Simplifying Tea Steeping: Design Innovation Driven by User Needs

by

Katherine Ann Tatar

Submitted to the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Mechanical Engineering at the Massachusetts Institute of Technology

June 2016

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Submitted to the Department of Mechanical Engineering on May 10, 2016 in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Mechanical Engineering

ABSTRACT

An affordable appliance was designed to make steeping a “perfect” cup of loose leaf tea easy and less labor intensive for the user. A survey of 235 people, primarily millennials between the ages of 18-27, was conducted to determine key user needs to be addressed in the design of the tea steeping device. Primary concerns identified were cleanability, time it takes to brew, and making the device compatible with travel mugs so users can drink their tea on the go. These key user needs were addressed through system architecture, form factor, and materials selection. A method of steeping a concentrate to minimize brew chamber size was developed. The automated single-serve device proposed brews tea at the required temperature and time to allow users to enjoy the best flavor out of their tea with just one step.

Thesis Supervisor: Dr. Dawn Wendell

Title: Senior Lecturer in Mechanical Engineering
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Thank you to Dr. Dawn Wendell for her unending encouragement and patience as my thesis advisor. I couldn’t have graduated without you!

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1. Introduction

Tea has a very different perception depending on the culture. For many Asian cultures, tea brewing is a ritual. As one article from “The Leaf” describes, “The taste of tea and Zen are the same, for it is your internal growth that makes better tea. Mastery of tea cannot be learned. You cannot get it from a thousand books on tea, or even a thousand cups. True mastery of any art comes from mastery of the self.” In contrast, for many Americans, tea brewing means heating up water in the microwave and dropping a tea bag in the hot water. The goal of this product is to take the high quality of the ritualistic art and make it possible in a straightforward and convenient method for the typical American consumer. The technology has to be innovative and creative and yet ensure the integrity of the tea has been respected.

Tea is the second most consumed beverage in the world, yet there has been very little technical advancement in the drink’s preparation. While consumers of coffee have a wide variety of options in their coffee makers including automation, fresh preparation of coffee grounds, and preset timed brewing, tea drinkers don’t have an equivalent affordable technology. Current consumer solutions for loose leaf tea steeping are currently very manual, sub-optimal in brewing time or temperature, or hundreds of dollars more than users are willing to pay. In my thesis, I have designed an affordable device for the on-the-go millennial, allowing them to easily brew the "perfect" cup of tea.

The taste of tea varies depending on the temperature of water at which it’s brewed and the brew time. Steeping at higher temperature or longer than recommended releases more bitter tannins in the water. Designing a device for the “perfect” cup requires controls, heating systems, and water delivery. In addition, there is a demonstrated consumer need for cleanability of the device. My project meets these needs while designing for a product that can be manufactured for a final retail price of under $100.

In order to make a tea brewing machine that meets requirements, the product must have variable temperature control between 65 and 100 degrees Celsius for a variety of tea types, be able to be programmed to brew for a set time in the future, and be automated with the final brewed tea being separated from the leaves. More importantly, the materials and form factor chosen will make the process simple from the user in both operation and cleaning of the product.

2. Survey of User Needs

Tea is more popular among millennials than any other age group in the United States, with 87% drinking the beverage. Equal numbers of people ages 18-29 prefer tea as those who prefer coffee, a sharp contrast to older coffee-loving Americans. This generational trend in tea consumption is aided by the growth of specialty tea shops like Teavana, DAVIDsTEA, and Argo Tea. Therefore, the market for this product was chosen to be college students and young professionals.
The survey included a mix of multiple choice and open-response questions, with only three of the twenty-one questions required ("How often do you drink tea?", "What kinds of teas do you currently drink and enjoy?", and "How much would you pay for an automatic tea maker?") in order to maximize survey participation. The survey was distributed via Facebook and to a variety of MIT email lists (including the discussion mailing lists for Random Hall, pika, and Alpha Chi Omega, and tea-lovers@mit.edu). The survey was shared and forwarded by at least seven people, reaching a larger audience. Five questions were demographic, asking for email, age, gender, type of residence, and whether they would be willing to be contacted in the future. Besides name and age, open-response questions were for answers with more nuance including users’ issues with mess/cleanability of loose leaf, whether users add sweeteners or milk and at what point in the brewing process, how strong users like their tea and how they achieve that strength, if users re-steep tea and how they adjust their brew process to do so, and what features users would include if they designed their own tea maker. Multiple choice questions primarily concerned users’ tea drinking habits, reasons for drinking tea, and factors that would discourage them from drinking tea. The full survey with multiple choice summaries can be found in the appendix.

