce diluted milk. We aim to extract the most liquid from the pulp mixture to ensure the highest almond concentration, or nuttiness, in the milk. We will weigh the pulp at the end of each process and compare it to the dry pulp after the hand-squeezed method, benchmarked as the highest standard. We will also weigh the volume of liquid produced. Lastly, taste will be evaluated through blind taste testing. Further specifications include usability and time, measured by user and time tests. We want our solution to be time efficient in both production of milk and cleaning of the device.

Table 3: General Specifications

Specification	Justification	Quantification	Test
Almond Milk Wasted	Product must not waste almond milk that could be used	Measure of the mass of pulp wasted against the SQ SQ = 160.4 g	Save the pulp after each straining process, mass it, and then compare it to the SQ value
Usability (Difficulty of Process)	Press shouldn't make a mess and it should be a simple motion of use	Mess/ease compared to current straining process (1-10) SQ = 6	Test potential users and survey their satisfaction with ease of use rating (1-10) (10 is best)
Almond Milk Produced	Users want a solution that can produce the most almond milk from raw ingredients.	Measure of the amount of almond milk (cups) Input: 4 cups water + 1 cup almonds SQ = ~4.86 cups almond milk	Measure of amount of cups created from a mixture of 4 cups of water/1 cup soaked almonds
Taste	Users want homemade milk without additives or artificial sugars	User blind taste testing comparing our product milk to others	Survey of almond milk drinkers of their reactions to ingredients in different milks (1-10) (10 is best)
Time	The process of straining almond milk should be quick and easy	Amount of time to make & clean full pint of almond milk (min) SQ = 15 min 28 sec	Time comparison with state of the art solutions with user testing and prototype testing

5. Alternate Solutions and their Evaluation

We categorized state-of-the-art solutions based on the specifications listed in Table 3 to compare against our prototype options and this analysis can be seen in Table 4.

Table 4: Alternatives Matrix

	Taste & Quality	Quantity	Usability	Safety	Purchase Cost	Feasibility	Time	Aesthetics	Versatility	Total
Weighting	4	4	4	4	4	3	2	2	1	
Almond Press	4	4	4	4	3	3	5	4	4	**107**
Natural/Organic Nut Milk (e.g. New Barn)	4	5	5	5	1	0	4	3	1	**95**
Conventional Nut Milk (e.g. Silk)	1	5	5	5	3	0	4	2	3	**91**
Handmade Almond Milk	4	3	2	4	5	0	1	1	4	**80**
Automated Almond Milk Maker	1	2	4	4	2	0	3	4	2	**68**
French Press	2	0	1	4	4	2	4	4	1	**67**

Prepackaged solutions scored low in both cost and quality. Higher quality brands such as New Barn are more cost-prohibitive, while cheaper almond milk brands such as Silk are unhealthy because of additives and sugars. The handmade almond milk process scored low in usability and time, since the process is messy to clean up and time-intensive. Automated almond milk makers, primarily the Almond Cow, was higher in cost but better in usability. However, the problem for these devices is the low quality of the milk produced. Even the best among the state-of-the-art options (New Barn or other expensive prepackaged organic brands) still has its faults.

6. Implementation and Implementation Matrix

The initial, potential prototypes were a French Press with an agitating mechanism, an automated French press with an agitating mechanism, a typical French press with different filter, an add-on to a high speed blender, and a completely automated almond milk maker (see Table 5). The juicer, aluminum can crusher, French Press, Cookie Press, Tomato Press, and Cider Press is discussed in Table 6.

Table 5: Implementation Matrix

	Taste & Quality	Quantity	Usability	Safety	Purchase Cost	Feasibility	Time	Aesthetics	Versatility	**Total**
Weighting	4	4	4	4	4	3	2	2	1	
French Press with Agitation Mechanism	5	4	4	4	3	3	5	4	4	**111**
Automated French Press with Agitation Mechanism	5	5	5	4	1	2	5	4	3	**103**
Typical French Press with Strainer	4	3	5	4	3	4	3	3	2	**102**
Blender Add On	4	3	3	2	3	2	5	2	5	**85**
Remake Automated Milk Maker	3	3	4	3	1	1	5	4	3	**80**

Our first ideas were to explore the French press. A traditional French press has too fine a mesh for almond milk, so we intended to modify the technology with a nylon filter from the handmade process. Based on advice from Professor Wegst, we realized that the pulp needed to be agitated to produce the maximum quantity of liquid possible. Therefore, we explored a French press with both a nylon filter and an agitation mechanism. We also looked into automating this option. Due to feasibility and price, we decided that a manual option would satisfy consumer needs best. While we decided to create our initial prototype based on the French press design with an agitation mechanism, after our progress report presentation, we did thorough research and created a new chart for other press technologies, seen below in Table 6.

Table 6: Implementation Matrix for Other Presses

	Taste & Quality	Quantity	Usability	Safety	Purchase Cost	Feasibility	Time	Aesthetics	Versatility	**Total**
Weighting	4	4	4	4	4	3	2	2	1	
Juicer (using a lever)	5	4	5	4	4	4	4	4	5	**121**
Aluminum Can Crusher	3	3	3	4	5	5	5	4	2	**107**
French Press	4	2	3	5	4	4	4	5	3	**105**
Cookie Press	3	2	3	5	5	4	3	5	3	**103**
Tomato Press	4	4	4	4	4	2	4	3	3	**103**
Cider Press	4	5	2	3	3	2	3	3	4	**90**

According to the matrix above, the juicer's technology is best suited to the almond milk straining process due to its ease-of-use. However, we also wanted to incorporate the unparalleled time efficiency and feasibility associated with the aluminum can crusher. Therefore, we developed our second prototype based on these two technologies (further detail in Section 9.2).

7. Initial Progress

7.1 Preliminary Designs

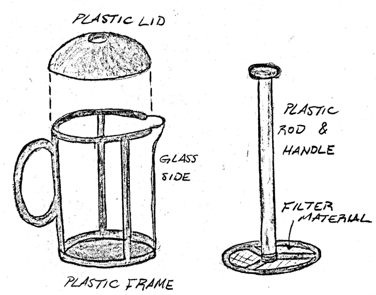

Figure 1: External Shell

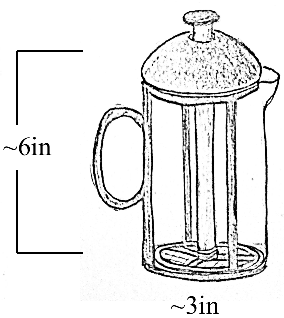

Figure 2: Internal Component

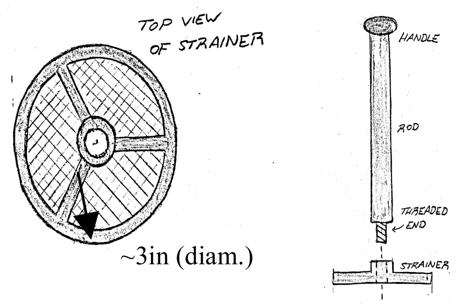

Figure 3: Press and Replaceable Filter

We reviewed our alternatives matrix to fill the gap left by the state-of-the-art solutions and proposed the Almond Press, inspired by the French press. Used in conjunction with a high-speed blender, the automatic almond milk strainer will mimic the handmade almond milk process with less time and effort. In order to produce almond milk, users will first blend soaked almonds and water to a fine, pulpy consistency. This mixture will then be poured into the almond milk strainer, which consists of an external shell (Figure 1) and an internal press (Figure 3) (Appendix E for CAD). Next, the user will press the filter down in a unilateral pushing motion, pumping the filter to agitate the pulp below. As the filter is pressed down, the almond milk will be extracted from the pulp, allowing the milk to rise above the filter while the pulp

Figure 4: Almond Press Prototype

remains below. The filter itself will be made out of nylon, similar to the nut bags used to create handmade almond milk. As illustrated in Figure 3, the filter will be easily removable, allowing users to discard them or replace them for cleaning.

7.2 Material Selection and Preliminary Prototyping

In order to create our prototype, we utilized a French coffee press and replaced the in-built filter with a nylon material as you can see in Figure 4. This prototype was created with a glass shell and a stainless steel frame and rod to apply pressure. The handle of the press was created with hard plastic. For the filter, we looked to modify the initial coffee filter with a nut bag material. Therefore, we purchased a nut bag material with high satisfaction ratings and modified its shape to fit the French press shape and inserted it into the press.

Once we decided to use the nylon mesh as a filter, we created a French press inspired design that was aimed at squeezing out almond milk via a downward pressure on the rod. We created a basic prototype by combining a French press with the nylon mesh, shown in Figure 5.

8. Benchmark Testing and Analysis of State-of-the-Art Limitations

8.1 Benchmark Testing of Handmade Process

We tested the handmade method for producing almond milk, requiring a blender and a nut bag which took 10 minutes. To standardize testing, we soaked the almonds for 8 hours, blended the mixture, and used a ratio of 1 cup of almonds to 4 cups of water.

Figure 5: Almond Pulp Produced by Almond Cow

The taste of the handmade almond milk was creamier and nuttier than alternatives – see Appendix F for blind taste tests results. The pulp after straining was dry and sandy. This is the ideal weight of pulp after extraction – shown in the graphs in Appendix G. It had the lowest mass of pulp (160.4g) and the highest volume of liquid extracted (4.86 cups). In Appendix H, we calculate that the milk produced here had the highest percent almond yield – an astounding 71%.

The handmade process was quite messy and laborious to clean up. It also took multiple people; one person had to hold the bag while the other poured. This process is also highly unsanitary for those who prefer little to no contact with the milk they are going to drink. Lastly, cleaning the nut bag was very difficult; a lot of the almond residue was caught within the bag.

8.2 Benchmark Testing of Automated Process

The next state-of-the-art solution that we tested was the Almond Cow Milk Maker. The process took 25 minutes (two times longer than the handmade process). The Almond Cow condensed blending and straining into one step and performed it automatically. The milk was extremely diluted – it only had a 46% almond yield (Appendix H). The largest problem with this Almond Cow device was leftover weight of the pulp after one run through on the machine, 295.8g (Appendix G). Almost all the almonds were still whole, as you can see in Figure 6, and the leftover pulp produced much milk when we squeezed the pulp manually. Another problem was closing the almond container. It took five minutes to fit the parts together, because you simply cannot fit the mechanism on the container if there are too many almonds.

