Identification of product and design characteristics of eucalyptus herbal tea bags

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Abstract. Eucalyptus leaves can also be used as herbal drinks to alleviate colds and coughs, in addition to being used as raw material for Eucalyptus oil. The leaves of Eucalyptus contain active compounds that can function as antibacterial, anti-inflammatory, antioxidant, and antiviral. One of the practical and easy to develop herbal drink items is herbal tea in a dye bag. This study aims to identify the characteristics of Eucalyptus tea products that meet customer requirements and to identify design characteristics that are critical to the development of Eucalyptus tea products. The method used in this research is the Quality Function Deployment (QFD). The results showed that product characteristics of Eucalyptus tea were efficacious, not too strong aromas, nice colors, quick brewing time, good taste, not too spicy, quality price, proper instructions, safe, halal, and long shelf life. Three critical design characteristics are defined, namely the type of supporting herbal materials from leaves or stem, and the best proportion of supporting herbal materials and Eucalyptus leaves that meets customer requirements.

1. Introduction
One of the forestry medicinal plants that grow well on Madura’s island is the Eucalyptus tree. The most widely used part of the plant is Eucalyptus leaves, which its essential oil is extracted into Eucalyptus oil or cajuput oil. Eucalyptus leaf extract contains flavonoids [1], terpenoids [2], tannins [3], 1,8-cineole [4] and others. Ghalem and Mohamed [5] reported that Eucalyptus globulus essential oil was able to inhibit the growth of E. coli and S. aureus test bacteria, where the inhibition of E. coli bacteria was very strong. In contrast, the S. aureus bacteria were classified as moderate.

In addition to Eucalyptus oil, there are Eucalyptus-based products that have been developed by the Agricultural Research and Development Agency of Indonesia and have been patented in 2020. The products are aromatic antivirals based on essential oils, inhalers based on Eucalyptus oil, and encapsulated powder ingredients made from Eucalyptus [6]. The development of products made from Eucalyptus increasingly massive as the corona pandemic is affecting 213 countries around the world because Eucalyptus is believed to have active compounds that can relieve colds and coughs, bronchitis, antibacterial [7], antifilm S. aureus [8], and antivirals [6]. The results of the research conducted by the Agricultural Research and development agency of Indonesia in 2020 stated that Eucalyptus could
kill viruses by up to 60-80% [9]. The most comfortable herbal product development from Eucalyptus leaves is to process it into Eucalyptus tea. The process of making Eucalyptus tea has been researched and patented by Shimabukuro [10], with raw materials 100% eucalyptus with manufacturing process stages starting from steaming, rumple-twisting, and drying eucalyptus leaves. Noting the many benefits of Eucalyptus, in the preliminary study, we have developed Eucalyptus herbal tea in dye bag packaging. This package is chosen due to its familiarity, practicality, and durability [11]. In our preliminary study, we made herbal teas in a dye bag of 100% Eucalyptus leaf powder. This product has been sensory analysis by the respondents and has not met the customer requirements because the taste and aroma of Eucalyptus are too strong, so we need more in-depth studies to develop Eucalyptus herbal tea products. One method for developing new products with a focus on customer requirements is the Quality Function Deployment (QFD) method [12].

QFD is a method for developing products of higher quality to satisfy customer needs by collecting and analyzing customer voices [12]. QFD is a structured approach for identifying customer requirements and converting them into technical requirements for manufacturing products that satisfy those requirements [13]. Customer needs are captured in a variety of ways: surveys, focus group discussions, interviews, etc. This interpretation of customer requirements is then outlined in the "House of Quality (HOQ)" product planning framework. Some of the advantages of using the QFD method are decreased design changes, reduced time to market, enhanced quality, reduced design, and manufacturing costs, and increased customer satisfaction [14]. So QFD can be a powerful tool for product development [15], including the development of food products. Nevertheless, the downside of using QFD for the development of food products would occur due to the complexity of food products, the many interactions between ingredients, and the impact of production processes on the functional properties of the product [16].

This study aims to identify the characteristics of Eucalyptus tea products that meet customer needs and to identify design characteristics that are critical to the development of Eucalyptus tea products. In this research, it can be obtained the characteristics of Eucalyptus herbal tea products, technical requirements in producing products, and design characteristics of Eucalyptus herbal tea products.

