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Ergonomics-based Design for Usable Kitchen Utensil: Multifunctional Compact Strainer

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Abstract

The cooking process consists of various processes, one of which is filtering. The strainer can be used on various solid materials such as flour, cocoa powder, sugar, and liquid materials such as oil. The strainer can separate coarse particles into finer particles. However, when using a strainer, the user must prepare other tools, comprising a container and spoon. This process is time-consuming and inefficient, and none of the recent designs accommodates this issue. To deal with these problems, this study aimed to solve them by designing a tool that can combine these various functions into a product. To reduce the time for preparing tools, the design intended to combine the functions of the tools needed in one product. Multifunctional strainers include the strainer, container, measurement glass, and spoon in one product. There is also a removable handle on the strainer that can make it easier for users to filter. The way to use this strainer is to open the strainer lid and insert the material to be filtered. The results of the strainer can be stored or measured directly using the product. If a spoon is required, the user only needs to take a spoon from the product's lid. By using the product, users do not need to perform many inefficient movements and minimize the distance between the tools that need to be reached.

Keywords
Strainer, filter, ergonomic, efficiency, multifunctional.

1. Introduction
In the culinary world, cooking utensils have a vital role in determining the result of each dish. One of the tools that is often considered trivial but very crucial is the strainer. Strainers are used in various processes, from filtering liquid materials to separating fine particles from mixtures. However, the strainer cannot function optimally without other supporting tools that play an essential role. Supporting tools such as spoons, measuring cups, lids, and handles have their roles that cannot be ignored. Measuring spoons and measuring cups, for example, helps ensure that the amount of ingredients used is by the recipe so that the result is accurate. The strainer cover is helpful for preventing the filtered materials from being scattered or contaminated. At the same time, the handle provides comfort and convenience in using the strainer, especially when moving materials from one container to another.

1.1 Objectives
Completeness of supporting tools is one of the factors that support the ease of cooking. Without complete supporting tools, obstacles will arise that can hinder the cooking process so that it can affect the quality and effectiveness of cooking. For example, without accurate measuring spoons, ingredients may miss the desired measurements. Similarly, a strainer is easier to use if it has a sturdy handle. Without a sturdy handle, the risk of accidents or chance of cooking mistakes will increase. In addition to the quality of the food produced, the completeness of the support equipment also has an effect on space efficiency. Multifunctional strainers that integrate with ancillary equipment in one unit can save storage space and reduce clutter in the kitchen. The use of integrated strainers and ancillary equipment together can improve the efficiency of the cooking process and ensure a tidy kitchen. To solve the problem, this research was conducted to create a strainer that can be easily installed and removed. The additional support tools that will be provided are a built-in measuring spoon, an attachable measuring cup, and a removable lid. By combining all these features into one unit, it will increase usability, improve efficiency in cooking, and optimize kitchen space efficiency.

2. Literature Review
2.1. Time and Space Efficiency
Time and space must be considered in activities and designing a facility. With good time and space management, the activities can occur efficiently and effectively. The kitchen is where a person performs daily activities such as cooking. Frequent use must also be balanced with an ergonomic system that is good for placing facilities and the work process. Activities in the kitchen are generally cooking and activities that may occur with frequent frequency for most people, so the activities that occur in it must minimize as much as possible the occurrence of excessive workload due to improper time and space management (Al-qamadi, 2024). In addition, time in the kitchen, especially in restaurants, is limited, and it is essential to process it as efficiently as possible (Demetry, 2013). To maximize time and space efficiency in the kitchen layout, the selection of tools used is one of the crucial things to be considered because the tool is used directly in the process that occurs in the kitchen (Salama, 2016).

2.2. Multifunctionality Appeal
Product design evolve continuously over time. It is the development of product design that provides innovation and various kinds of products with different designs, functions, and processes (Tekmen, 2007). When buying products, customers choose between products with better functions or attractive designs. Product functionality is one of the primary keys to attracting buyers. Products with many functions make activities easier with their use and the possibility of increasing efficiency. Apart from efficiency, multifunctional products have their appeal to customers. Multifunctional products tend to make buyers who take into account the quantitative aspect feel that they are buying little but getting much profit (Chen & Liu, 2023).