Of the 235 people surveyed, the majority (182) were between the ages of 18 and 22, primarily female college students. The next largest group (26) were young adults between ages 23 and 27. While there were twenty responses from middle aged people and two from people in their sixties, the vast majority were young people in the target market.
Figure 1: Histogram showing number of people surveyed within the age ranges ≤17, 18-22, 23-27, etc.

The retail price aimed to suit this market would be between $75 and $100, a price about 12% of the target market is willing to pay for an automatic tea maker, according to survey results seen in Figure 22. A product at a lower price point would not be able to incorporate important distinguishing features like variable temperature. The least expensive variable temperature tea kettle that reaches temperature rather than cooling down from boiling, the Bonavita 1.7L Variable Temperature Digital Electric Kettle, has a retail value of $79.99 on Amazon.com. Well-tuned inline copper water heaters like that found in the Moccamaster coffee maker are sold at over $50 as replacement parts. While this percentage of users is relatively small, it indicates a larger market than current luxury tea makers like the Breville Tea Maker and Teforia. Only one out of 235 surveyed would be willing to spend $200 or more on a tea maker, showing that the $250 Breville and the $1300 Teforia are far out of the range of the average consumer.
Helpful Assistant: The image contains a bar chart titled "Price Users Would Pay for an Automatic Tea Maker." The chart shows the distribution of responses to a survey question regarding the price users would pay for such an appliance. The chart is split into price ranges and includes a category for users who would not buy a tea maker. The categories range from $0-25 to $250+, with a significant number of respondents indicating they would pay $0-25.

The accompanying text explains that while loose leaf tea sales are on the rise compared to bagged tea, there are still significant barriers to users’ consumption of loose leaf. As shown in Figure 33, half of tea drinkers avoid steeping loose leaf because of the mess and time involved in the process. Loose leaf is particularly difficult in environments like an office or dorm room where access to sinks is limited. One person described, "keeping the wet strainer around is annoying at a desk when I can't just pitch it into the sink (a wet bag can just be tossed). I can't just leave it in the cup, it'll oversteep!" The difficulty cleaning strainers and the trouble users have with tea leaves clogging their sink shown in Figure 44 indicates the importance of a brew chamber that can be easily emptied in a trash can.

Figure 2: Survey responses regarding price of a tea brewing appliance. This indicates the importance of designing with minimizing cost in mind.
Factors Deterring Users from Steeping Loose Leaf Tea

- Can't brew on the go
- Availability
- Cost (too expensive)
- Don't want to buy empty tea bags
- Own tea balls/strainers, but too low quality
- Don't own tea balls/strainers/empty filters/teapot
- Messy
- Time
- Prefer tea bag flavor options
- Other

Figure 3: Survey results showing needs of users who are deterred from drinking loose leaf tea. This data shows that in making a loose leaf tea brewer, cleanability, reducing time of brew, and allowing users to drink loose leaf tea on the go are important functional requirements.
Difficulties with Loose Leaf Cleanability

- Difficult to rinse strainer
- Clogs sink
- Too many dishes
- Leaves get in tea
- Herbal bits or leaves get stuck
- Gets gross if forgotten
- Spilling dry tea in process
- Takes time
- Can't just toss in trash
- Generally messy/difficult
- Incovenient at work
- Tea smells linger
- Taking strainer out of cup makes a mess

Figure 4: Summary of open responses to “What kind of issues do you have with mess/cleanability of loose leaf tea? (if applicable)” question in survey.
Figure 55 further shows the importance of making a device that is easy to clean. Over fifty of the people who described features they wanted in a tea maker mentioned cleanability in some way. As one user wrote, "It is difficult to rinse strainers/tea balls/pots as the wet leaves cling to things and get stuck in corners." Another described, "Strainers are just UGH. I have yet to find a good one." An automated simple-to-use product that brews tea leaves for desired temperature and time and dispenses well-strained tea would fulfill eight of the other top desired features. With regards to tea drinking temperature, a cooling system could be incorporated to cool the tea as it is dispensed. If the tea maker is preset to brew at a certain time before it is to be drank, that would be another way to introduce cooling time. While the device will not keep tea warm its own, the user can buy a good insulating mug to use in conjunction with the appliance. Finally, while the appliance itself is not portable, it will be specifically designed to work with travel mugs so the tea brewed can be easily drank on the go. While other tea brewing appliances like the Breville Tea Maker and Teforia are designed for multiple servings and a sit-down experience, a single serving device will better fit the needs of on-the-go students and young professionals.