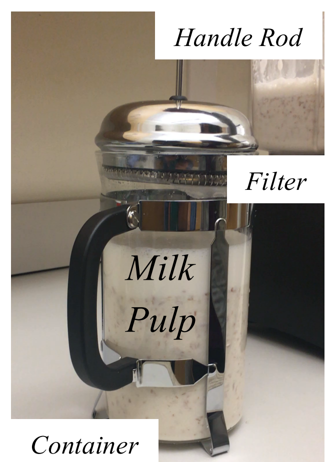

Figure 6: Almond Press Test

8.3 Benchmark Testing of Prepackaged Options

We conducted a blind taste test of the different milks produced, as well as the prepackaged options of Silk, Almond Breeze, and New Barn with our 10 identified almond milk users. The average results of this test are recorded in

Appendix F. Our device scored similar to the handmade process in the taste and quality of milk produced.

9. Proposed Solution and Works-like Prototype

9.1 Initial Prototype

Similar to the handmade process, a cup of soaked almonds were first blended with four cups of water to create a pulp that was poured into our prototype. Unfortunately, our initial prototype was only able to contain approximately half of the mixture, implying that our next iteration should be able to hold a larger volume of pulp. While testing our prototype's straining ability, we found that the filter press itself was easy to use. However, it came to a quick halt after straining approximately a quarter of the mixture. The pulp directly below the filter had formed a compact layer, seen in Figure 7, that prevented the press from pushing the mixture down and straining the moist pulp underneath. Therefore, our prototype had a high volume of residual pulp and unstrained milk – the mass of this pulp was nearly three times our ideal benchmark (Appendix G). Fortunately, the milk produced was extremely easy to pour out and the entire process was far more user-friendly and clean than the handmade process. In addition, the milk had a creamy, nutty taste that was identical to that of the handmade process – seen in Appendix F where we quantified our milk quality standards.

Since our initial prototype underperformed severely and had structural issues, after feedback from our progress report presentation, we created a new implementation matrix, in Table 6, and began working on a second iteration of our prototype.

9.2 Prototype: Second Iteration

Based on our oral progress report presentation feedback, our team looked into various pressing mechanisms, including a juicer, aluminum can crusher, cookie press, cider press, and tomato press (see Appendix I). As detailed in our second implementation matrix (Table 6), our team found design inpsiration through the juice press as it closely simulates the handmade process and will work well to squeeze almond pulp. Each of the other technologies have considerable flaws: the cookie press would result in compact pulp as our French press prototype did, the cider press would utilize a non-user-friendly twisting mechanism, and the tomato press would not fit the shape, size, and consistency of almonds. We created a second iteration that combined the mechanical advantage of a can crusher with the pressing mechanism of a juicer.

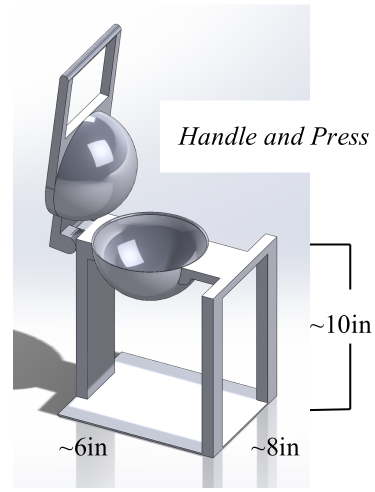

Figure 7: Citrus-Juicer-Inspired Prototype

As illustrated in Figure 8, this prototype was similar to a citrus press, scaled up and modified for the purpose of straining almonds. It consisted of two concentric concave up hemispheres, with their tops flush with one another. The user would use a lever to push the upper hemisphere down onto the lower hemisphere, which contains the mesh filter. This lever has a pivot point fixed at one side and is aided by the force of gravity. It providse more leverage to compress the two hemispheres together. The press is elevated, so when the user pours the almond pulp mixture into the nylon filter, the strained almond milk would flow through into a container below. The user then pushes the level to lower the top hemisphere, compressing any remaining pulp. This pressure would push almond milk through the filter. See Appendix J for the full CAD portfolio.

We considered modifying the texture of top hemisphere of the device with grooves or bumps to increase surface area and agitation. We also planned to consider a rotating mechanism in order to increase pressing capability.

10. Systematic Selection of Materials and Processes

10.1 Requirements for Material Selection

In order to construct the second iteration of our device, we created a list of specifications before ordering materials (see Appendix K). We decided that the device should be made primarily out of metal to ensure strength and durability. The first specification is that our metal should be able to withstand pressures up to 80 pounds of force; this benchmark comes from the literature review we performed (see Appendix L). Second, we need the metal to be classified as food-safe. Third, the metal should be malleable as we plan to create a rounded shape for both the strainer and press of our device. The variables that were not determined at the time of materials selection were the price of the materials, the amount of materials ordered, and the density of the metal. These depended on other considerations such as cost and ease of production.

10.2 CES Material Analysis

In our CES material analysis, we narrowed our search down to a select few materials in the following categories: metal, glasses, and plastics (labeled in the Appendix M graphs). For our second iteration, discussed in section 9.2, we eliminated glass as the primary material for our structural design due to the amount of pressure the user would apply. Using the design requirements seen in Appendix K, we ultimately selected stainless steel and aluminum for our second iteration. Although many

Figure 8: Almond Press Prototype detached with Rod to contain nylon mesh filter

metals met our basic requirements, we selected stainless steel and aluminum because they are food-safe, durable, and common in many kitchen appliances. According to CES, both aluminum and steel also have high compressive strengths to withstand user force. We ultimately selected aluminum for our device based on price (see third graph) and accessibility, as well as stainless steel for the press and strainer.

10.3 Selection of Processes

Through CES analysis, we were able to determine what processes would be most compatible with our materials. For shaping both aluminum and stainless steel we found drilling and milling to be the two most ideal and feasible processes for our product.

10.4 EcoAudit

We performed a sustainable resource analysis using EcoAudit and found that the majority of our product's environment energy and CO_2 emission impacts come from material production, rather than the milk making process itself (see Appendix N). Since our device is manual rather than automatic, it will not consume additional energy after production. An important thing to note is that we do not take into account the energy use from running the blender to create the pulp for our device because this occurs before actually being used in the device.

11. Final Prototype

11.1 Proposed Solution

For our final prototype, we chose to design the Almond Press. The engineering mechanism of our final device is based off of can crushing technology, and the physical design is based off of an orange juice press. The SolidWorks CAD model of our final prototype is shown below in Figure 9. After blending almonds and water in a high-speed blender, the user pours the mixture into a strainer lined with nylon mesh. The top press, attached to a lever arm pulled down by a user, will crush the pulp, filtering the milk into the cup below (see Appendix O). The press and bottom strainer are intentionally hemispheres because this design allows for the pulp to distribute up the sides of the bowls when pressed, while forcing liquid to be strained directly down (Appendix P). Because the machine easily moves up and down by control of a lever, the user can repeatedly press the almond pulp, as well as continuously add more of the almond-water mixture to produce more milk. All of our materials and device components were built in the Thayer Machine Shop. The physical model of our finished prototype is shown in Figure 10 below.

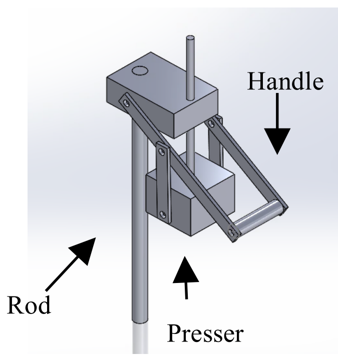

Figure 9: CAD

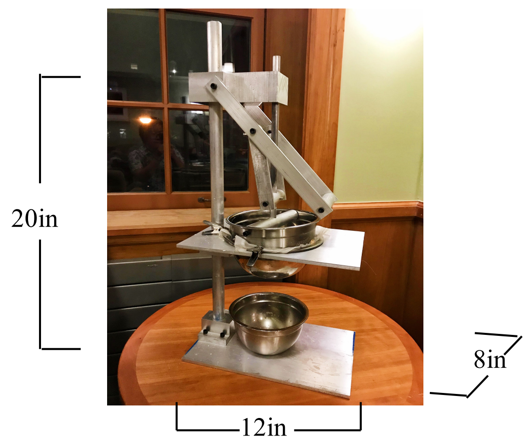

Figure 10: Almond Press Final

11.2 Benchmarks vs. Final Prototype

Testing

Objective: We compared the functionality of the Almond Press to the benchmark to test the efficiency of the Almond Press through the volume of almond milk produced and the mass of pulp wasted. These measurements should be compared to that of the benchmark, the handmade process, and then used to gauge overall efficiency of our device.

Method: First, we created a batch of pulp using our standardized recipe for all benchmark testing (four cups of water/one cup of almonds). Then we strained this pulp, using our Almond Press, and saved the pulp that was left in the strainer as well as the milk produced after straining.

Results: In the process of using the Almond Press, one small disadvantage was that the entire batch could not be strained in one pour into the strainer. It took four pours to strain the batch so the strainer will hold about half a cup of pulp mixture per strain. There was no need to clean out the pulp between each pour, which made the cleaning process easier than that for the homemade process. We measured the volume of milk produced by the Almond Press. This was about 4.69 cups of almond milk - very close to the benchmark of 4.86 cups. Then we massed the relatively dry pulp left in the strainer bowl which reached a mass of 168.2 grams. This neared the completely dry benchmark pulp weight from the handmade process of 160.4 grams. The Almond Press is nearly as efficient as the homemade process.

Second, we used the equation for calculating percentage almond yield from Appendix H to quantify the nuttiness specification in the taste. We concluded that we surpass the commercial pre-packaged options, with yield of only 25%, and nearly meet the benchmark since we have 69.55% almond yield, as Appendix H shows. Based on the all of the testing we have done to test the specifications our Almond Press device exceeds or at least meets the benchmark results from the best state-of-the-art devices and the homemade process (see Appendix Q).

We also used the scanning electron microscope (SEM) to look at the differences between the particulates of milk made from the various processes (Almond Cow, handmade, prototype). Comparing high resolution SEM images of the milk produced from the Almond Cow and the handmade process showed that the automated process contained almond particles that were more clumped together than those of the handmade process. Furthermore, in comparison to alternatives, our prototype's milk had the most evenly spread almond particles (see Appendix R).