2.3. Customer Needs
In designing products you want to market, a target market in the form of customers is needed. Customers themselves certainly have different preferences for each product available. To compete with innovative products in this era, knowledge of the wishes and needs of customers is needed to adjust the product design they want to make (Lee, 2007). There are various ways to identify the needs of customers. One easy, fast, and common way to find out the characteristics of a target customer is to use the survey method (Roberts, 1999). Various survey methods, such as phone, face-to-face, online, or offline questionnaires, affect the answers obtained from respondents, both in terms of

variation of answers and how respondents assess the scale and criteria given (Zhang et al., 2017). This paper will obtain data from respondents by conducting an online survey. The choice of this method is due to time constraints, and online surveys produce fast data that can be accessed in real time (Evans & Mathur, 2005). The survey is carried out using a quantitative method so that the answers from respondents will be measured and analyzed the data. The measurement scale for quantitative surveys is divided into nominal, ordinal, interval, and ratio. In the study, a nominal scale is used where the scale has no numeric value and no sequence number (Bager-Charleson & McBeath, 2023).

3. Methods

3.1. Questionnaire

Understanding customer needs is essential in the product design to target product functionality and value. Data was collected from respondents and targeted homemakers to collect customer responses regarding the problem and the product to be designed. A total of 68 respondents filled out an online questionnaire. Five questions were included in the questionnaire, and below are the questions in the questionnaire (Figure 1).

1. Do you use a strainer for cooking?
This first question in the questionnaire determines how many respondents use and own a strainer for daily cooking. This question aims to find out the respondents' frequency of using such a kitchen tool . Moreover, this information could provide insight into the need for cooking equipment and habits of using certain household tools, which can be used as a basis for decisions regarding marketing, product development, or consumer education.

2. Do you find the process of preparing a strainer and supporting tools, such as a strainer container, ladle, measuring cup, and lid (to prevent contamination), time-consuming or inconvenient?
The second question addresses the views held by the respondents concerning the efficiency and ease of use of the standard kitchen equipment, which is usually used together in a cooking session. Understanding whether the preparation, use, and management of such tooling are time-consuming or too complicated, it will be possible to understand the need for optimization in tool design or the introduction of more efficient products. Moreover, this question will help to highlight what factors determine the choice of the respondents regardi ng kitchen utensils and to what extent these factors contribute to comfort and productivity when working in the kitchen.

3. Do you think storing a strainer and supporting tools such as a strainer container, ladle, measuring cup, and lid separately requires a lot of space?
This question aims to determine whether storing these tools separately requires significant space. The third question aims to understand if kitchen space limitations are a constraint and assess whether a more efficient storage solution is needed.

4. Do you think a strainer like the one pictured below could help you more easily prepare and store tools and be more time-efficient?

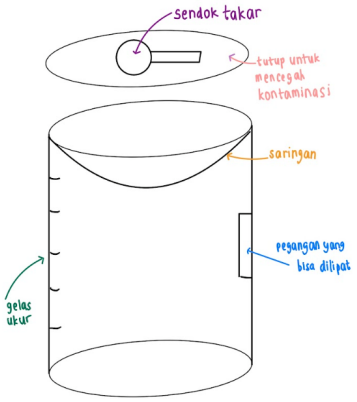

Figure 1. Illustration of Multifunctional Strainer Inputted in Survey Form

The fourth question aims to give respondents an idea of the presented strainer innovation. A rough product outline is provided to help respondents better visualize the form of the strainer.

5. Do you have any suggestions for strainer innovations?
This question aims to understand respondents' preferences for strainer innovations. Through this question, insights into respondents' specific needs and preferences regarding strainers can be collected.

3.2. Task Analysis
Task analysis is a method used to understand and analyze the steps or actions required to use a strainer. To perform task analysis, a breakdown of the steps when using a strainer can be done. The resulting output is ergonomic risks and ergonomic solutions.