**Top Features Desired In Tea Maker**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>To-go</td>
<td></td>
</tr>
<tr>
<td>Lightweight/collapsible/portable</td>
<td></td>
</tr>
<tr>
<td>Hot water</td>
<td></td>
</tr>
<tr>
<td>Perfect temp for drinking</td>
<td></td>
</tr>
<tr>
<td>Quick</td>
<td></td>
</tr>
<tr>
<td>No leaking tea leaves into tea</td>
<td></td>
</tr>
<tr>
<td>Keep warm</td>
<td></td>
</tr>
<tr>
<td>Removes tea leaves</td>
<td></td>
</tr>
<tr>
<td>Simple to use</td>
<td></td>
</tr>
<tr>
<td>Timer</td>
<td></td>
</tr>
<tr>
<td>Proper water temperature for variety</td>
<td></td>
</tr>
<tr>
<td>of teas</td>
<td></td>
</tr>
<tr>
<td>Easy to clean</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5:** Summary of open response answers to the question "If you were to design a tea maker, what features would you include?" Only features that were mentioned by ten or more people are included in this chart.
3. Summary of Current Systems

**Table 1**: Summary of current tea brewing systems on the market and how they do not meet user needs.

<table>
<thead>
<tr>
<th>Systems</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a) Keurig Brewing System</strong></td>
<td>Optimized for temperatures and brew time for coffee, not for tea. Unable to use own loose leaf teas in the device, only KCups. Flavor from coffee brewed may linger in the tea brewed later.</td>
</tr>
<tr>
<td><strong>b) Breville Tea Maker</strong></td>
<td>At $250, the Tea Maker is out of the price range of most consumers interviewed. Only one out of 234 surveyed would pay over $200 for a tea maker. Brews a minimum of 500mL (16.9 fl oz), or two cups of tea, which is not ideal for an individual serving.</td>
</tr>
<tr>
<td><strong>c) IngenuiTea</strong></td>
<td>While low cost and the correct size for individual portions, the IngenuiTea requires a separate water heater. It also has a failure mode where it can dispense tea sooner than desired when not over a cup, creating a mess.</td>
</tr>
<tr>
<td><strong>d) Teforia</strong></td>
<td>While offering value-added features to the customer like smartphone integration, Teforia’s price of $1300 ($650 for the first customers) targets only the super-rich. The tea carafe adds to dishes the user has to clean and neither the infusion globe nor the tea carafe are dishwasher-safe.</td>
</tr>
</tbody>
</table>
4. Designing the User Experience

4.1 System Approach

The main goal of this project is to simplify and automate the tea brewing process. Figure 66 is an illustration of the traditional manual tea steeping process. Currently, the user waits around 4 minutes for water to come to a boil (8+ minutes if using a stovetop kettle). If they don’t own a variable temperature kettle and are making green tea, they may also have to keep watch over the water until it reaches 75°C or cools to 75°C from boiling. They measure a teaspoon of tea leaves to put in the strainer. The user pours water into a mug with a tea strainer, waits around 4 minutes before removing the hot strainer and dumping out the tea leaves. They also have to wait for the tea to cool before they can drink it. It can take 7 minutes for a 75°C cup of tea to cool to a drinkable temperature. The total process is over 14 minutes.

Figure 6: Flowchart for current tea brewing process of green tea. Boxes represent when the user must wait. Text outside of boxes represent active steps by the user. Including the time for tea to cool to drinking temperature, it can take fourteen or more minutes for the tea to be ready to drink.

With the new proposed product: user prepares tea brewer to brew in the morning, or adds loose leaf and water and sets to brew when they start their day. The user no longer has to “babysit” their tea- they can make breakfast, get dressed, or prepare for the workday instead of having to interact at each step of the process. By having the tea brewing a one-step process instead of segmented, proper tea brewing can be as hassle-free as turning on the coffee maker in the morning. The process is also quicker due to the instant in-line heating of the water as it flows through the device. 14 users described how they would design a tea maker that brewed tea fast and 19 users wanted a tea brewer that is simple to use. As 52% of those surveyed are deterred from brewing loose leaf tea due to the time involved, this new process will make steeping loose leaf tea easier for the majority of users.
Figure 7: Simplified process to drink tea with tea brewer design. Boxes represent when the user must wait. Text outside of boxes represent active steps by the user. The new tea brewer allows the user to interact less with the tea brewing process as well as have their tea ready quicker.