2. Materials and Methods

2.1. Samples
There were two herbal teas from Eucalyptus that are made using a different formula. At the focus group discussion, the two products with different formulae were presented to be sensitively examined by the panelists. Through this sensory test, the panelists are expected to explain Eucalyptus herbal tea's customer requirements. In warm conditions, all the samples were served in a 200 ml clear cup glass before evaluating their sensory properties in the consumer survey. Intentionally, product information was blinded and labeled as samples A and B. They served samples in random order. Water was served for mouth washing, among the samples, to reduce residual effects between samples.

2.2. Collecting customer data
A focus group discussion (10 panelists) was held to gather customer information about Eucalyptus herbal tea products' customer requirements. The focus group also obtained information about the purchase and consumption of herbal drinks in specific herbal teas. This information was then used to develop a survey of Eucalyptus herbal tea products about customer requirements. The customer survey was being conducted for 40 herbal drink customers in Bangkalan Regency, focused on the 26-60-year-old customer age groups. The customers were randomly recruited on campus and public places of the universities. They were asked to fill out customer requirement questionnaires and the level of importance of Eucalyptus herbal tea customer requirements.
2.3. Creating the house of quality (HOQ)

HOQ reflects a powerful tool for product development. However, its general structure must be adapted when applied to food products [3]. One of the commonly used HOQ models is the HOQ Four-Phase Model [12, 17]. Figure 1 shows the QFD phases of the product delivery process.

Each of QFD’s phases relates to ensuring both the specification development and its subsequent implementation with a product development cycle. Figure 1 shows the beginning and ending of the QFD phase cycle at the customer. It is the customers who define the quality standard in terms of their specifications, and therefore it is the customer who decides whether the product satisfies these requirements [17].

Only the first and second QFD phases were generated through this study. A QFD1 matrix is a systematic approach in which customer requirements are converted into technical requirements. Using the QFD1 matrix to address the first research goal was to identify Eucalyptus herbal tea customer requirements and technical requirements. A QFD2 matrix represents a systematic approach for the conversion of technical requirements into parts characteristics. The QFD2 matrix may produce critical designs or parts characteristics of Eucalyptus herbal tea.

![Figure 1. QFD phases of product delivery process [17].](image)

The creation process for the first HOQ (QFD1 matrix) consists of six stages, as shown in Figure 2:

1. Identify customer requirements by focus group discussion (10 panelists) then assess the importance of customer requirements (40 respondents).
2. Identify technical requirements by filling out questionnaires by 3 experts of herbal tea. The experts were 1 owner of the herbal tea industry and 2 lecturers of the Agroindustrial Technology Study Program.
3. Connect between customer requirements and technical requirements (relationship matrix) with three rating scales 1 (weak), 3 (medium), and 9 (strong) by filling out questionnaires by three experts of herbal tea (point 2).
4. Determine the target values of each customer's requirements.
5. Connect between technical requirements by giving a rating: strong positive (++), positive (+), strong negative (--), or negative (-). This rating is made by three experts.
6. Determine the target values of each technical requirement.

The QFD2 matrix is arranged to convert the technical requirements of the QFD1 matrix into design or parts characteristics [17]. The process of creating the second HOQ (QFD2 matrix) consists of five stages, as shown in Figure 2:

1. Placing technical requirements as "what" the product must do and how much (technical importance)
2. Fill in the columns by asking how does it accomplish whatever it must do, in other words, and it identifies parts characteristics
3. Establish the relationship between the technical requirements and parts characteristics
4. Fill in the target value row by entering the target value of each technical requirements
5. The link between parts characteristics by giving a rating: strong positive (++), positive (+), strong negative (--) or negative (-). This rating is made by three experts.
6. Fill in the target value column by entering the target value of the characteristics of each part

![QFD matrix](image)

(a) QFD1 matrix. (b) QFD2 matrix.

**Figure 2. QFD matrices.**

### 3. Results and Discussion

#### 3.1. Focus group discussion
The discussion of the focus group was held involving ten trained panelists who were accustomed to consuming herbal drinks. A new product was given to the panelists, namely Eucalyptus herbal tea (powder) packed into a dye bag. Researchers in this focus group discussion provides a different formula for the two products and serve them in 200 ml clear cups. Furthermore, the panelists discussed the customer requirements of Eucalyptus herbal tea in a dye bag. The customer requirement is a definition of the advantages of the product/service in the words of the customer [18]. Focus group discussion produced 11 customer requirements of *Eucalyptus* herbal tea, including efficacious, not too strong aromas, nice colors, quick brewing time, good taste, not too spicy, the price associated with product quality, proper instructions, safe, halal, and long shelf life.