3.3. Anthropometric Data Analysis
In anthropometric data analysis, anthropometric data that is used is hand length and width. These data are used to calculate the diameter and length of the handle part of the strainer. The hand length and width data are taken from the Indonesian anthropometry data bank (Anthropometric *Indonesia*) bank data. This bank data is the most extensive anthropometry data in Indonesia. 14 universities in Indonesia act as contributors to this data, Institut Teknologi Bandung (ITB), Institut Teknologi Sepuluh Nopember (ITS), Universitas Kristen Maranatha (Maranatha), Sekolah Tinggi Teknologi Angkatan Laut (STTAL), Universitas Trisakti (Trisakti), Universitas Trunojoyo (Trunojoyo), Universitas Atma Jaya Yogyakarta (UAJY), Universitas Surabaya (UBAYA), Universitas Udayana (UDAYANA), Universitas Diponegoro (UNDIP), Universitas Mulawarman (Universitas Mulawarman), Universitas Katolik Parahyangan (UNPAR), Universitas Pelita Harapan (UPH), and Universitas Sumatera Utara (USU) (Figure 2).

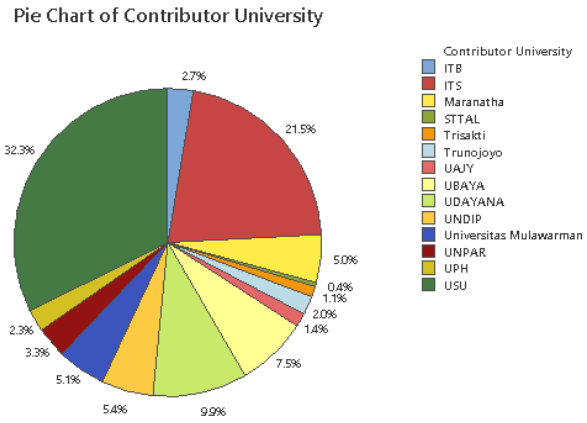

Figure 2. Pie Chart of Contributor University

4. Data Collection
4.1. Questionnaire
The following is the data collected from the questionnaire. Of the five questions, only four questions can be put into a pie chart. The last question is short-answer, so it cannot be converted to a pie chart (Figure 3).

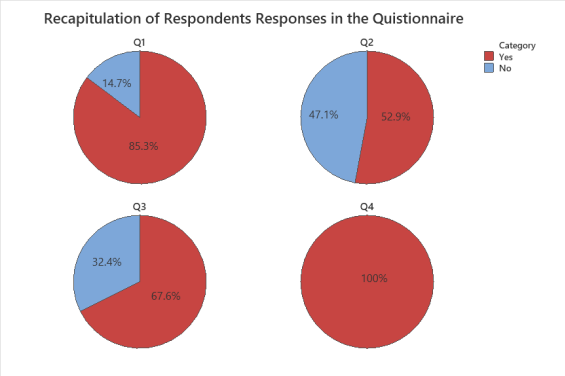

Figure 3. Recapitulation of Respondents

Figure 3 shows four pie charts showing respondent's answers. Red means the answer is "Yes" and blue means "No". In general, the answer "Yes" dominates the answers from respondents.

4.2. Task Analysis Data

Based on the simulation of the use of strainers, the following steps are used to use strainers.

1. Step Positioning the strainer

The initial step in utilizing a strainer is to place it accurately. This requires gripping the strainer with one or both hands, positioning it over an appropriate container, lifting the lid, and getting a measuring spoon ready if needed.

2. Pour the ingredients into the strainer

Subsequently, the components need to be poured into the strainer. This involves grasping the materials container with one or both hands, measuring the ingredients as necessary, and gently pouring them into the strainer to guarantee uniform distribution.

3. Waiting for the screening process to complete

After the ingredients are added, the screening process starts. At this phase, fluids or substances can pass through the strainer. If sifting or further processing is necessary, the strainer handle should be attached. The volume of liquid or substance gathered can be tracked by the indicators on the measuring cup.

