Packaging development for fresh avocado (*Persea americana*) using quality function deployment method

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Abstract. Avocado is a favorite tropical fruit that offers many benefits. However, the packaging of fresh avocados has not been able to protect the fruit from physical injury and the lack of information obtained by consumers. The aim of this study was to develop avocado packaging that is good and appropriate according to consumer needs. The method used was the Quality Function Deployment (QFD) approach. The QFD method includes the stage of collecting the voice of the customer, creating the House of Quality (HoQ), and the stage of analysis and evaluation. The results indicated that attributes required by the customers include fruit size, information completeness, perforation, design, shape, and material of packaging. While, the technical responses to be created were i.e. homogeneous fruit size, attractive packaging design, packaging with shapes that match the avocado, packaging that can explain the product in detail, eco-friendly packaging materials and protect from physical damage, and packaging with a circulation hole or perforation.

1. Introduction

Indonesia as a tropical country has various types of tropical fruits and spices from all over Sumatra to all corners of Papua. Avocado is a tropical fruit that has the potential to be exported to foreign countries and has high economic value, with a high volume of production in Indonesia. Based on information from the Central Statistics Agency (2018), Indonesia’s avocado production in 2017 was 363,157 tons. While in 2018, it was 410,097 tons, which led to a production growth rate of 12.92%. Avocado, which is known as *Persea americana*, has various names in Indonesia, including avocado (West Java), boah pokat, jamboo pokat (Batak), and avocado (East Java or Central Java). With a low price and can be found anywhere, the fruit has become the favorite of Indonesian.

According to the Development Management Information System in Rural Areas, BAPPENAS, there are two types of avocado varieties in Indonesia. The first type is the superior varieties that have superior characteristics such as high production, uniform fruit, and good quality fruits, such as avocado green long and green round. The second variety is germplasm, which is grown in the experimental garden of the Technology Research and Research Installation, Tlekung, Malang. Types of avocado included in
this variety include long red avocado, round red, dickson, butler, Winslowson, etc [1]. Down to date, most avocado in Indonesia still uses high-density polyethylene (HDPE) packaging. Consumers can take the number of fruit by themselves, then the weight of the fruit selected will be measured. The packaging is less effective because, in addition to the very thin packaging materials used, the packaging is also less informative and attractive. The thin HDPE packaging material has the risk of making avocado easily bumped which will affect the texture and quality of the fruit. The disadvantage of existing avocado packaging is the risk of reducing the quality of the fruit about mechanical injuries such as scratches and bruises are often found as a result of collisions between fruits and packaged fruit during transportation as well as stress due to overloading [4]. The mechanical damage that occurs in the handling of avocados that experience bruises will experience loss of quality and damage to the fruit. In the future, this will have an impact on decreasing consumer interest in the product, which could have an impact on reducing the selling price of the product [5]. Besides, to design a package for both storage and distribution of fruit, it is necessary to pay attention to air circulation by providing ventilation to maintain the freshness of the fruit [6]. The research suggests that the highest physical damage was experienced by avocado samples in non-ventilated packages stored at room temperature. However, the current packaging is unable to protect the fruit from external damage as well as the lack of information that consumers get from this packaging. Based on the description above, it is necessary to conduct a research entitled "Development of Avocado Fruit Packaging (Persea americana) using Quality Function Deployment (QFD) Method".

Quality function deployment (QFD) is an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production. For example are marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, and sales. QFD was originally proposed, through collecting and analyzing the voice of the customer, to develop products with higher quality to meet or surpass customers' needs. [5]. Thus, the primary functions of QFD are for product development, quality management, and customer needs analysis.