The device will incorporate a thermosiphon to transport heated water to the brew chamber. Benchmarking off existing beverage brewers, a typical gravity fed system has a flow rate of 1.5 cups/min. Therefore, for the maximum volume brew of 475 mL (16 fluid ounces), water flow will add 1.3 minutes to the tea process. From start to finish, the user can get a large mug of green tea in four and a half minutes, compared to more than seven minutes for a traditional brew (or fourteen minutes if they wait for it to cool).

4.2 Device Footprint

4.2.1 Determining Dimensions of the Device

A key requirement of the tea brewer is the ability for users to enjoy tea on the go. 51% of users surveyed already use a travel mug on the go for tea. A search for travel mugs on Amazon.com reveals that these taller mugs range from 20.3cm to 24.6cm tall, and have a capacity of 415 to 475 mL. This indicates that the minimum dispensing height of the appliance should be 25cm.

Concerns with splashing are an important consideration in choosing dimensions. 58% of users surveyed were deterred from brewing loose leaf tea because of the mess, so minimizing potential mess was a critical design criterion. As shown in Figure 88, hot water heaters can result in significant splashing if water is dispensed into a short mug. After proving that 30 cm above the counter would be too high for water to dispense without making a mess, splash tests were conducted at 27 cm and 25 cm. The resulting splash pattern was captured on the paper towel.
Figure 8a: Splash resulting from use of Rosewill R-HAP-01 Electric 4L Hot Water Dispenser that dispenses water from 30 cm above the counter into a small 8cm tall cup.

Figure 8b: When water is dropped from 27cm, there are a few splash marks.
Figure 8c: Since there is negligible splashing from water poured at 25cm, water dispensing at 25.4cm would provide adequate space for a tall travel mug without splash resulting with short cups.

Figure 8d: Comparison between (from left to right) splash patterns from water poured from 30 cm, 27cm, and 25cm. Negligible mess at 25cm indicates that 25.4cm (10") is an ideal dispensing height.

The water should be dispensed from a height of 25.4cm to accommodate tall travel mugs while minimizing splashing in short mugs. The total height of the machine should be short enough to fit under kitchen cabinets with enough room to spare. The typical kitchen has cabinets that are 46 cm above the countertops\textsuperscript{13}, so the upper bound on the appliance height is 40 cm.
4.2.2 Minimizing Brew Chamber Height

An important goal of the design is to fit the lifestyle of the user and optimize the use of space. Companies like KitchenAid and GE are releasing smaller products to fit the lifestyle of millennials who often live in small apartments with limited kitchen counter space. In order to minimize footprint of the device and allow it to fit comfortably under a kitchen counter, a small brew chamber was adopted to minimize the space needed to steep the tea leaves while still accommodating large mugs under the device.

The small brew chamber was inspired by the Turkish tradition. Turkish tea is served with two teapots— one with filled with very strong tea and the other with hot water. The user dilutes the strong tea with hot water to their liking. Similarly, with this tea brewing appliance, the user places the amount of tea recommended for their mug of tea into the brew chamber. The brew chamber fills with a third of the volume of the mug, creating a concentrated brew. When the steeping time has elapsed, the concentrate is dispensed and hot water is dispensed.

In order to determine the ideal proportion of concentration, two blind user taste tests were conducted. A black PG Tips tea bag was brewed in a quarter, third, half, and full cup of boiling water each for four minutes. After the tea bag was removed, each mug was filled with hot water to reach a total volume of one cup. There was a repeat of each condition for eight samples in total, to account for variability in the brewing process. Subjects sampled each brew and were asked how the flavors compared to the control normally brewed tea. Order of the tea samples were randomized for each subject and they were blind taste tests.

While some subjects had difficulty distinguishing between the different samples (as one subject described, “I rescind... I can’t tell any difference”), an overall trend emerged. The ⅓ concentrate samples were mainly described as weaker. One subject stated it “lacks the bitterness entirely. It’s like sweet hot water.” The ½ concentrate brew was consistently described as strong and more bitter than the control. The ⅓ concentrate brew had the closest similarities to the control. In a second blind tea taste tasting with a group of five subjects, the ⅓ concentrate brew was determined to be comparable to the normally brewed cup of tea. The finalized brew chamber will be 5.5 fl oz (158mL), large enough to hold one third of a 16 fl oz (475mL) serving.

![Figure 9: Stylized illustration of amount of water used in each concentrate. (Tea bag not to scale.) The ¼, ⅓, and ½ cup concentrates were filled up to one cup with hot water after brewing was complete.]