11.3 Customer Feedback

After ensuring that our device performed better than state-of-the-art technology in terms of extraction capacity, we then needed to test the taste and quality of the almond milk produced and the usability and aesthetics of the device. Since these tests are subjective, we surveyed users. First, we tested usability and aesthetics. We took the device to a high-traffic location, King Arthur Flour, and asked visitors whether they had tried almond milk before or made almond milk before. If a user answered yes to either question, they tested our device. They poured the pulp, strained the milk out of the device, and drank the milk to test quality. Then, we had these users fill out a survey about the usability of the device and the aesthetics of its design. The results of this survey, in Appendix S, were overwhelmingly positive. The usability had an average rating of 9.48 and the aesthetics, a rating of 8.32 in 25 users surveys. These numbers show that users are satisfied with the device's design.

Second, we gathered the ten users from the survey in Appendix A. We then conducted a blind taste test with these users using almond milk form pre-packaged options, state-of-the-art technology, and our prototypes. We had them then fill out a survey rating the milk on consistency, taste, creaminess, and nuttiness from one to ten, ten being the best. The complete average results are in Appendix F. The results indicated that the users preferred the milk from our Almond Press in three categories over the milk from the handmade process (the benchmark) which shows that our device is able to produce good quality almond milk.

13. Economic Analysis

13.1 Business Model

Our potential market includes vegan and dairy intolerant consumers, who make up 15.5% of the U.S. population, or 50 million Americans. We narrowed this market down to those who drink and make their own almond milk—approximately 1.2 million (see Appendix T). Based on the large size of our target market and the high demand for affordable and easy-to-use almond milk makers, we determined that Almond Press should be a for-profit enterprise.

Our operational business plan involves manufacturing at a small factory in New Hampshire and distribution to natural and organic food retailers, such as Whole Foods, and ecommerce retailers, such as Amazon, to accurately capture our younger target market. Our funding will come from three sources: venture capital, personal investment, and a loan. Each will contribute $250,000, $100,000, and $150,000 (with 7% interest), respectively, for a total of $500,000 in available capital at the start of Year 1.

13.2 Analysis of Cost of Production

Our total variable costs (COGS) can be viewed in Table 7 below. Our primary expense is aluminum, which is broken down by part in Appendix U. In order to minimize COGS, we opted to purchase materials for 1,000 units at a time, leading to a cost of $65.90 per Almond Press. Purchasing materials for 1 unit alone would cost $10.09 more per unit.

Table 7: Total Variable Costs and Economies of Scale

Materials	1 Unit	100 Units	1000 Units
Aluminum	$64.35	$64.35	$64.35
Stainless Steel	$7.65	$3.25	$0.30
Nylon	$2.99	$1.50	$0.25
Hardware	$1.00	$1.00	$1.00
Total Variable Costs (COGS)	**$75.99**	**$70.10**	**$65.90**

In order to maintain this high production capacity, we intend to rent a 2,000 square foot factory and hire two employees to regulate production. These and additional fixed costs, such as marketing, legal fees, and insurance are listed in Appendix V. As a low-incident, low-risk product, the Almond Press will require a maximum of $1,000 in insurance per year. Our overall annual overhead rate is $108,170 and our hourly overhead rate is $56. Using data from CES, we also accounted for equipment and tooling costs in the first year. As mentioned previously, our two main processes are drilling and milling, each of which will cost between $5,000 - $10,000 (see Appendix W).

13.3 Cash Flow Analysis

Through user surveys, we found that our potential consumer would be willing to pay up to $150 for our device. Therefore, based on our COGS, we chose to price our Almond Press at $114.99, resulting in a 43% margin of $49.09 per unit. This price ensures that our product is profitable, affordable, and competitive, priced $60 below the Almond Cow device.

Using our market estimation, price, variable costs, and fixed costs, we conducted a cash flow analysis for the next three years, beginning January 2018. As displayed in Figure 11, our Almond Press is forecasted to breakeven in October 2020 and end Year 3 with a cumulative profit of $58,622. Net profit, cumulative profit, and other details can be found in Appendix X.

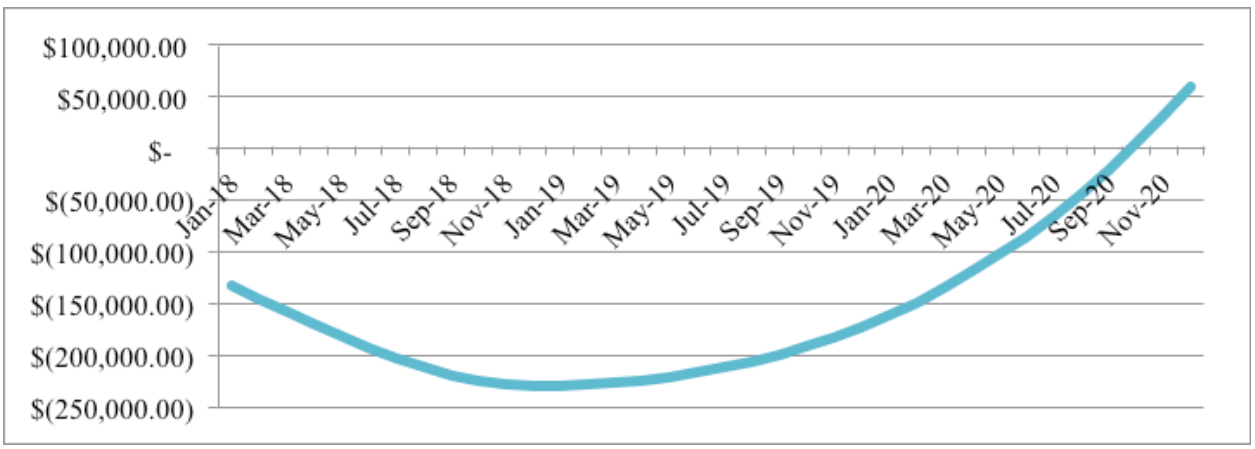

Figure 11: Cumulative Profit of 2018 – 2020

With monthly payments of $4,632, our loan will be paid off by October Year 3 (see Appendix Y).

13.4 Summary of Economic Analysis

Our Almond Press will be priced at $114.99 and sold in both natural food retailers and ecommerce outlets. We will break even in Year 3, ending 2020 with nearly $60,000 in cumulative profit.

14. Conclusions and Recommendations

The final prototype of our Almond Press successfully combines all the key benefits of the handmade and the automated processes, while skillfully avoiding their respective disadvantages. The Almond Press is affordable, easy to clean, time efficient, and creates additive-free and high-quality almond milk; in this way, our product exceeds all of the specification that were previously defined for benchmark testing. Furthermore, our prototype was extremely user friendly and well-liked as supported by our population surveys.

Concerning our project plan, we were able to follow our timeline and finished designing our final prototype, completed testing, and developed a business plan on November 14th (See Appendix AA). In the future, there are a couple of recommendations we would like to implement. Concerning the machine components, we want to explore a more secure nug bag attachment mechanism, a second strainer support bowl, and potentially an agitation device. Engineering-wise, we are considering the use of brass bushings or shoulder bolts to mininize the friction of our device's moving parts. Lastly, we hope to improve our design's aesthetics to emulate the appearance of other kitchen appliances and attract more consumers.

We recommend that the Foundation proceed with the development of our Almond Press. We plan to file a provisional patent, and have already considered reaching out to local Hanover cafes and Dartmouth College Dining Services to produce and sell almond milk to customers using our product. Our individiaul tasks are clearly outlined in a responsbility matrix (see Appendix Z).

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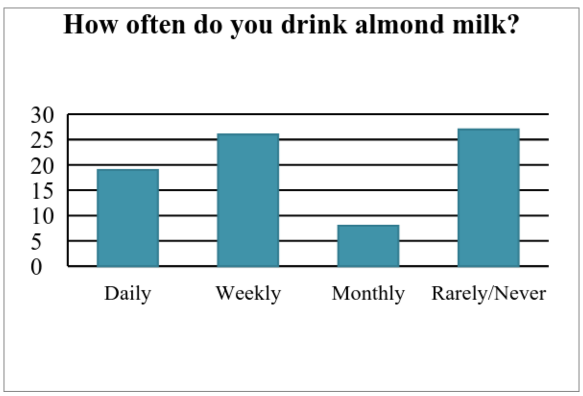
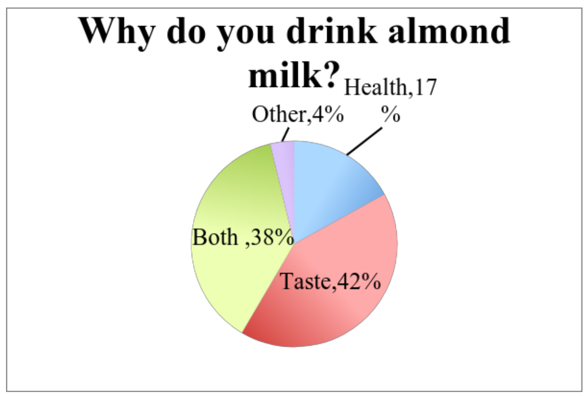
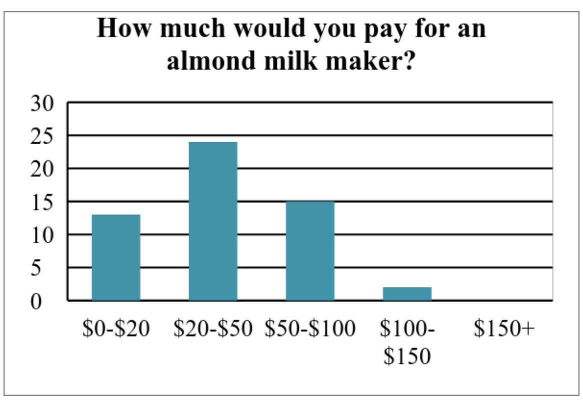
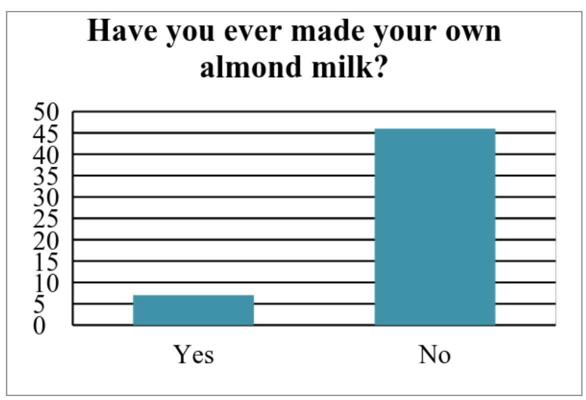
Appendix A
Initial Survey Results