2. Materials and Methods

2.1. Conceptual model

This research uses the QFD method with the initial stage of the voice of the customer collection. Information needed from respondents is collected using questionnaires. Respondents are chosen based on age and must have bought avocado in the supermarket. The voice of customer excavation is then processed and then it will generate technical characteristics. Through the brainstorming process, alternative development concepts are obtained. The design of the concept is carried out using the HoQ matrix in QFD Iteration 1, where the QFD iteration stage 1 among others [8]:
1. Matrix customer needs, containing customer needs gained from the interview
2. Matrix planning, to indicate the level of importance and satisfaction of the needs of customers
3. Technical characteristics
4. Matrix relations
5. Correlation of technical characteristics
6. Technical matrix

The next step is to determine the target of each critical part obtained based on the benchmark of similar products and consider the ability of the company to meet the targets set. The proposed visualization of the package design concept is made using AutoCAD 2017.
2.2 Data analysis
This study uses the QFD method with the initial stage of interviewing respondents. Respondent data is captured and grouped then calculated to determine the value of the attribute. The next stage is determining the technical characteristics and creating the House Of Quality (HoQ). The development of the packaging design concept was carried out based on information in the HoQ and literature. Conclusions are drawn from the research that has been done and followed by the submission of suggestions.

3. Results and Discussion

3.1 Product
Avocado is classified as a fruit that has a climatic respiration pattern, that in a certain period will suddenly experience biological changes that are monitored by the formation of ethylene so that the ripening process occurs [2]. Beginning to ripen, avocados are easily damaged, rotten, and experience rapid weight loss due to their thin skin and rotten flesh. Avocado has the most increase in climatic respiration on the 15th day after being picked, and its freshness can only last for 2 to 8 weeks [3]. The packaging itself is the key to protect products from damage, maintains product quality, extends shelf life. Attractive packaging design is made by the company so that it can get the attention of the consumers.

Avocado packaging is currently underdeveloped and only using plastic which is not eco-friendly. In our opinion, avocado is suitable as an object of packaging development by considering important things related to product characteristics and packaging characteristics. This packaging development carried out
to maximize important aspects of avocado packaging and as well as increase consumer interest in buying packaged avocado products.

3.2 Developing the house of quality

Figure 2. House of quality for avocado design development.

QFD method works to change the customer’s desire to be parameters and values so that it can be applied to the product accurately [10]. QFD can not only transform customer desires into parameters and values for products and services but also bring customer needs down to a detailed level of operation. By using this, it is expected that the customer’s desire towards good quality can also be accommodated by applying the method in the company [11].

Percent significant degree that placed in the planning matrix is obtained by dividing the importance score of each customer demand to the importance score column. Both customer thoughts and the carrying value of customer demands in terms of the company are also taken into account during the calculation of the percent importance degree. The importance degree is affecting the coefficient of weighting factor and specific statistical results in matrix. Here, if the number has a lower importance degree it is less important; if the number has a higher importance degree this means it is highly important [12].

Importance customer is the consumer’s expectation of the product to be developed. Respondents were asked to rate the product with several attributes on a rating scale of 5. The attributes assessed included color of avocados, the size of avocados, ease of carrying, design of packaging, the form of packaging, completeness of information, material of packaging, and air circulation. The importance of each value is 4.438; 4.063; 4.5; 4.563; 4.688; 4.625; 4.375; and 4.375. From the value above, we can calculate the
improvement ratio. The highest improvement ratio is obtained in the design of packaging, completeness of information, the form of packaging, and the material of packaging.

Then, from the normalized raw weight value, it is decided that 6 attributes are fixed. To be able to make improvements, a technical requirement design must be created. Furthermore, making targets for technical requirements that can be done to achieve the target. The first attribute is the color of avocado. The design is sort based on the weight and form of the avocado. For the design of packaging, it is expected that it is similar to the color of avocado. In the form of packaging attributes, it is expected to create the packaging that is fit to the shape of the avocado with air circulation. The completeness of the information attribute will add information to the packaging such as net weight. In the material of packaging, you will use eco-friendly carton packaging.