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4.3 Proposed System

4.3.1 Materials Selection with Cleanability in Mind

Water has to pass from a water reservoir, to a brew chamber, then into the user’s cup. A key consideration in the design will be choosing inexpensive materials that are food-safe and do not leach chemicals into the hot water. Five users surveyed described the importance of watching their tea as it steeps, and an equal number emphasized the importance of an elegant device. A transparent brew chamber also helps the user quickly ascertain how far along the tea is in the brew process. The clear plastic copolyester Tritan would be an optimal choice for a brew chamber material, as it is BPA-free, does not retain taste or odor, and is designed to be durable even after 500 dishwasher cycles\textsuperscript{16}. A plastic brew chamber has the additional benefit of thermal insulation. This means the tea can maintain a constant temperature in the brewing process. This takes the traditional practice of brewing tea in a well-insulated earthenware clay teapot to a more convenient convenience-focused appliance.

The most common complaint with regards to the cleanability of loose leaf is that strainers are difficult to rinse. Over half of tea drinkers surveyed are discouraged from brewing loose leaf tea because of the mess involved. Users complain of difficulty in rinsing the strainer, particularly when making tea infusions with dried fruit pieces or when brewing fine-leaf rooibos or yerba mate. In addition, these fine-leaf teas can pass through the strainer into the user’s mug. The strainer portion of the device must make it easier to dislodge tea leaves into a trash can, as a common complaint is that sinks without garbage disposers clog easily when they are rinsing out their current tea infusers. It ideally will be easy to clean both right away and after the tea leaves have been sitting for a long time. A common user error is forgetting about the cup of tea or simply not having the time to clean up in the morning. Twelve individual responses to the survey mentioned forgetting their tea and/or the tea leaves. Since the leaves “get really gross really quickly” when left out, it is ideal for there to be minimal user contact with the leaves in the cleaning process.

Particularly for tea blends with fruit pieces, a slick surface would prevent sticking compared to a textured mesh. Multiple users described how they loved the idea of novelty tea balls like the ManaTea, but all the edges and crevices in these infusers can trap the leaves. A rounded cylinder shaped brew chamber makes for easy rinsing. Both loose leaf tea and tea bags can be used in the brew chamber. Loose leaf tea can be spooned into the brew chamber, while a tea bag (with paper tag removed) can just be dropped in. Creating the chamber out of a solid material also addresses another pressing issue—small tea leaves leaking into the user’s cup. A single valve with a fine filter can stop very small leaves from passing through, while the solid structure makes the chamber structural and easy for the user to handle. As one person described of their normal infuser, “I hate the intermediate mess of removing this drippy ball.” A closed valve will stop more liquid from dripping and the outside of the brew chamber will remain dry.
This is ideal if the appliance is being used in an office or other non-kitchen location. Instead of having to remove a leaking infuser to stop the brew process, the person can just enjoy their tea right away. When the user does go to clean the brew chamber, it won’t drip on the papers on their desk or on their work clothes on the way to the office kitchen.

For an alternative appliance marketed toward a higher end market, materials such as stainless steel and glass are an obvious choice. They are food safe and have a perception of high quality amongst consumers. It could feature a double-walled chamber with an inner layer of glass and an outer layer of plastic, similar to the Teforia infuser. The dual-layer would help with insulation and provide impact protection for the glass. However, the construction of the infuser would make it no longer dishwasher-safe.

4.3.2 Heating and Water System

The goal of this product is to take the effort out of the tea making process while still brewing quality tea. As such, a capacitive sensor like that found in the Taylor Digital Scale with Measuring Cup would take measuring or volume estimation of water out of the picture. The user would fill up their mug to the desired volume, and pour the water in the appliance reservoir. The mass of the water would signal how much flow there should be to the brew chamber to create the 1/3 volume tea concentrate. After the specified brew time, the hot tea concentrate dispenses, and the rest of the water is heated and pours to extract the last of the flavor from the tea leaves and dilute the concentrate.

There are two main options for heating systems in the system: a calrod heater to heat a larger volume of water or an inline heater to heat flowing water. An inline heater was chosen for several reasons. First, it allows for variety in serving size. Calrod heaters have a minimum fill requirement to avoid overheating and damage to the heating coil. This appliance will be functional for a small teacup (175 mL or 6 fluid ounces) of tea to a large travel mug (475mL or 16 fluid ounces), so a calrod would have to be rather small to be submerged by the 6 fl oz volume, thus increasing heating time for a larger volume. Second, it integrates the heating element with the already needed transport from the water storage to the brew chamber. The brew chamber cannot have the heating element included, as that could burn delicate leaves.
Figure 10: Photo of replacement calrod heating element for a Russell Hobbs kettle. A calrod heater was not chosen as a heating element because it has a minimum fill requirement to prevent overheating, which is not ideal for a single-serving device.