How often do you drink almond milk?	*Daily*	*Weekly*	*Monthly*	*Rarely/Never*
	19	*26*	*8*	*27*
Why do you drink almond milk?	*Health*	*Taste*	*Both*	*Other*
	9	*22*	*20*	*2*
Have you ever made your own almond milk?	*Yes*	*No*		
	7	*46*		
What brand of prepackaged milk do you prefer?	*Silk*	*Almond Breeze*	*New Barn*	*No Prepackaged milks*
	29	*14*	*6*	*4*
How much would you pay for an almond milk maker?	*$0-$20*	*$20-$50*	*$50-$100*	*$100-$150*
	13	*24*	*15*	*2*









Appendix B

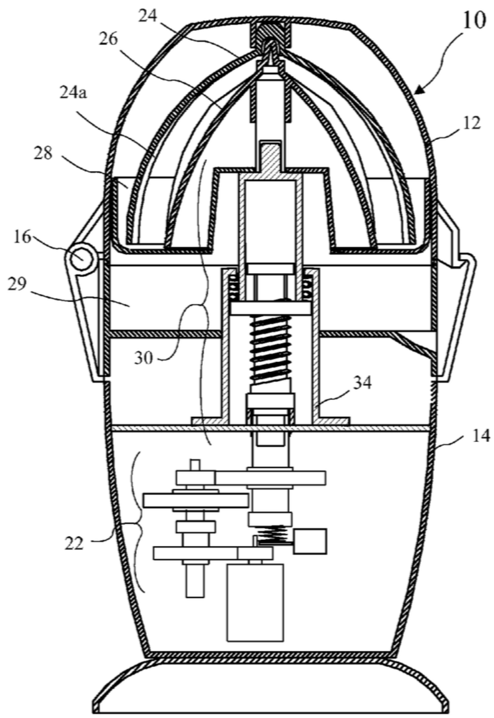
Images for SOA table

State of the Art Products Images				
 Almond Cow Milk Milker [16]	 Handmade Process [17]	 Silk Almond Milk (Commercial Offering) [14]	 New Barn (Commercial Offering) [15]	 Almond Breeze (Commercial Offering) [13]

Product Name	Description	Strengths	Weaknesses
Almond Cow Milk Machine [16]	• All-in-one machine • Designed specifically to make almond milk • Can be used for any other nut based milk at home	• Automatic - less laborious for the user • Results in less mess than handmade process • Eliminates need for nut bag	• Expensive (cost around $175) • No high speed blender • Produces diluted milk • Has poor extraction (pulp after process still contains liquid)
Handmade Process [17]	• 4 steps: 1) soak almonds in water overnight 2) blend soaked almonds with water in high-speed blender 3) strain mixture in a nut bag 4) squeeze pulp	• Healthy • Additive free • Consumer control over the ingredients	• Labor intensive • Messy • Time-intensive (60 minutes) • Does not last long (lack of preservatives)
New Barn Almond Milk (Commercial Offering) [14]	• Higher end brand that contains just 4 to 6 ingredients • Unsweetened contains only spring water, organic almonds, organic acacia gum, and sea salt	• No carrageenan (a common food additive) • Many flavor options (Vanilla and Original)	• Expensive ($5 per purchase) • Not distributed or available everywhere
Silk Almond Milk (Commercial Offering) [15]	• Second Market Leader at 33.4% Market Share of brands of U.S. refrigerated almond milk in 2017	• Convenient • No carrageenan • Comes in a variety of flavors, such as Vanilla and Dark Chocolate	• Contains many potentially harmful additives and significant sugar levels • Does not foam well (hard to make lattés and other barista drinks)
Almond Breeze (Commercial Offering) [13]	• Top Market Leader at 38.6% Market Share of brands of U.S. refrigerated almond milk in 2017	• Convenient, comes in a variety of flavors such as Vanilla, Light Vanilla and Original, as well as unsweetened and sweetened	• Contains many potentially harmful additives and significant sugar levels • Difficult to use for baking due to strong after taste

Appendix C

Patent US20100058940 (Automatic Juicer) Image [12]



A patent for an automatic electric juicer that contains a base, a hinged lid, a juicing cone, and a motor/gearing mechanism.

Patent does not contain dimensions.

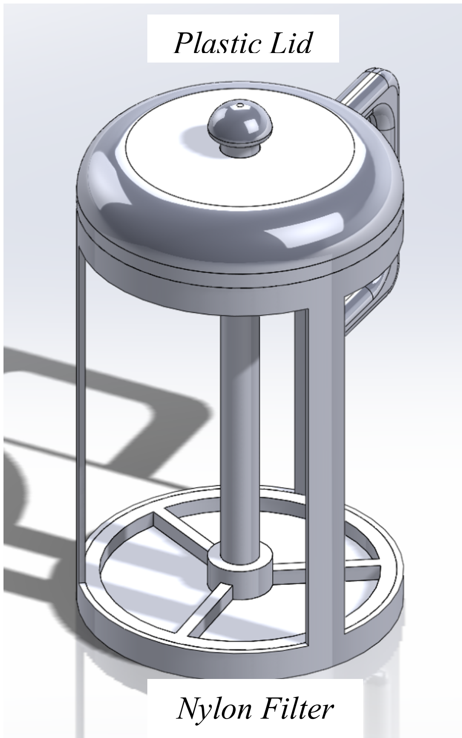
Appendix D

General Specifications

Specification	Justification	Quantification	Test
Purchase cost	Product must be affordable for users	Retail price ($) Almond Cow = $175	Cost comparison Find the user willingness to pay using a survey (currently up to $150)
Almond Milk Wasted	Product must not waste almond milk that could be used	Measure of the mass of pulp wasted against the SQ SQ = 160.4 g	Save the pulp after each straining process, mass it, and then compare it to the SQ value
Usability (Difficulty of Process)	Press shouldn't make a mess and it should be a simple motion of use	Mess/ease compared to current straining process (1-10) SQ = 6	Test potential users and survey their satisfaction with ease of use rating from 1-10
Almond Milk Produced	Users want a solution that can produce the most almond milk from raw ingredients.	Measure of the amount of almond milk (cups) SQ = ~4.86 cups	Measure of amount of cups created from a mixture of 3 cups of water/1 cup soaked almonds
Taste	Users want homemade milk without additives or artificial sugars	User testing on taste compared to both	Survey of almond milk drinkers of their reactions to ingredients in different milks (1-10) (10 is best)
Consistency	The product should be creamy and able to foam	Level of foaming - user survey and taste test - pulp mass is also useful SQ = 8	Test to see whether the milk will foam -survey almond milk drinkers to see whether the milk is too watery (1-10)
Time	The process of straining almond milk should be quick and easy	Amount of time to make & clean full pint of almond milk (min) SQ = 15 min 28 sec	Time comparison with state of the art solutions with user testing and prototype testing
Aesthetics	Users want a product that looks professional	Preference on a scale from 1-10 SQ = 10	Survey our potential clients (1-10)
Feasibility	Must be completed within the scope of ENGS21	Man hours (hrs) SQ = N/A	-

Appendix E

CAD Drawings of the Initial Prototype



Isometric views of the initial prototype French press with handle up (right) and down (left)

Side view

Appendix F

Averages from Blind Taste Test

User ranked from 1-10 (10 being the best)

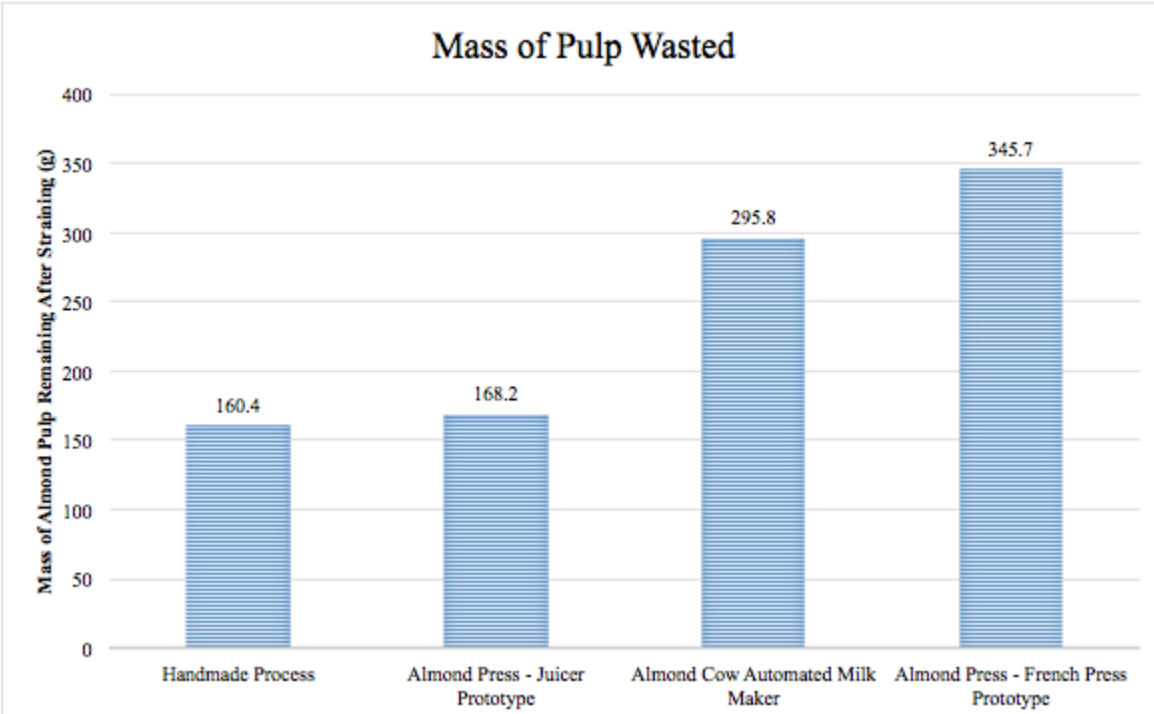
	Consistency	Taste	Creaminess	Nuttiness
Pre-Packaged				
Silk	8.4	6.9	7.3	4.4
Almond Breeze	6.7	5.1	4.8	4.2
New Barn	9.2	3.6	5.3	7.6
SOA Technology				
Homemade	8.9	9.3	8.2	7.9
Almond Cow	2.3	2.6	1.4	4.6
Our Devices				
French Press	9.0	8.2	8.7	8.2
Almond Press	8.9	9.4	8.6	9.3