QFD uses a set of interrelated matrix diagrams. The first matrix is the HoQ, which converts the customer needs into requirements that must be fulfilled throughout the supply chain. The starting point on the left of the house is the identification of basic customer needs. The next step is the definition of the priority levels customers assign to these needs. Customer ratings, shown on the right side of the house, enable benchmarking with competitor's products. The section just below the roof states the technical attributes used to meet customer needs. The relationship between the customer and technical attributes constitutes the main body of the HOQ, called the relationship matrix. The correlation matrix defines the relationships among technical attributes; as represented by the roof of the HOQ. The bottom of the house evaluates the competition in terms of technical requirements and target values are defined in this matrix [13].

The salespoint table contains the importance value of the customer and sales points per attribute which can be seen in Table 1. Salespoint aims to compare the actual values of management with the rival management and then determine target values in the light of this information [16].

| No. | Attributes             | Importance to Customer | Sales Point |
|-----|------------------------|------------------------|-------------|
| 1   | Color of Avocados      | 4.438                  | 1.5         |
| 2   | The Size of Avocados   | 4.063                  | 1.5         |
| 3   | Easy of Carrying       | 4.5                    | 1           |
| 4   | Design of Packaging    | 4.563                  | 1.5         |
| 5   | Form of Packaging      | 4.688                  | 1.5         |
| 6   | Completeness of Information | 4.625              | 1.5         |
| 7   | Material of Packaging  | 4.375                  | 1.5         |
| 8   | Air Circulation        | 4.375                  | 1.5         |

Table 1 shows that almost all attributes have a high sales point value of 1.5 except for portability. This shows that attributes such as color, size, packaging design, packaging materials, information, packaging form, and the presence of circulation holes need to be highlighted as a marketing focus for developing avocado packaging. The packaging developing priority is seen from the value of importance to the customer, starting from the form of packaging, information, and design. The targets from the house of quality are sorted to get the appropriate form of packaging, designing packaging that can
describe avocado, making packaging that fits the avocado, adding detailed information, using environmentally friendly materials, and completing packaging with air circulation.

Developing the new packaging was conducted based on the data analysis results of the QFD method and House of Quality. Attributes of whats and hows with strong relationships should be prioritized, followed by those with moderate and weak relations. Likewise, hows attributes with strong positive and positive relationships should also be prioritized. The graphic design of avocado packaging is made from cardboard packaging material containing 4 avocados and a circular label that is smaller than the package. Based on the responses of several respondents who have been determined to choose avocado with a new package, the price is IDR 30,000 to IDR 35,000. The packaging that is made must be able to protect the product from physical collisions but also partially open so that the product inside the package can be seen and attract consumers buying interest. The cardboard used is 3-layer cardboard with a divider per piece to reduce impact risk.

Figure 3. Alternative packaging design 1-3.

Three alternative packaging design concepts were created. The advantages of the first packaging design are that the fruit can be seen in shape, easy to carry, and has an attractive packaging design. There is a barrier so that the fruit does not collide, air circulation with an adjustable number and size of holes. The second packaging design has the advantages that can neatly arrange fruit, resistance to external impacts, minimal damage, easy filling, and a barrier between fruits. The third packaging design's advantages are more durable fruit and longer shelf life, does not require air circulation, does not rot easily, safe on imported fruit delivery trips. But the third design packaging costs are more expensive, more difficult to manufacture, and less practical.

The result of the selected concept is concept number one, due to an attractive concept design that is not available in Indonesia. Besides, this concept design also uses environmentally friendly packaging materials, which is the paper pulp that is shaped to match the avocado. This packaging is also completed by a respiration hole for the air exchange to maintain the freshness of the fruit. The design of the avocado fruit itself is carried to minimize collisions between fruits and attract the attention of consumers because it has a different design from avocado packaging in general.