Figure 11: Image of replacement Moccamaster copper inline water heater. The water passes through the center of the copper cylinder, heating it as it flows from the heating reservoir.
Due to the variation in ambient temperature and initial water conditions, a control system is necessary to ensure that the water reaches specified temperatures for brewing. A thermistor will be used to measure the temperature of the water before tea leaves come in contact with the water. Thermistors are less expensive than thermocouples and work well in the temperature range between room temperature and boiling. Temperature input will determine the duty cycle controlling the heater outputs. The following chart describes the temperature ranges required for brewing different types of tea.  

Table 2: Recommended temperature ranges and brew times for types of tea.

<table>
<thead>
<tr>
<th>Type of Tea</th>
<th>Temperature Range</th>
<th>Brew Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Tea</td>
<td>65°C - 70°C</td>
<td>3 min</td>
</tr>
<tr>
<td>Green Tea</td>
<td>75°C - 80°C</td>
<td>3 min</td>
</tr>
<tr>
<td>Oolong Tea</td>
<td>80°C - 85°C</td>
<td>3 min</td>
</tr>
<tr>
<td>Pu-erh Tea</td>
<td>95°C - 98°C</td>
<td>4 min</td>
</tr>
<tr>
<td>Black Tea</td>
<td>98°C</td>
<td>4 min</td>
</tr>
</tbody>
</table>

The single-step process of the device makes it particularly useful for users who wish to drink tea on their commute. The user can set the appliance to pour tea with enough time for it to cool to drinking temperature, whereas normally one risks burning their tongue because the insulated mug prevents the drink from cooling quickly. In addition, if the user is in a rush, they don’t have to fumble with wet tea leaves or empty tea bags. They can simply choose to clean the brew chamber later in the day.

An additional feature can be easily added to dispense the last of the water at a lower temperature to cool the tea. 58°C has been determined to be the optimal temperature that provides satisfaction to the user while reducing risk of scald burns, according to research at University of Texas. In addition, ten of the users surveyed stated that if they were to design a tea maker, it would dispense tea at the perfect drinking temperature. This is particularly important for people drinking tea on their daily commute, as insulated travel mugs prevent hot tea from cooling to a safe drinking temperature quickly.

The pour-in-cup dispensing of the tea makes the appliance work well for both hot and iced tea. Iced tea can be brewed in a similar method to Japanese iced coffee- a more concentrated brew instantly chilled when poured over ice. This results in more “body and richness” than refrigerating hot tea and works well for sweeter loose leaf tea blends. Like other specialty tea stores, DavidsTea sells tea blends or herbal tisanes with dried fruit pieces that are specially marketed on their website as “Iced Tea Shop- for all your summer steeping.” These fruit blends require a deep infusion to extract the flavor.

According to the Tea Association of the USA, 85% of the tea drank in the United States is iced tea. Ready-to-drink bottled iced tea sales have increased fifteen fold over the past decade. High quality steeped brands like Honest Tea are increasingly popular compared to those made with tea powder. Yet, 22 of the “other” responses to “How often do you drink tea?” survey
question described more consumption of tea in the fall and winter months, while only two stated they drank more in the summer. Quick preparation of iced tea at home may increase the consumption of loose leaf in the summer months. As one user describes, “I most often drink iced tea, but rarely brew it on my own. I would really enjoy the ability to brew fresh, not-Snapple iced tea.” Cold brew or sun tea methods can take hours\textsuperscript{30}, while cooling down hot tea requires more dishes (tea strainer, teapot or a heat tolerant mug, glass filled with ice). The pour-in-cup functionality of the tea brewer proposed with its 10” height accommodates most drinking glasses and allows for quick iced tea preparation. This accomplishes goals of making it easier for users to enjoy loose leaf tea in all seasons.

For the 52% of users who avoid steeping loose leaf tea because it takes too long and the 58% of users who find loose leaf tea brewing too messy, this device will make it possible for those people to enjoy their favorite loose leaf blends at any time of year. The controls system and enhanced cleanability will not only make the process quicker, but also a less hands-on process. Users will be able to spend less time in steeping and cleaning up the tea leaves, and spend more time actually enjoying their tea.

5. Conclusion

Through the integration of heating systems and controls, a simple solution for on-the-go users was developed to make high quality tea steeping easier. The proposed appliance design is easy to clean, affordable, and fits users’ lifestyles and needs. It uses a concentrated brew system to steep good tea while minimizing space. The appliance is designed to fit in a small kitchen countertop space or to be used on a desk at work where users used to not be able to enjoy loose-leaf tea easily. The device will work equally well to brew both hot and iced tea and dispense a single serving of tea into a range of mug sizes without mess.