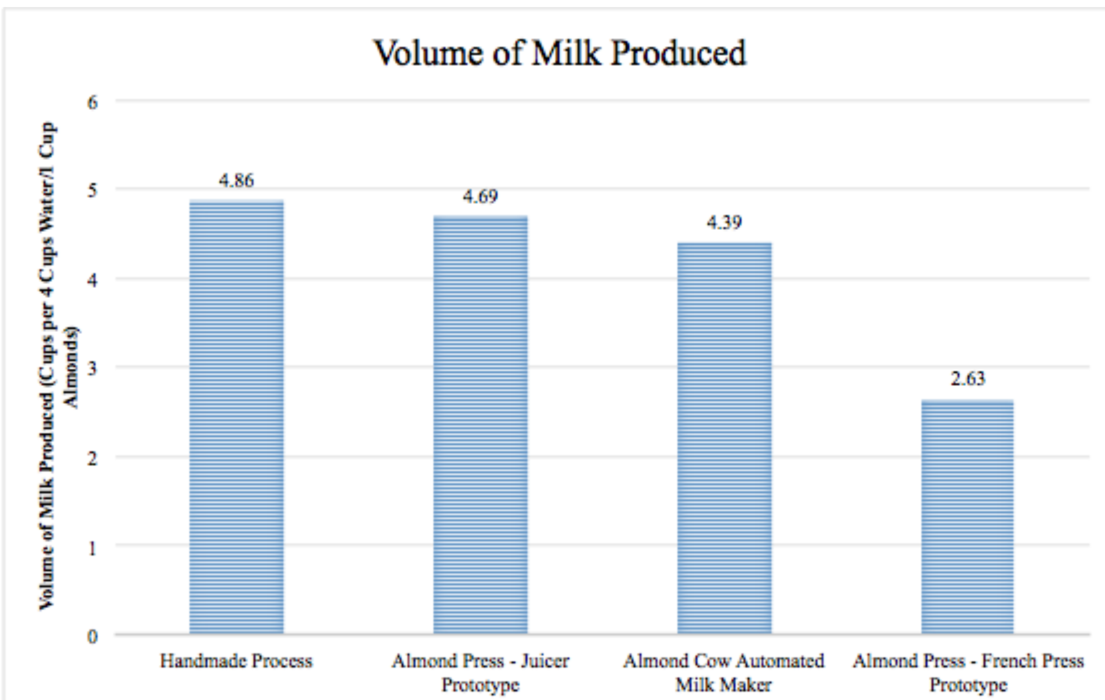
Sample Size: 10

We had our 10 key users who regularly drink and/or make almond milk at home do a blind taste test of the pre-packaged almond milk brands (Silk, Almond Breeze, and New Barn), and almond milk produced via the homemade process, Almond Cow, and our Almond Press. They ranked all 1-5 and we can see that our device scored favorably, even slightly higher than the homemade process. This is based on the averaged score.

Appendix G

Graphs of Weight of Pulp per Process and Volume of Liquid





Our device produces the most almond milk of all devices. This is inversely true for pulp wasted. We compared our device to the handmade process, which is the overall best performer.

Appendix H

Calculations for Percent of Almond Yield

Typical recipe: $[4\ cups]\, water + [1\ cup]\, almonds \rightarrow x\ grams\ of\ pulp + y\ cups\ of\ almond\ milk$

$$\%\,Yield\ of\ Almonds = 100 \times \left|\frac{Total\ Almond\ Weight - Almond\ Pulp\ Weight}{Total\ Almond\ Weight}\right|$$

	Total Almond Weight	**Weight of Wasted Almond Pulp**	**% Almond Yield**
Handmade Process	552.4 g	160.4 g	70.96%
Final Almond Press	552.4 g	168.2 g	69.55%
Almond Cow Automated Milk Maker	552.4 g	295.8 g	46.45%
Almond Press Prototype	552.4 g	345.7 g	37.42%

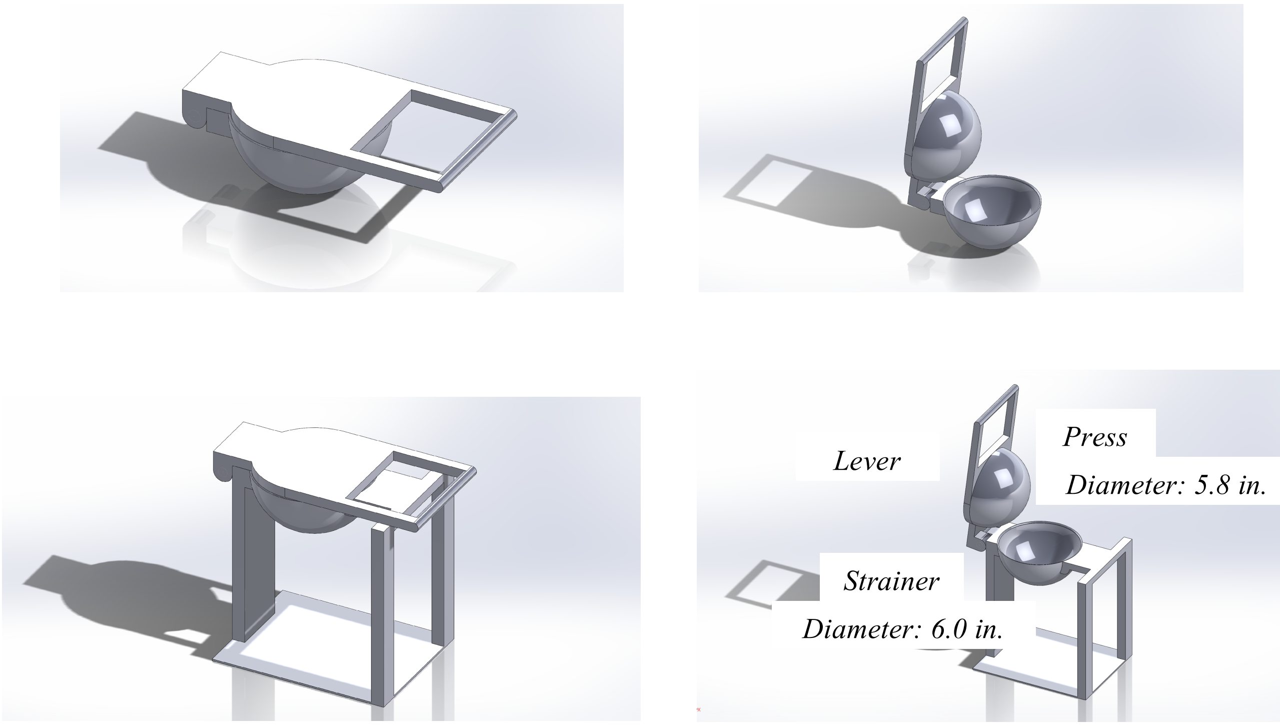
Appendix I

Existing Press Technologies

Press Name	Technology
 Juicer (using a lever) [18]	• Rounded concave-down press • Handle that takes advantage of leverage to bring top portion down onto lower filter • Juice collected in the bottom
 Aluminum Can Crusher [19]	• Simple lever increase leverage to compress the tops of cans downwards. • Lever design that increases mechanical advantage can be applied to our product to get a greater compression force with less physical mechanical energy required • Fairly compact and simple mechanism
 Cookie Press [20]	• Hand-powered trigger mechanism with ratchets pushes down plunger incrementally • Cookie dough is extruded through the other end • Potential strainer use: ○ Nylon nut bag material placed across bottom end ○ Almond pulp mixture poured into top of device ○ Hand-powered trigger used to press pulp down ○ Almond milk is extruded through the bottom end, pulp remains within the device
 Cider Press [21]	• Apples are ground using a crank-powered blade • Ground apples are crushed using a twist-down press, cider is released below • Large flat, wooden surface "pressing plate" lowers down to compress apples • Juice comes out of the bottom (or sides) of the container (an idea we tried to implement in our new prototype) • The plate is controlled by a rod (stem, etc.) the user turns to adjust the height of the plate
 Tomato Press [22]	• Tomatoes fall into a press and a handle is cranked to push them out of a • horizontal chute through a mesh • Very little force required to use and most of it can be plastic (except for the mesh) • Can be used for variety of other fruits as well

Appendix J

CAD Drawings of the Secondary Prototype



Isometric views of the second iteration of the Almond Press prototype closed (top left), open (top right), with a stand closed (bottom left), and with a stand open (bottom right).

Appendix K

Materials Requirements

Function:	Free Variables:	Constraints:	Objectives:
- Material must withstand pressures up to 80 lbs. (See Appendix) without changing shape - Material must be food-safe - Material must be malleable to form a curved shape for the press	- Material volume - Material density	- Be strong enough - Be malleable enough - Is on the food safe metals classification - Can tolerate temperatures between $0^{\circ}C$ and $100^{\circ}C$	- Minimize cost

The above chart contains lists of the specifications we initially compiled before CES analysis in order to come up with the ideal materials to use for the construction of the device. We also listed the variables we would not be as stringent about and the overall objective so that we could do the proper CES plots.

Appendix L

Literature Review

For the Literature Review, we looked over two studies focused on Hand Grip Strength and Human Capacity Performance. These were used to conceptualize the force needed to effectively push down the pulp for the first iteration.