#### 3.2. QFD1 matrix of eucalyptus herbal tea

**3.2.1. Rate the importance of customer requirements and the target value of customer requirements**
This stage was carried out using a survey of 40 respondents who had consumed Eucalyptus herbal tea. Respondents were asked to assess the importance of 11 customer requirements *Eucalyptus* herbal tea, as shown in Figure 3. The five attributes have values of 6 (important) to 7 (very important), starting from the most important, respectively is efficacious, not too strong aromas, good taste, nice color, and safe. Rate the importance of customer requirements was very important because it can influence customer purchasing behavior and achieve customer satisfaction [19].

The highest customer requirement of *Eucalyptus* herbal tea is efficacious. It is matched with the research of Clement [20] that most consumers perceived that herbs are efficacious. Based on this perception, the popularity of herbal tea will increase and sustain. It is evidenced by [10] that *Eucalyptus* tea is an herbal drink that is effective because it reduces cholesterol and blood sugar levels. The second
highest customer requirement attribute is eucalyptus herbal tea with a mild aroma (not too strong aromas). *Eucalyptus* leaves have a sweet scent, which is a mixture of menthol and honey [21]. It is caused by the content of terpenes that have strong and distinctive aromas and tastes [22]. If Eucalyptus leaves are brewed and made into herbal drinks, the strong menthol aroma is not favored by consumers. Based on these results, *Eucalyptus*’ herbal tea is expected to be developed to meet customer requirements, including efficacious and not too strong aromas.

The target value for each attribute of the customer requirements has been determined by the panellists using a scale of 1 (worse) to 5 (very good). Seven attributes are targeted with a value of 5 (very good), including efficacious, not too strong aromas, good taste, the price associated with product quality, proper instruction, safe, and halal. This target value can be achieved through an excellent production process by paying attention to the technical requirements which are strictly related to each attribute.

### 3.2.2. Technical requirements

| Customer Requirements | Type of supporting herbal materials | The proportion of supporting herbal materials | Net Weight of herbs in a bag | Moisture content | Extract content | The duration of tea brewing | Total phenols | Antioxidant activity | Active compounds | Information in packaging | Halal in all production stages | Total plate count |
|-----------------------|------------------------------------|---------------------------------------------|----------------------------|-----------------|----------------|-----------------------------|---------------|---------------------|----------------|------------------------|-----------------------------|-----------------|
| Efficacious           | 9                                  | 9                                           | 9                          | 9               | 9              | 5                           | 9             | 5                   | 9              | 9                      | 9                           | 661.4           |
| not too strong aromas | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 5                   | 9              | 9                      | 9                           | 526.8           |
| Nice color            | 9                                  | 9                                           | 3                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 468.3           |
| Quick brewing time    | 9                                  | 9                                           | 3                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 258.8           |
| Good taste            | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 193.3           |
| Not too spicy         | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 33             |
| The price associated  | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 100.4           |
| with the product quality | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 94.7            |
| Proper instructions   | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 94.7            |
| Safe                  | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 94.7            |
| Halal                 | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 94.7            |
| Long shelf life       | 9                                  | 9                                           | 9                          | 9               | 9              | 9                           | 9             | 9                   | 9              | 9                      | 9                           | 94.7            |

**Figure 3.** QFD1 matrix of *Eucalyptus* herbal tea.
The method of QFD translated customer requirements into engineering or technical requirements [2]. The three experts were asked to identify technical requirements related to 11 customer requirements of focus group results. The identification results showed that there were 14 technical requirements (Figure 4) that must be considered in the development of Eucalyptus tea products. They were the type of supporting herbal materials, the proportion of Eucalyptus leaves and supporting herbal materials, particle size, net weight of herbs in a bag, moisture content, the duration of tea brewing, total phenols, antioxidant activity, active compounds, the information in packaging, halal in all production stages, and total plate count.

Customers want eucalyptus herbal tea that is efficacious and does not have too strong aromas. Therefore, we have to add supporting herbal materials to meet the requirements. It is crucial in product development to identify and prioritize technical requirements that can maximize the customers’ satisfaction [23]. So, the producer must pay attention to the technical requirements which have the highest weight to meet the customer requirements [11]. Figure 3 reveals that the fourth highest weight of technical requirements is the type of supporting herbal materials, the proportion of Eucalyptus leaves, the proportion of supporting herbal materials, and net weight of herbs in a bag. This means, to meet customer requirements regarding mild aroma, eucalyptus tea must be blended with other dried herbs ingredients. Blended tea is a blend of dried herbs ingredients that are usually made to improve aromas, flavors and colors [24]. In blended tea making, the type and proportion of ingredients mixed can affect the aroma of the blended tea [25]. In addition, Peterson [26] stated that the weight of teabag and brewing techniques can affect tea flavonoid content.