Moving forward, more user feedback through prototyping will be important. While the overarching needs in tea brewing were addressed, actual human-device interaction was not explored deeply for the purposes of time. The brew chamber should be tested with people with a range of hand sizes to make sure it’s easy to grip and click into the appliance. Testing button pressure and click-and-hold sensitivity will need to be tested to make sure selecting custom temperature, steeping time, and programmable start time is easy and intuitive.

While price was a consideration in the materials suggestions in this design, base prices of components are not readily available on the internet. It will be necessary to work with an Original Equipment Manufacturer (OEM) of beverage makers to identify the cost of the bill of materials and make further design changes to minimize cost. After development of a controls system that incorporates the lowest cost reliable inline heater, an alpha prototype could be created and eventually brought to market. With the introduction of this affordable appliance, steeping high-quality tea can become as simple as pressing a button.
5. Appendix: Tea Survey

What is email address?

What is your age?
What is your gender?

Where do you live?

How often do you drink tea?

Why do you drink tea?

Male 39 16.9%
Female 184 79.7%
Other 8 3.5%

Dorm with convenient kitchens 88 37.6%
Dorm without convenient kitchens. 32 13.7%
Fraternity/Sorority/Independent Living Group 30 12.8%
Private Apartment/House 80 34.2%
Other 4 1.7%

Daily or most days 130 55.3%
Weekly 79 33.6%
A few times a month 38 16.2%
About once a month 8 3.4%
Rarely 9 3.8%
Other 36 15.3%

Enjoy the flavor 227 96.6%
Social experience 76 32.3%
Caffeine Boost 125 53.2%
Helps with sleep 45 19.1%
Relaxation 174 74%
Improves Mood 143 60.5%
Health Benefits (antioxidants, low calories, etc) 91 38.7%
Health when sick (throat soothing, settle stomach, etc) 174 74%
Other 28 11.9%
Do you make coffee/tea before you arrive at work or school?

- Yes, often: 85 (36.3%)
- Yes, sometimes: 69 (29.5%)
- Yes, rarely: 29 (12.4%)
- No: 51 (21.8%)

Do you drink tea on the weekends?

- Yes, often: 96 (41%)
- Yes, sometimes: 108 (46.2%)
- Yes, rarely: 23 (9.8%)
- No: 7 (3%)

Do you use a travel mug on the go?

- Yes, I use it frequently for tea: 49 (20.9%)
- Yes, infrequently for tea: 72 (30.8%)
- Yes, but not for tea: 27 (11.5%)
- No: 86 (36.8%)
Do you drink loose leaf teas? How often?

- Yes, the majority of the time that I drink tea. 38 (16.2%)
- Yes, about half the time. 60 (25.6%)
- Yes, occasionally. 78 (33.3%)
- No. 58 (24.8%)

Are there any factors that deter you from steeping loose leaf tea?

- Cost (too expensive) 43 (20.1%)
- Availability 59 (27.6%)
- Can't brew on the go 75 (35%)
- Prefer tea bag flavor options 25 (11.7%)
- Time 112 (52.3%)
- Messy 124 (57.9%)
- Don't own tea balls/strainers/empty filters/teapot 75 (35%)
- Own tea balls/strainers, but too low quality 24 (11.2%)
- Don't want to continually buy empty tea bags/filters 25 (11.7%)
- Other 27 (12.6%)

What kind of issues do you have with mess/cleanability of loose leaf tea? (if applicable)
What kinds of teas do you currently drink and enjoy?