4. Cleaning the strainer

It is crucial to clean the strainer to ensure hygiene and facilitate future use. This involves taking out the strainer from the container, washing its components, putting them back together, and sealing the strainer to maintain its cleanliness for future use.

4.3. Anthropometric Data

Two anthropometric data are used as a reference when making this strainer. The first data used is hand length (D28). The second data used is the hand width (D29).

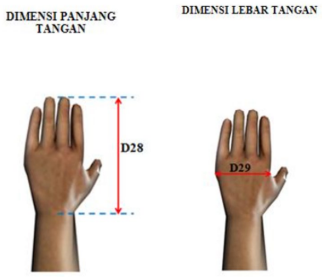

Figure 4. Anthropometric Hand Dimension
(Source: https://www.antropometriindonesia.org/)

Figure 4 shows the dimensions of the anthropometric data used. The image on the left is the hand length dimension with (D28), and the image on the left is the hand width dimension (D29).

Table 1. Length of Hand and Width of Hand Data

Dimension	Detailed Size	5th Percentile (cm)	50th Percentile (cm)	95th Percentile (cm)	Standard Deviation (cm)
D28	Hand Length	11.81	17.12	22.44	3.23
D29	Hand Width	3.75	9.36	14.98	1

Table 1 presents anthropometric measurements for hand length and width according to the 5th, 50th (median), and 95th percentiles, along with the standard deviation. Hand length varies from 11.81 cm (5th percentile) to 22.44 cm (95th percentile), exhibiting a median of 17.12 cm and a standard deviation of 3.23 cm. At the same time, hand widths varied between 3.75 cm and 14.98 cm, showing a median of 9.36 cm and a lower standard deviation of 1 cm.

5. Results and Discussion

5.1 Questionnaire Analysis Result

Based on the results from the questionnaire, most of the participants used a strainer. This can be seen from the answer to the first question (Q1), where 100% of the participants answered "Yes". In the second question (Q2), which asked whether preparing the strainer and accompanying tools was troublesome, the participants gave almost the same answer. Of all respondents, 52.9% answered "Yes," and 47.1% answered "No." This shows that most participants found the preparation process relatively straightforward, while some still found it quite tricky. In addition, most respondents believed that separating the strainer and its accompanying tools, such as the strainer holder, spoon, measuring cup, and lid, took up much space. This is shown by the answer to the third question (Q3), where 85.3% of participants answered "Yes," indicating that many users face challenges in storing these tools. Nonetheless, in the fourth question (Q4), every participant (100%) supported the depiction of a multifunctional strainer. This indicates that strainers with additional features capable of integrating support tools are preferred.

Multifunctional strainers help save storage space and minimize the time required to prepare and store tools. It can be concluded that most respondents use a strainer, and they find the process of preparing the strainer and its supporting tools, such as the strainer container, ladle, measuring cup, and lid (to prevent contamination), time-consuming and cumbersome. In addition, they also think that storing the strainer and supporting tools, such as the strainer container, ladle, measuring cup, and lid, separately takes up much space.

5.2 Task Analysis Result

After an evaluation using task analysis, the following are corrective measures that can be taken to improve the ergonomics of the strainer. The strainer must be designed to be comfortable so that it does not cause fatigue or injury (Table 2). In addition, to maximize the function of space, a strainer container is needed with a design that is easy to carry without handles. The strainer container needs an anti-slip design at the bottom to prevent slipping and falling. The size of the strainer container needs to be adjusted to the strainer and has a size that matches the size of the human body. A tool for pouring ingredients, such as a measuring spoon, must be added to provide convenience. Installing a lid on the strainer is also necessary so it does not get dirty during further use.

Table 2. Task Analysis

Step	Task Description	Risk Ergonomists	Ergonomic Solutions
Positioning the strainer	Holding the strainer with one or two hands	The strainer may be too thin, big, or slippery, causing strain on the hands and wrists.	Use a strainer with a comfortable, anti-slip, polymer body.
	Placing the strainer on top of a suitable container	Imbalance can lead to instability, spillage, or additional effort to adjust the position.	Use a strainer with a stable base to prevent it from shifting during use.