1. Hand Grip Strength
(Masse-Westropp et al. 2011)

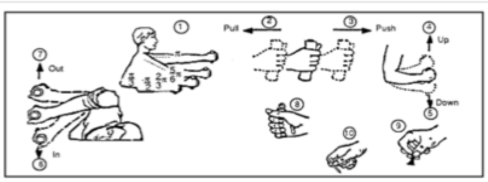
- Normative data for hand grip strength
- Methodology – Jamar Analogue Hand Dynamometer
- Comparison to homemade nut bag squeezing process

2. Human Performance Capabilities
(NASA 1995)

- Data for arm, hand, and thumb/ finger strength
- Methodology – Force gauges and force plates
- Comparison to machine press motion

Human Performance Capabilities (NASA 1995)

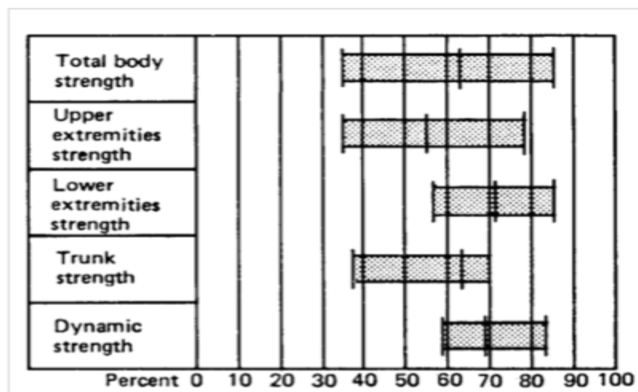
Figure 4.9.3-4 Arm, Hand, and Thumb/Finger Strength (5th Percentile Male Data)



(1) Degree of elbow flexion (rad)	(2) Pull L**	Pull R**	(3) Push L	Push R	(4) Up L	Up R	(5) Down L	Down R	(6) In L	In R	(7) Out L	Out R
π	222	231	187	222	40	62	53	75	58	89	36	62
5/6 π	187	249	133	187	57	80	80	89	67	89	36	67
2/3 π	151	137	116	160	76	107	93	116	89	98	45	67
1/2 π	142	165	98	160	76	89	93	116	71	80	45	71
1/3 π	116	107	96	151	67	89	80	89	76	89	53	76

Hand Grip Strength (Masse-Westropp et al. 2011)

Figure 4.9.3-5 Comparison of Female vs. Male Muscular Strength

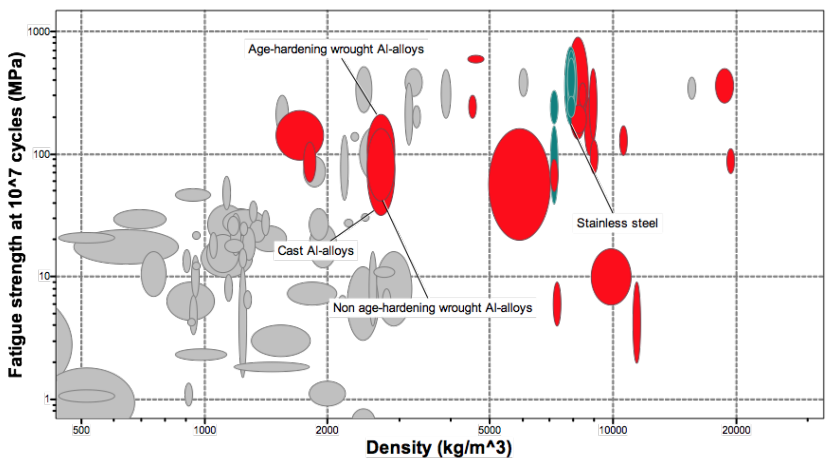


Muscular Strength by Gender

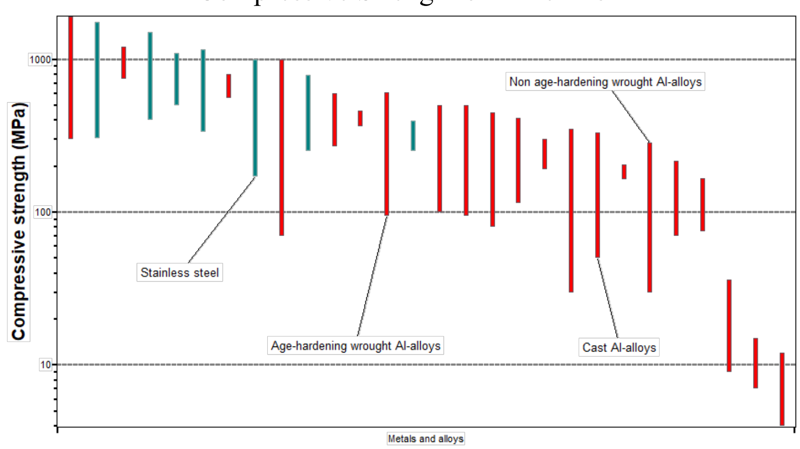
Appendix M

Materials Analysis

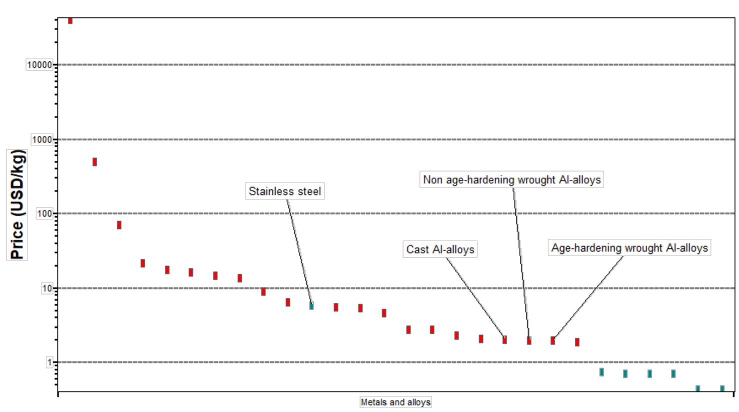
Fatigue Strength vs Density



Compressive Strength of Materials

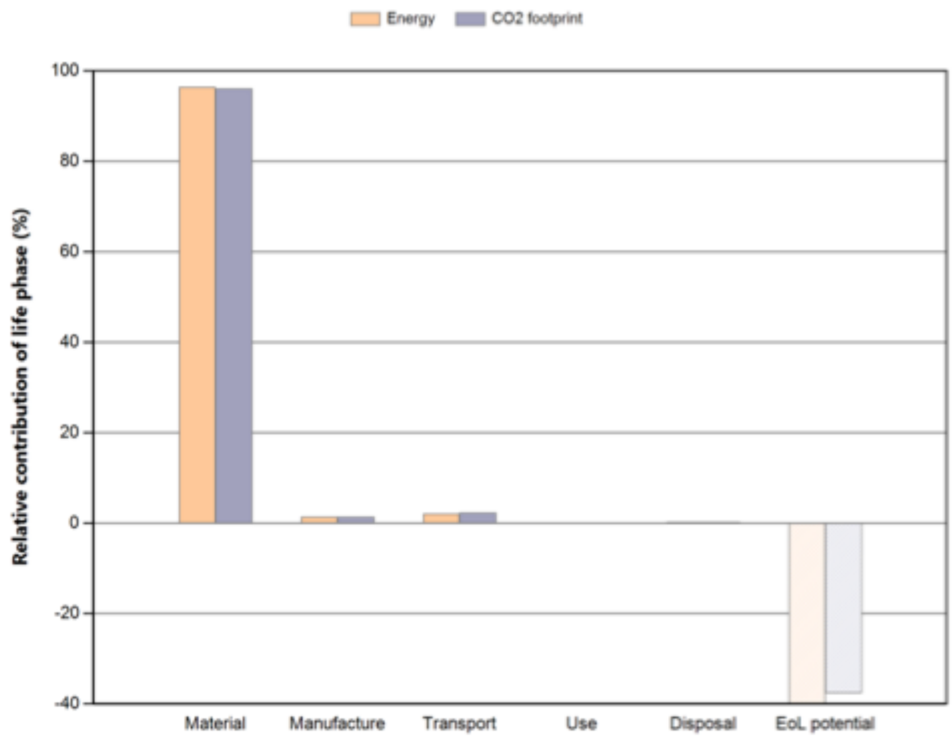


Price for all Materials



Appendix N

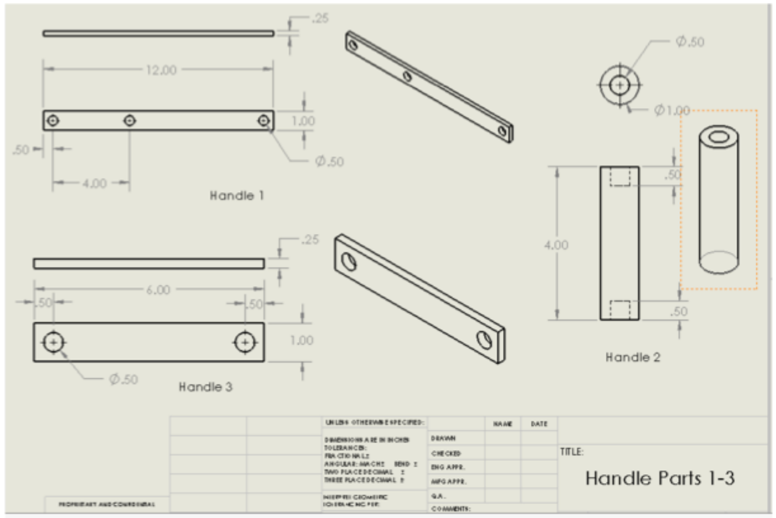
Eco Audit Analysis

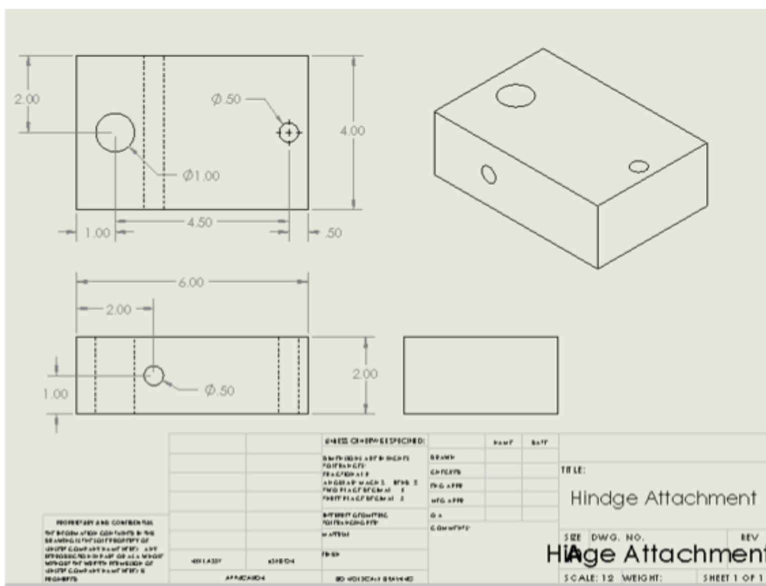


This is a graphical representation of the carbon footprint that our device will leave. As mentioned before, most of the emissions impacts come from the machining of the materials to manufacture our device, not the almond milk making process itself.