### 3.2.3. Relationship between customer requirements and technical requirements

The relationship between customer requirements and technical requirements, as shown in Figure 3, was assessed by three experts based on three values: 9 (strong relationship), 3 (moderate relationship), and 1 (weak relationship). Four technical requirements have relationships with five or more customer requirements at once. They were the type of supporting herbal materials, the proportion of Eucalyptus leaves, the proportion of supporting herbal materials, net weight of herbs in a bag. The relationship between customer requirements and technical requirements is significant to note because one of the critical factors in developing new products is understanding and managing the relationship between customer requirements and technical requirements [23]. So that, the producer must pay attention to the four technical requirements to meet the customer requirements.

### 3.3. QFD2 matrix of eucalyptus herbal tea

The QFD2 matrix can be seen in Figure 4. There are 11 parts or design characteristics that are related to technical requirements, as shown in Figure 4. The parts characteristics with the highest weight value are the best proportion of Eucalyptus leaves and supporting herbal materials based on sensory evaluation. This results in line with [111] stated that the proportion of supporting herbal materials is very crucial in developing herbal teas that can meet customer requirements. Of the 11 parts characteristics, 6 parts need to be investigated in more depth through experimental research to determine how much the appropriate target value is and can produce eucalyptus herbal tea that meets the customer requirements. The six parts are:

1. The supporting materials from dried leaves that meet customer requirements
2. The supporting materials from dried stem that meet customer requirements
3. The best proportion of Eucalyptus leaves and supporting herbal materials based on sensory tests
4. The grinding processes
5. Drying temperature
6. Drying time

Based on the QFD1 and QFD2 matrices in this study, there is further research to define the target values for six design of characteristics to develop Eucalyptus herbal tea bags that meet customer requirements. The primary research that must be carried out through experiments in the laboratory is
determining the best types and proportions of supporting herbal materials because this relates very strongly to almost all technical requirements.

| Max Relationship value in column | Weight/importance | Relative weight | Parts Characteristics | Technical Requirements |
|----------------------------------|-------------------|----------------|----------------------|-----------------------|
| 9                                | 661.7             | 23.0           | Type of supporting herbal materials | 9 |
| 9                                | 526.8             | 18.4           | The proportion of Eucalyptus leaf powder | 9 |
| 9                                | 468.3             | 16.3           | The proportion of supporting herbal materials | 9 |
| 1                                | 19.3              | 0.7            | Particle size | 9 9 |
| 9                                | 228.8             | 8.0            | Net Weight of herbs in a bag | 9 |
| 9                                | 158.3             | 5.5            | Moisture content | 1 1 9 9 |
| 9                                | 94.7              | 3.3            | Extract content | 9 9 9 |
| 9                                | 100.4             | 3.5            | The duration of tea brewing | 3 3 9 9 |
| 9                                | 94.7              | 3.3            | Total phenols | 9 9 9 |
| 9                                | 94.7              | 3.3            | Antioxidant activity | 9 9 9 |
| 9                                | 94.7              | 3.3            | Active compounds | 9 9 9 |
| 9                                | 89.3              | 3.1            | Information in packaging | 9 |
| 9                                | 80.8              | 2.8            | Halal in all production stages | 3 3 |
| 9                                | 158.3             | 5.5            | Total plate count | 9 9 |
| Max relationship value in column | 661.7             | 23.0           | 526.8                | 468.3                |
| Weight/importance | 361.7             | 21.2           | 21.2                | 21.2                |
| Relative weight | 361.7             | 21.2           | 21.2                | 21.2                |
| Target Value | Score 4 – 5 in sensory evaluation | Score 4 – 5 in sensory evaluation | Score 4 – 5 in sensory evaluation | Meet the standards |
| | 70 mesh | 50–60°C | 18–24 hours | 2 g/bag |
| | 94.7 | 8.1 | 8.1 | 9 |

**Figure 4.** QFD2 matrix of *Eucalyptus* herbal tea.

4. Conclusions

There were two conclusions from this study. First, there are five product characteristics of *Eucalyptus* herbal tea bags that have the highest values starting from the most important, respectively, is efficacious, not too strong aromas, good taste, nice color, and safe. The second, the design characteristics with the highest weight value, are the best proportion of *Eucalyptus* leaves and supporting herbal materials based on sensory evaluation. For further research, we need to do the experimental study in the laboratory to
determine the best types and proportions of supporting herbal materials, because of highly related to almost all technical requirements.

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