	Opening the strainer lid	Too tight or rigid lids can require excessive force, causing wrist strain.	Design the strainer with easy-to-open hinges or soft-touch handles to reduce hand fatigue.
	Take a measuring spoon if needed.	Repetitive movements can cause strain if the measuring spoon is not within easy reach.	Keep measuring spoons near the work area to reduce unnecessary movement. I'm looking for a strainer container with a spoon.
Pour the ingredients into the strainer.	Holding the container of materials with one hand or both hands	Containers that are too heavy can cause strain on the arms, shoulders, or lower back, especially if lifted with one hand.	Use a strainer with a container that is sized to fit both hands so that it is possible to hold with two hands.
	Measure ingredients using a measuring spoon if needed	Small repetitive movements can cause long-term discomfort.	Use pre-measured measuring spoons.
	Slowly pour the ingredients into the strainer	Pouring unevenly can cause spills, increasing the workload for cleanup.	Use a strainer container with a large enough diameter or use a funnel to control the flow of ingredients when pouring. Adjust the pouring angle to avoid strain on the wrist.
Wait for the screening process to complete	Allowing liquids or materials to flow through the strainer	Holding an uncomfortable body position for too long can cause muscle strain. An unstable strainer can cause spillage and repeated cleaning work.	Ensure the strainer is securely attached to the container so that it does not need to be held constantly.
	Installing the strainer handle if sifting or other processes are required	Less ergonomic handles may require extra effort or uncomfortable movements.	Design a strainer with a firm grip and a comfortable position.
	Viewing the amount of liquid or material entering the strainer measuring cup through the markers present on the measuring cup	Poor visibility may cause users to bend over or take uncomfortable angles to check the amount of ingredients.	Use measuring containers with clear, high-contrast markers for easy reading.
Cleaning the strainer	Removing the strainer from the container	It could be that there is a part of the filter that is not well interlocked, so it isn't easy to open	Make sure that the interlock area is at the right size and appropriate so that it is easy to remove.
	Cleaning and installing the strainer parts	Small or intricate parts can be challenging to clean, requiring repeated hand movements.	Use a strainer with removable parts that are easy to clean.
	Close the strainer so that it does not get dirty when it is going to be reused, and it makes it easier to use later.	If the lid is difficult to install or remove, it may cause unnecessary effort and strain.	Design a strainer with a lid that is easy to install and remove. Store in an easily accessible location to reduce the load when lifting.

5.3 Anthropometric Data Analysis Result

Hand length (D28) and hand width (D29) are anthropometric data used in the middle of the strainer container. The value of hand length is used to calculate the grip diameter of the container. The value of width length is used to calculate the width of the grip diameter.

1. Hand Length (D28) Calculation

Circumference of the circle = $11{,}81\ (cm)\ x\ 2$
Circumference of the circle = $23{,}62\ cm$

$$C = \pi d \tag{5.1}$$

where:
C = Circumference
d = Diameter
$\pi \approx 3.1416$

$$d = \frac{C}{\pi} \tag{5.2}$$

$$d = \frac{23{,}62}{3{,}1416}$$

$$d \approx 7{,}52 \text{ cm}$$
$$d \approx 8 \text{ cm}$$

The circumference value was obtained from the 5th percentile, measuring 11.81 cm. The 5th percentile was chosen because it signifies the lowest 5% of participants in the data set. This choice ensures that individuals with smaller hand sizes can easily hold the strainer. By basing the design on the smallest hand size, the product is accessible to those who may find it difficult to use larger dimensions, thereby increasing the value of ergonomic function and comfort. This method avoids issues such as grasping difficulties, loss of control, or discomfort that may occur if the design is focused on a higher percentile. Furthermore, focusing on the 5th percentile promotes inclusivity, allowing a wider range of users to use the filter effectively. In product design, considering lower percentiles reduces user strain and improves accessibility, especially for individuals with smaller hands, including children, older adults, or those with naturally smaller hand sizes. This design decision harmonizes practicality and comfort, ensuring that the filter remains helpful for every user instead of only accommodating individuals with average or larger hand sizes.