<table>
<thead>
<tr>
<th>Tea Type</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Tea</td>
<td>195</td>
<td>83%</td>
</tr>
<tr>
<td>Green Tea</td>
<td>173</td>
<td>76.2%</td>
</tr>
<tr>
<td>Oolong Tea</td>
<td>104</td>
<td>44.3%</td>
</tr>
<tr>
<td>White Tea</td>
<td>83</td>
<td>35.3%</td>
</tr>
<tr>
<td>Pu-erh (a fermented black tea)</td>
<td>38</td>
<td>16.2%</td>
</tr>
<tr>
<td>Lapsang souchong (smoked black tea)</td>
<td>17</td>
<td>7.2%</td>
</tr>
<tr>
<td>Masala Chai</td>
<td>102</td>
<td>43.4%</td>
</tr>
<tr>
<td>Flavored tea blends</td>
<td>114</td>
<td>48.5%</td>
</tr>
<tr>
<td>Herbal: Rooibos (redbush)</td>
<td>95</td>
<td>40.4%</td>
</tr>
<tr>
<td>Herbal: Yerba Mate</td>
<td>35</td>
<td>14.9%</td>
</tr>
<tr>
<td>Herbal: Chamomile</td>
<td>110</td>
<td>50.6%</td>
</tr>
<tr>
<td>Herbal: Mint</td>
<td>116</td>
<td>48.6%</td>
</tr>
<tr>
<td>Herbal: Fruity &quot;tea&quot;</td>
<td>110</td>
<td>46.8%</td>
</tr>
<tr>
<td>Herbal: Medicinal teas</td>
<td>38</td>
<td>16.2%</td>
</tr>
<tr>
<td>Other</td>
<td>23</td>
<td>9.8%</td>
</tr>
</tbody>
</table>

Which of the following do you want to drink more often?

<table>
<thead>
<tr>
<th>Tea Type</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Tea</td>
<td>65</td>
<td>31.4%</td>
</tr>
<tr>
<td>Green Tea</td>
<td>89</td>
<td>43%</td>
</tr>
<tr>
<td>Oolong Tea</td>
<td>73</td>
<td>35.3%</td>
</tr>
<tr>
<td>White Tea</td>
<td>69</td>
<td>33.3%</td>
</tr>
<tr>
<td>Pu-erh (a fermented black tea)</td>
<td>41</td>
<td>19.8%</td>
</tr>
<tr>
<td>Lapsang souchong (smoked black tea)</td>
<td>28</td>
<td>13.5%</td>
</tr>
<tr>
<td>Masala Chai</td>
<td>65</td>
<td>31.4%</td>
</tr>
<tr>
<td>Flavored tea blends</td>
<td>40</td>
<td>19.3%</td>
</tr>
<tr>
<td>Herbal: Rooibos (redbush)</td>
<td>46</td>
<td>22.2%</td>
</tr>
<tr>
<td>Herbal: Yerba Mate</td>
<td>31</td>
<td>15%</td>
</tr>
<tr>
<td>Herbal: Chamomile</td>
<td>36</td>
<td>17.4%</td>
</tr>
<tr>
<td>Herbal: Mint</td>
<td>41</td>
<td>19.8%</td>
</tr>
<tr>
<td>Herbal: Fruity &quot;tea&quot;</td>
<td>38</td>
<td>18.4%</td>
</tr>
<tr>
<td>Herbal: Medicinal teas</td>
<td>21</td>
<td>10.1%</td>
</tr>
<tr>
<td>Other</td>
<td>19</td>
<td>9.2%</td>
</tr>
</tbody>
</table>
Which of these factors deter you from making those teas?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>30.6%</td>
</tr>
<tr>
<td>Availability</td>
<td>53.4%</td>
</tr>
<tr>
<td>Inconvenient to brew at recommended temperature</td>
<td>22.8%</td>
</tr>
<tr>
<td>Don't own proper strainer</td>
<td>16.6%</td>
</tr>
<tr>
<td>Harder to clean</td>
<td>13.5%</td>
</tr>
<tr>
<td>Takes too much time to prepare and brew</td>
<td>24.4%</td>
</tr>
<tr>
<td>Dislike setting timer for brewing</td>
<td>9.8%</td>
</tr>
<tr>
<td>Other</td>
<td>24.4%</td>
</tr>
</tbody>
</table>

Do you add sweeteners and/or milk to your tea? If so, at what point in the brewing process do you add them?

How strong do you like your tea? How do you achieve this strength?

Do you reuse tea bags or steep loose-leaf multiple times? How do you adjust the way you brew the tea the second or third time?

If you were to design a tea maker, what features would you include?
How much would you pay for an automatic tea maker?

- $0-25: 167 (71.1%)
- $26-50: 124 (52.8%)
- $51-75: 54 (23%)
- $76-100: 27 (11.5%)
- $101-125: 8 (3.4%)
- $126-150: 2 (0.9%)
- $151-200: 3 (1.3%)
- $201-250: 1 (0.4%)
- $250+: 1 (0.4%)
- I would never buy a tea maker: 35 (14.9%)

Would you like to be contacted for more tea interviewing or user testing?

- Yes! Count me in: 106 (46.5%)
- If need be: 64 (28.1%)
- No thanks: 58 (25.4%)
6. References


13 Larsen, E., “Designer's Cheat Sheet,” This Old House.


Original Creative Commons image from vectorish.com adapted in figure.