4. Conclusions
Based on the results it can be concluded that the results of the questionnaire show that there were 8 attributes used to determine consumer preferences for avocado packaging. Respondents prioritized the importance of the attributes of packaging form and product detail information on avocado packaging with values of 4.688 and 4.625, respectively. The alternative packaging design concept chosen is the first packaging design concept. The use of packaging materials is environmentally friendly because it utilizes paper pulp. It has the shape of an avocado and a hole for air circulation to maintain the freshness of the fruit itself.
References

[1] Badan Pusat Statistik Indonesia 2019 Statistik tanaman buah-buahan dan sayuran tahunan 2018 (Statistics of annual fruit and vegetable plants indonesia 2018) (Jakarta: BPS-Statistik Indonesia) [In Indonesian]

[2] Sistim Informasi Manajemen Pembangunan di Perdesaan BAPPENAS 2000 Alpukat / Avokad (Persea americana Mill / Persea gratissima Gaerth) ed K Prihatman (Jakarta: Menegristek Bidang Pendayagunaan dan Pemasyarakatan Ilmu Pengetahuan dan Teknologi) pp 1-18 [In Indonesian]

[3] Chan L Wu M 2002 Quality function deployment: A literature review European Journal of Operational Research 143 3 463–497

[4] Taufiq F M 2019 Pembuatan dan pengujian kemasan buah alpukat menggunakan serbuk gergaji kayu (Making and testing packaging avocado fruit using wood sawdust). Undergraduate Theses, University of Langlangbuana Bandung [In Indonesian]

[5] Fauzia K, Lutfi M, Hawa L 2013 Penentuan tingkat kerusakan buah alpukat pada posisi pengangkutan dengan simulasi getaran yang berbeda (Determination of avocado fruit damage levels at the position of transportation with different vibration simulation) Jurnal Keteknikan Pertanian Tropis dan Biosistem 1 1 50-54. [In Indonesian]

[6] Muthmainnah N 2008 Mutu fisik sawo (achras zapota l.) dalam kemasan pada simulasi transportasi (The physical quality of sapodilla (Achras zapota l.) in the simulation transport packaging). Undergraduate Theses, Bogor Agricultural University [In Indonesian]

[7] Destiyan E 2010 Pengkajian kemasan karton untuk transportasi buah alpukat (Persea americana, Mills) Carton package’s research for simulation transportation of avocado (Persea americana, Mills). Undergraduate Theses, Bogor Agricultural University [In Indonesian]

[8] Kusniati D 2011 Kajian pengaruh tipe ventilasi dan suhu penyimpanan terhadap perubahan mutu buah alpukat (Persea americana, Mills) dan sebaran suhu dalam kemasan (Study of the effect of the type of ventilation and storage temperature on changes in quality of avocado (Persea americana, Mills) and temperature distribution in packaging). Undergraduate Theses, Bogor Agricultural University [In Indonesian]

[9] Alisa K, Iqbal M, Wulandari S 2015 Usulan perbaikan desain kemasan stick strawberry kencana mas menggunakan metode quality function deployment (The proposed improvement of packaging design for strawberry kencana mas stick using method quality function deployment) Jurnal Rekayasa Sistem dan Industri 2 1 52-59 [In Indonesian]

[10] Akao Y, Mazur G H 2003 The leading edge in QFD: past, present and future International Journal of Quality & Reliability Management 20 1 20-35

[11] Termini J 1997 Step by step QFD: customer-driven product design (Nottingham, NH: Responsible Management Inc.) 1-240

[12] Bottani E, Rizzi A 2006 Strategic management of logistics service: a fuzzy QFD approach International Journal of Production Economics 103 2 585-599

[13] Hauser J R, Clausing D 1988 The house of quality The Harvard Business Review 363-73

[14] Tan K C, Pawitra T A 2001 Integrating servqual and kana's model into QFD for service excellence development Managing Service Quality 11 6 418-430

[15] Paryani K, Masoudi A, Cudney E A 2010 QFD application in the hospitality industry; a hotel case study 17 1 7-29

[16] Yildiz M S, Baran Z 2011 Application of QFD on food and beverage management. XI.
Manufacturing Research Symposium, "The Evolving Role of Social Development and Production" Presentations Book, Istanbul Commerce University 23-24 June 2011