Based on the calculation, we can determine that the diameter value is about 7,52 cm. To facilitate the manufacture and measurement of the product, the diameter value is rounded up to 8 cm. Therefore, the gripping part of this container has a diameter of 8 cm.

2. Hand Width (D29)

The design selects a hand width of 14.98 cm at the 95th percentile to ensure it fits users with wider hands. This method aids in developing a product that is comfortable, accessible, and user-friendly for most individuals. If a lesser percentile, like the 50th percentile, were applied, people with bigger hands might face challenges with a snug fit, discomfort, or problems holding objects. Opting for the upper range guarantees improved handling minimizes stress, and boosts user safety, particularly in tools, gloves, and control surfaces. Moreover, this approach adheres to established ergonomic principles, suggesting a design for the 5th percentile for minimal limitations and the 95th percentile for optimal usability. Hand sizes differ among various populations, and the 95th percentile guarantees the product accommodates a broad user range, so it may enhance its practicality and ease of use.

5.4 Production Cost Calculation

This strainer is made using high-quality materials to ensure its strength and durability. The central part and handle of this strainer are made of Polypropylene. Polypropylene is a type of plastic that is durable and comfortable to hold. The lid of the strainer and spoon should be made of polyethylene plastic. This material was chosen because it has lightweight but sturdy properties that protect the contents. The following is a breakdown of the costs required to produce a multifunctional strainer.

Price for producing the strainer
PP plastic pellet price: Rp.13,400/1kg
PE plastic pellet price: Rp. 36,000/1kg
Rubber plastic pellet price: Rp. 13,000 /1kg
304 Teal Stainless Wire (1mm) Price: Rp. 1,800/meter

The price of the machine used to make the strainer
Blow molding machine price: Rp.

Overhead Costs:

1. Electricity Cost: Rp. 6,149,280/month
   1 working day = 8 hours * 20 days = 160 hours

$$\text{Electricity cost} = \text{Electric power (kW)} \times \text{Time of use} \times \text{Electricity rate per kWh}$$
$$= 2 \text{ kW} \times 8 \frac{\text{hour}}{\text{day}} \times 20 \text{ working hour}$$
$$= 20 \text{ kWh}$$

   Injection blow molding machine → 20 kW / 8 hours * 20 working days = 3,200 kWh

$$\text{Electricity cost} = \text{Electric power (kW)} \times \text{Time of use} \times \text{Electricity rate per kWh}$$
$$= 20 \text{ kW} \times 8 \frac{\text{hour}}{\text{day}} \times 20 \text{ working hour}$$
$$= 3{,}200 \text{ kWh}$$

   Injection molding machine → 10kW/ 6 hours * 20 working days = 1,200 kWh

$$\text{Electricity cost} = \text{Electric power (kW)} \times \text{Time of use} \times \text{Electricity rate per kWh}$$
$$= 10 \text{ kW} \times 8 \frac{\text{hour}}{\text{day}} \times 20 \text{ working hour}$$
$$= 1{,}200 \text{ kWh}$$

   Wire Mesh weaving machine → 3 kW/ 10 hours * 20 working days = 600 kWh

$$\text{Electricity cost} = \text{Electric power (kW)} \times \text{Time of use} \times \text{Electricity rate per kWh}$$
$$= 4 \text{ kW} \times 10 \frac{\text{hour}}{\text{day}} \times 20 \text{ working hour}$$
$$= 600 \text{ kWh}$$

   Laser cutting machine → 2.5/ 10 hours * 20 working days = 500 kWh

$$\text{Electricity cost} = \text{Electric power (kW)} \times \text{Time of use} \times \text{Electricity rate per kWh}$$
$$= 2 .5 \text{ kW} \times 10 \frac{\text{hour}}{\text{day}} \times 20 \text{ working hour}$$
$$= 500 \text{ kWh}$$

   Total electricity consumption = 5,520 kWh
   Assumption of Rp. 1,114/kWh
   Total: Rp. 6,149,280

Based on the calculations that have been made to find the amount of energy consumption of the engine used during the process of making the filter and assuming the electricity tariff in medium industry with power above 200 kVA is Rp. 6,149,280.