Appendix O

Hinge Attachment and Spacer SolidWorks Drawings

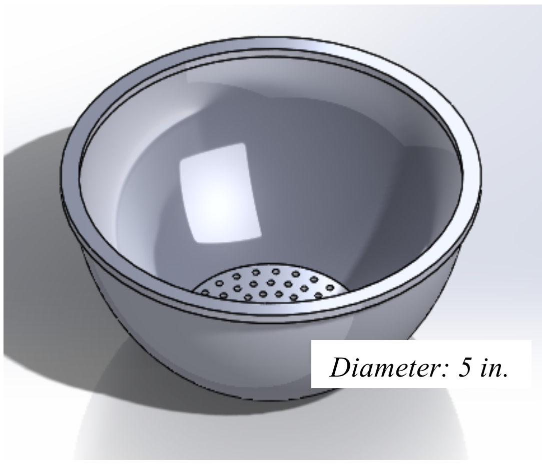


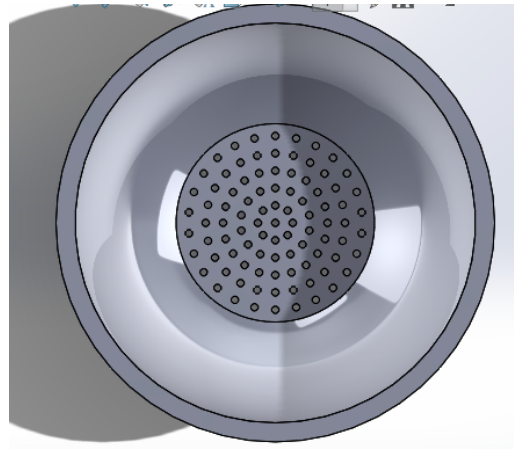


The above blueprints clearly illustrate the specific dimensions and hole placements for the handle parts and the hinge attachments for our final prototype.

Appendix P

CAD Drawings of the Strainer for the Final Prototype





Isometric views of the bottom strainer bowl for our final prototype from a side view (left) and a top view (right).

Appendix Q
Customer Evaluation and Target Specifications

Specification	Target	Our Device: Almond Press
Purchase cost	Retail price ($) Almond Cow = $175	$114.99
Almond Milk Wasted	Measure of the mass of pulp wasted against the SQ SQ = 160.4 g	168.2 g
Usability (Difficulty of Process)	Mess/ease compared to current straining process (1-10) SQ = 6	10
Almond Milk Produced	Measure of the amount of almond milk (cups) SQ = ~4.86 cups	4.69 cups
Taste	User testing on taste compared to both	See Final Blind Taste Test
Consistency	Level of foaming - user survey and taste test - pulp mass is also useful SQ = 8	9
Time	Amount of time to make & clean full pint of almond milk (min) SQ = 15 min 28 sec	~10 min
Aesthetics	Preference on a scale from 1-10 SQ = 10	10

The chart above succinctly combines the results of our testing and analysis on our device with the benchmarks that were established as a result of earlier testing. We can see that our Almond Press meets or exceeds expectations in almost every category.

Appendix R

Results of Scanning Electron Microscopy (SEM)

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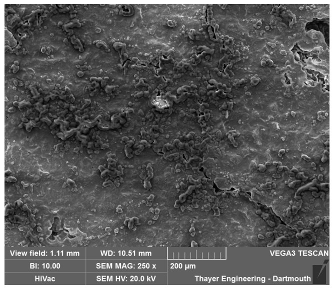
<td>
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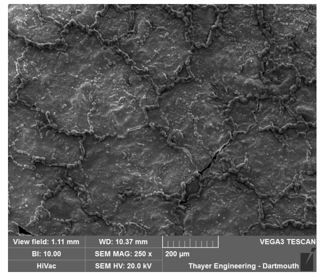
<td>
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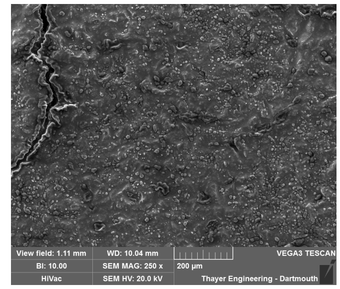
<td>
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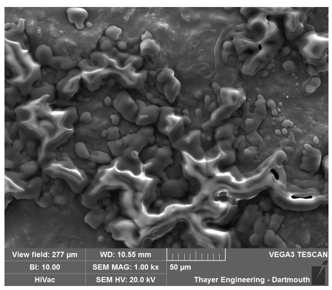
<td>
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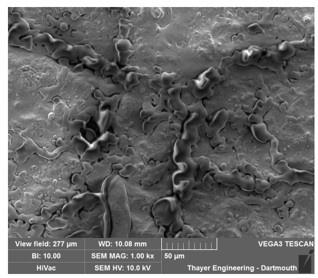
<td>
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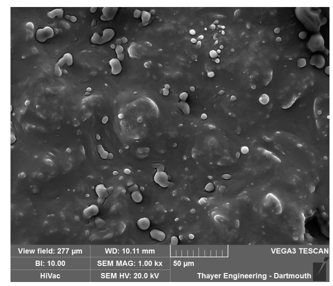
<td>
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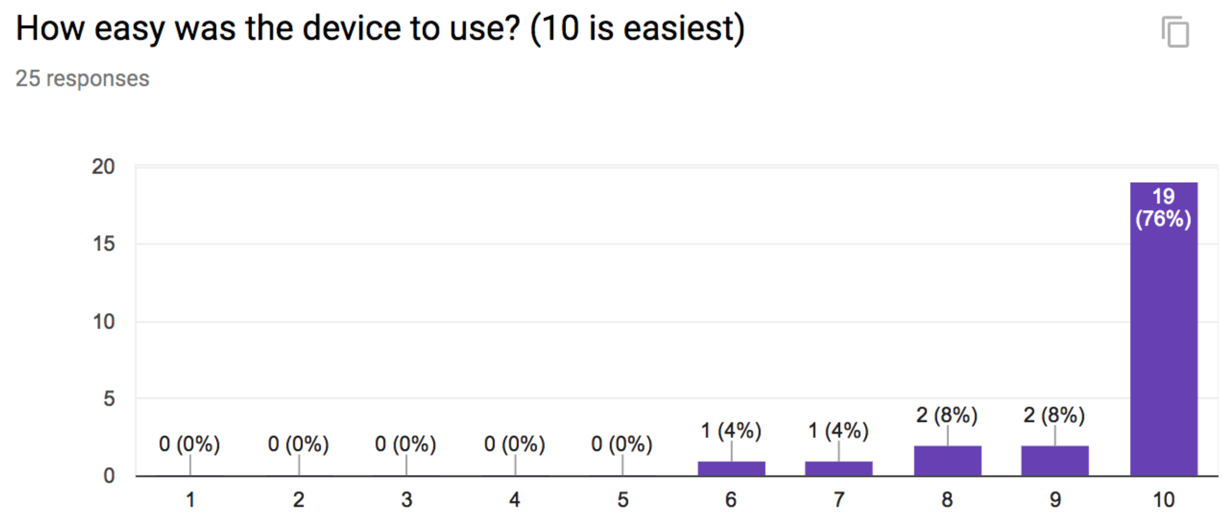
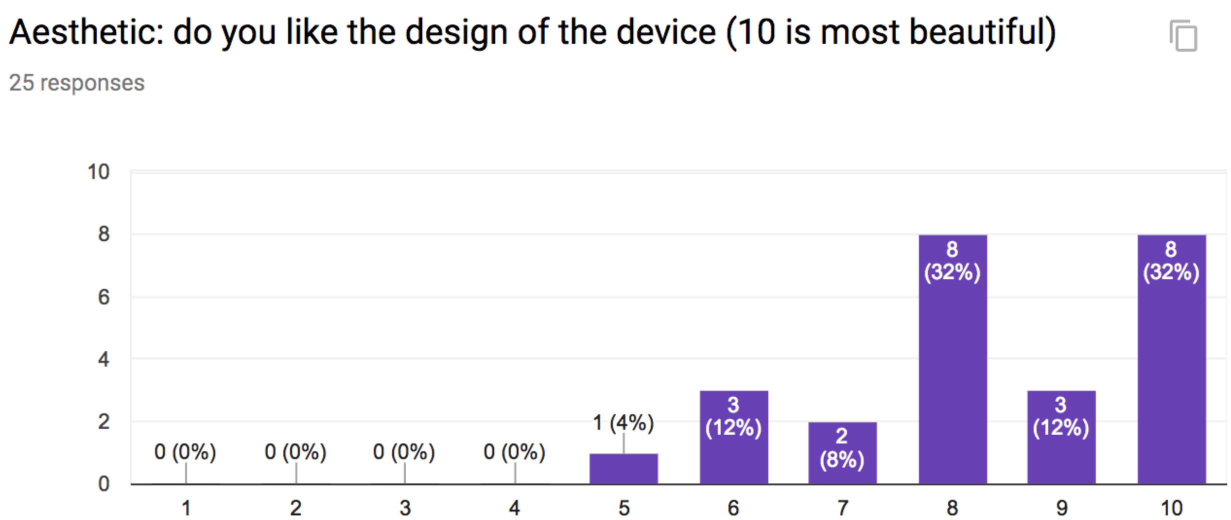
From the images we took with the SEM, we could see that in the milk produced with the Almond Cow had almond particles that were more clumped together than the handmade almond milk. In comparison to both, our prototype produced milk with the most evenly spread almond particles.

Appendix S

Customer Evaluation: Survey Graphical Results





These are the survey results in graphical form from the online surveys distributed to students who have experience tasting or making their own almond milk. We used these surveys to gain a more quantitative analysis of our device's usability and aesthetic value.

Appendix T
Market Estimation

Assumptions/Logical Reasoning	Numerical Estimation	Percentage of Population
U.S. Population 2017	323.1 Million	Not applicable
Vegan and dairy intolerant (percentage of Americans)	50.4036 Million	15.6% of U.S. Population
Since Almond Milk is one of the most popular dairy alternatives next to soymilk, assume 30% of vegan and dairy intolerant Americans will drink almond milk	15.12108 Million	30%: vegan and dairy intolerant Americans that will drink almond milk
Most people will buy pre-packaged almond milk due to convenience, let's assume 20% will actually make their own almond milk	3.024216 Million	20%: almond milk drinkers that make their own almond milk
Of the market of people who make their own almond milk, there're devices such as Almond Milk and handmade milk processes; this is our competition and we expect due to surveys and customer evaluation we hope to capture 40% of that market (target market)	1.2096864 Million	40% of the target market (almond milk drinkers that make their own almond milk) we will capture; this is high due to our device's high performance in the quantitative analysis (percent almond yield) and the customer evaluation

The above assumptions reflect an estimation of our market size from the entire United States population. We predict that 1.21 million Americans make up our target market.