2. Minimum Wage Cost: Jogja: Rp. 2,492,997

$$= \frac{\text{Minimum wages}}{\text{Working days}}$$

$$= \frac{\text{Rp.2.492.997}}{20}$$
$$= \text{Rp.124.649,85}$$

The estimated number of product that can be produced in a day is 5 products.

5.5 Prototyping

The 3D design of the multifunctional strainer was made using Solidworks software. There are seven components of the multifunctional strainer: body strainer, bottom rubber, strainer holder, main body, spoon, lid, and strainer net. The following is a 3D image of the assembly results and parts of the multifunctional strainer (Figure 4- Figure 7).

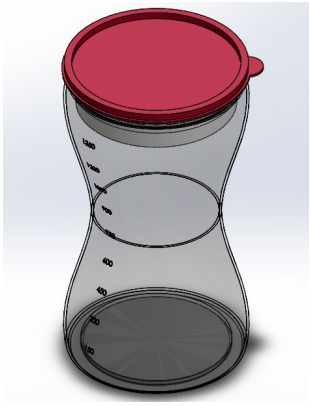

Figure 5. 3D Model of Multifunctional Strainer

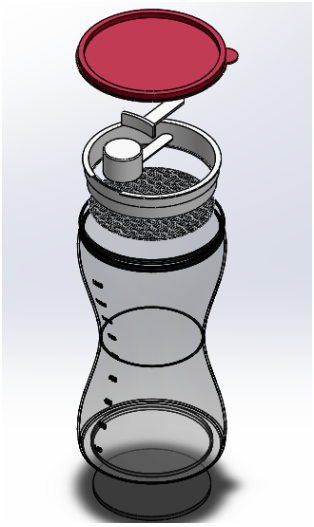

Figure 6. 3D Exploded View of Multifunctional Strainer

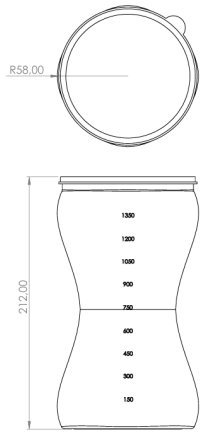

Figure 7. Drawing Model of Multifunctional Strainer

The process required to perform screening activities involves the use of hands. The hand dimensions taken as product anthropometric data based on the previous are hand length and hand width. In order for the product to be used by many people with various hand sizes, the anthropometric data for both dimensions use the 5th percentile for hand length and the 95th percentile for hand width. The diameter of the ladle is designed according to the diameter of the strainer to ensure optimal fit. In Figure 6, the height of this strainer is 212 mm. This strainer can hold up to 1.48 liters of water.

6. Conclusion

Based on the research conducted, it was found that many users still rely on strainers as an essential kitchen tool. On the other hand, the absence of an accurate measuring spoon, a proper container for the material being strained, and a sturdy handle often hinders the efficiency of the cooking process. A multifunctional strainer designed to address these issues by integrating a built-in measuring spoon, an attachable measuring cup with measurement marks, and a removable lid. In addition, this strainer is equipped with a sturdy handle that enhances user comfort and safety. This multifunctional strainer not only improves usability by providing accurate measurements, but also optimizes kitchen space efficiency by reducing clutter. The design of the strainer container is ergonomically made according to the dimensions of the human body, namely the length and width of the hand. The design of the strainer container is ergonomically made according to the dimensions of the human body, namely the length and width of the hand. With an ergonomic design on the strainer container, users will find it easier to use this strainer. Cost calculations were also carried out to determine the feasibility of making this multifunctional sieve.

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