Appendix U
Aluminum Material Costs

Material	Cost	Quantity	Total Cost
1/2" x 1/2' Aluminum Rod	$3.08	1	$3.08
1" x 2' Aluminum Rod	$14.89	1	$14.89
1/4" x 8" x 1' Aluminum Bar	$17.91	2	$35.82
1/4" x 1" x 1/2' Aluminum Bar	$1.72	3	$5.16
1/4" x 1" x 1' Aluminum Bar	$2.70	2	$5.40
Total:			**$64.35**

Our aluminum materials include various rods and bars that total a cost of $64.35 per unit.

These materials were purchased from McMaster Carr by Kevin Baron.

Appendix V

Overhead (Fixed) Costs

Overhead	Cost per Unit	Units	Total Cost per Year
Rent (Factory and Warehouse)	$6.50 per SF/Year	2000 SF	$6,500.00
Heat (Natural Gas)	$0.20 per SF/Year	2000 SF	$200.00
Electricity	$1.50 per SF/Year	2000 SF	$1,470.00
Computers and Software	$1,000.00 per PC & Software	2	$2,000.00
Marketing and Advertising	$1,000.00 per Year	-	$1,000.00
Trade Shows	$5,000.00 per Year	-	$5,000.00
Insurance	$1,000.00 per Year	-	$1,000.00
Employees	$45,000.00 per Person/Year	2	$90,000.00
Legal Fees	$1,000.00 per Year	-	$1,000.00
Annual Overhead Rate			**$108,170.00**
Monthly Overhead Rate			**$9,014.17**
Hourly Overhead Rate			**$56.00**

Our overhead costs include a variety of factors that contribute to an annual rate of $108,170, a monthly rate of $9,014.17, and an hourly rate of $56.

Appendix W
Manufacturing Processes

Drilling:	Milling:	Threaded Fasteners:
CES Information Tooling Cost: Low Equipment Cost: Medium Labor Intensity: High	**CES Information** Tooling Cost: Low Equipment Cost: High Labor Intensity: Medium	**CES Information** Tooling Cost: Low Equipment Cost: Low Labor Intensity: Medium
Estimated Cost Drill: $5,000 - $10,000 total	**Estimated Cost** Mill: $5,000 - $10,000 total	**Estimated Cost** Threaded Fasteners: $0.10

Process	Tooling Cost	Equipment Cost	Total
Drilling	$500.00	$10,000.00	$10,500.00
Milling	$500.00	$100,000.00	$100,500.00
Threaded Fasteners	$500.00	$10,000.00	$10,500.00
Total			**$121,500.00**

Drilling, milling, and threaded fasteners are the processes required to manufacture the Almond Press. Their equipment and tooling costs total a one-time cost of $121,500.

Appendix X

Cash Flow Analysis

Year 1	2018	Expected Monthly Sales Growth Rate		30%								
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sales Volume	15	20	25	33	43	56	72	94	122	159	207	269
Revenue	$1,725	$2,242	$2,915	$3,789	$4,926	$6,404	$8,326	$10,823	$14,070	$18,291	$23,779	$30,912
Cost of Goods Sold (COGS)	$989	$1,285	$1,671	$2,172	$2,823	$3,670	$4,771	$6,203	$8,063	$10,483	$13,627	$17,716
Gross Profit	$736	$957	$1,244	$1,618	$2,103	$2,734	$3,554	$4,620	$6,007	$7,809	$10,151	$13,197
Overhead Costs (annual amounts shown below)												
Rent	$542	$542	$542	$542	$542	$542	$542	$542	$542	$542	$542	$542
Leasing of computers/software	$167	$167	$167	$167	$167	$167	$167	$167	$167	$167	$167	$167
Heat	$17	$17	$17	$17	$17	$17	$17	$17	$17	$17	$17	$17
Electricity	$123	$123	$123	$123	$123	$123	$123	$123	$123	$123	$123	$123
Marketing/Advertising	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83
Trade Shows	$417	$417	$417	$417	$417	$417	$417	$417	$417	$417	$417	$417
Insurance	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83
Employee	$7,500	$7,500	$7,500	$7,500	$7,500	$7,500	$7,500	$7,500	$7,500	$7,500	$7,500	$7,500
Legal Fees	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83	$83
Loan Payments	$4,632	$4,632	$4,632	$4,632	$4,632	$4,632	$4,632	$4,632	$4,632	$4,632	$4,632	$4,632
Total Overhead Cost (TOC)	$13,646	$13,646	$13,646	$13,646	$13,646	$13,646	$13,646	$13,646	$13,646	$13,646	$13,646	$13,646
One Time Equipment/Tool Cost	$121,500											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Net Profit	($134,409)	($12,688)	($12,401)	($12,028)	($11,543)	($10,912)	($10,092)	($9,025)	($7,639)	($5,837)	($3,495)	($449)
Cumulative Profit	($134,409)	($147,098)	($159,499)	($171,527)	($183,070)	($193,981)	($204,073)	($213,098)	($220,737)	($226,574)	($230,069)	($230,518)
Available Capital	$115,591	$102,902	$90,501	$78,473	$66,930	$56,019	$45,927	$36,902	$29,263	$23,426	$19,931	$19,482

With an expected monthly sales growth rate of 30%, our cash flow analysis for Year 1 (2018) predicts negative net profit and cumulative profit throughout the year.

Year 2 - 2019	Growth Rate - 5%
Sales Volume	4493
Revenue	$516,633.04
Cost of Goods Sold (COGS)	$296,078.94
Gross Profit	$220,554.10
Total Overhead Cost (TOC)	$163,748.77
Net Profit	$56,805.32
Cumulative Profit	($173,712.80)
Available Capital	$76,287.20

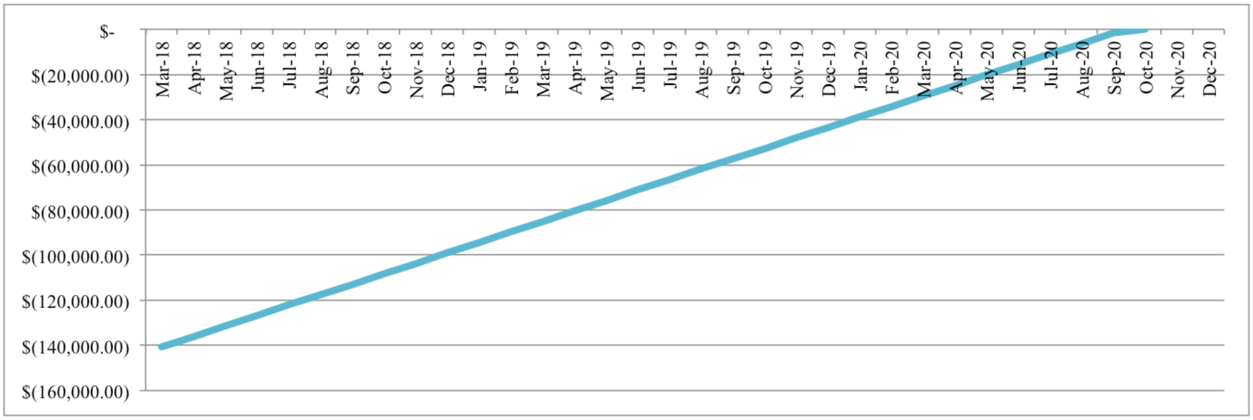
With an expected monthly sales growth rate of 5%, our cash flow analysis for Year 2 (2019) predicts positive net profit and negative cumulative profit throughout the year.

Year 3 - 2020	Growth Rate - 5%
Sales Volume	8069
Revenue	$927,798.71
Cost of Goods Sold (COGS)	$531,715.24
Gross Profit	$396,083.47
Total Overhead Cost (TOC)	$163,748.77
Net Profit	$232,334.70
Cumulative Profit	$58,621.90
Available Capital	$308,621.90

With an expected monthly sales growth rate of 5%, our cash flow analysis for Year 3 (2020) predicts that we will hit our breakeven point in October with positive net profit and cumulative profit through the end of the year.

Appendix Y

Loan Payment 2018 – 2020



With monthly payments of $4,632 on our loan of $150,000 with a 7% interest rate, we intend to pay off our loan in full by October 2020 (Year 3).

Appendix Z

Responsibility Matrix

P = primary responsibility
S = secondary responsibility

	Team Member						Hours	Completion Date
	AB	DP	HN	MCB	RW	SJ		
Task								
Develop Proposal								10/13/17
Research/Find Need	S	P		S			3	9/25/17
Customer/Market Research			S		P	S	2	9/27/17
Research patents	S	P		S			2	10/4/17
State-of-the-Art indentification			P		S	S	2	10/10/17
Develop Progress Report								10/27/17
Benchmark testing and analysis			P				12	10/18/17
Order parts and materials	S	S			S	P	2	10/23/17
Design schematics			S	P			4	10/16/17
Mock-up (SolidWorks)		S		P			5	10/20/17
Fabricate prototype		S	S		P		2	10/21/17
Develop test protocol for specs			P				3	10/19/17
Test prototype, analyze results	S		S		S	P	6	10/24/17
Iterate design - create next iteration	S	P		S			10	11/1/17
Research options for other press iterations	S	S	S	S	P	S	7	10/26/17
Determine production costs	P			S			3	11/3/17
Develop venture proposal			S		S	P	4	11/10/17
Develop Final Report								11/12/17

Appendix AA
Gantt Chart

	Week 7	Week 8	Week 9	Week 10
Development of Almond Milk Strainer				
Internal Technology Prototype	■			
Material Research	■			
Outer Shell Prototype	■			
Final Design of Device	■	■	■	■
Testing				
Material Durability	■			
Product Quality	■			
Prototype Versatility	■			
Final Iterations	■	■	■	■
Aesthetic Survey			■	■
Business Model Development				
Explore Cost of Current Technology	■			
Cost Analysis of Our Model	■	■		
Investigate Market Size	■	■		

The above chart details our final prototype development timeline.