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Design of a Shallot Peeling Machine for EA Kitchen MSME Using Voice of Customer, Quality Function Deployment, and Anthropometric Analysis

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Abstract: Manual shallot peeling remains a time-consuming and labor-intensive activity in small-scale food-processing enterprises. Therefore, appropriate peeling equipment is needed to improve efficiency while remaining suitable for the operational conditions of micro, small, and medium enterprises (MSMEs). **Objective:** This study aimed to develop a user-oriented shallot peeling machine design that meets the operational, ergonomic, and economic requirements of EA Kitchen, a food-processing MSME located in Driyorejo, Gresik, Indonesia. **Methods:** This study employed a product design and development approach. Data were collected through field observations, interviews, questionnaires, and anthropometric measurements. User requirements were identified using the *Voice of Customer* (VoC) approach and translated into technical priorities through *Quality Function Deployment* (QFD) and the *House of Quality* (HoQ). Anthropometric analysis was used to determine the appropriate machine height, while preliminary cost analysis was conducted to estimate fabrication requirements. **Results:** The results showed that design was the highest-priority customer attribute, with a weight of 47.3%, followed by quality at 31.5% and safety at 21.0%. Large capacity was identified as the most important technical response at 31.49%, followed by ease of maintenance at 28.03%, ease of operation at 21.80%, and material selection at 18.69%. The proposed machine height was 83 cm, while the preliminary cost of the identified main components was IDR 900,000. **Implications:** The findings provide a practical basis for developing a shallot peeling machine that is more compatible with the production capacity, ergonomic requirements, operational simplicity, and financial limitations of small-scale food-processing enterprises. **Originality:** The originality of this study lies in the integration of VoC, QFD, anthropometric considerations, and cost evaluation into a single user-centered design framework specifically applied to the development of shallot-peeling equipment for MSMEs.

Keywords: shallot peeling machine; Voice of Customer; Quality Function Deployment; anthropometry; MSME

INTRODUCTION

Micro, small, and medium enterprises (MSMEs) in the food-processing sector play an important role in meeting consumer demand, generating employment, adding value to agricultural commodities, and supporting regional economic activities. Indonesia recorded approximately 4.85 million food and beverage service businesses in 2023, representing an increase of about 21.13% compared with the number recorded in 2016 (Badan Pusat, 2024).

This number increased to approximately 5.28 million businesses in 2024, indicating the continued expansion of food-related business activities in Indonesia (Badan Pusat, 2025). The growth of this sector creates opportunities for MSMEs, but it also intensifies competition and requires business owners to improve productivity, production consistency, and operational efficiency. Product development for small enterprises should therefore consider not only technical performance but also affordability, maintainability, and suitability for actual operating conditions (Ulrich & Eppinger, 2016). Manufacturing costs must also be considered from the initial design stage because material selection, component complexity, assembly processes, and production methods directly affect the economic feasibility of the resulting equipment (Boothroyd et al., 2011).

Despite the importance of production efficiency, many food-processing MSMEs continue to use manual methods for repetitive operations, including sorting, cutting, and peeling raw materials. This condition is also experienced by EA Kitchen, a food-processing MSME located in Driyorejo, Gresik Regency, Indonesia. EA Kitchen produces spring rolls and boxed meals and requires approximately 3–5 kg of shallots during each production cycle. The shallot skins are currently removed manually, resulting in relatively long processing times, repetitive hand movements, increased operator workload, and inconsistent peeling results. Mechanized peeling can reduce the dependence on manual labor and improve processing capacity when the operating mechanism is appropriately matched to the physical characteristics of the raw material. El-Ghobashy demonstrated that the configuration of the peeling chamber, rotating components, airflow, and water supply affected the performance of an onion-peeling machine (El-Ghobashy et al., 2012). Maghfurah subsequently developed an onion epidermis peeling machine based on a rubber-friction mechanism driven by an electric motor (Maghfurah et al., 2020). A similar mechanical approach was applied by Fadeyibi and Ajao, who evaluated a multi-tuber peeling machine using peeling efficiency, flesh loss, and processing capacity as its main performance indicators (Fadeyibi & Ajao, 2020). Ulum also showed that the design and manufacturing stages must be systematically integrated when developing onion-processing equipment for small-scale production (Ulum, 2023).

Previous research concerning the development of peeling machines has generally focused on mechanical components, operating principles, motor power, rotational speed, peeling efficiency, and processing capacity. Although these parameters are essential, an equipment design developed solely from an engineering perspective may not adequately represent the expectations and limitations of its intended users. The Voice of Customer (VoC) approach provides a systematic method for identifying user expectations before they are translated into measurable product specifications (Cohen, 1995). Customer involvement during product development can also reduce the risk of design mismatch and increase the likelihood that the resulting product will be accepted by its target users (Gustafsson et al., 1999). Quality Function Deployment (QFD) supports this process by translating customer requirements into technical responses through a structured House of Quality matrix. Widiasih and Murnawan used QFD to establish product-design concepts based on user priorities (Widiasih & Murnawan, 2016). Hakim similarly demonstrated that QFD could be applied to determine the prioritized attributes of a product developed for a small business (Hakim et al., 2022). These studies confirm that customer-oriented design can complement conventional engineering calculations during product development.

The application of QFD has continued to develop in various product and service-design contexts. Wahyuningsih integrated the Kano model with QFD to distinguish basic, performance, and attractive product attributes during electric motorcycle development (Wahyuningsih, 2023). Sabilah and Daonil applied QFD to connect user expectations with technical improvement priorities in a business environment (Sabilah & Daonil, 2023). More recent developments have also incorporated sustainability and multi-criteria evaluation into the QFD framework. Example, proposed a modified QFD approach that considered both customer expectations and environmentally conscious product characteristics. Shi used an entropy-based fuzzy QFD model to improve the transformation of customer requirements into prioritized technical characteristics (Shi, 2024). Nevertheless, limited research has applied an integrated VoC and QFD framework specifically to the design of a shallot-peeling machine for a micro-scale food enterprise. Existing peeling-machine studies mainly emphasize mechanical performance, whereas existing QFD studies are more frequently concerned with consumer products, service quality, or general product development.

Ergonomic considerations constitute another important aspect of equipment development because inappropriate machine dimensions may cause uncomfortable postures, unnecessary physical effort, and musculoskeletal strain. Anthropometric data enable designers to determine dimensions that correspond to the body characteristics of intended users rather than relying exclusively on arbitrary measurements (Pheasant & Haslegrave, 2006). Nugroho demonstrated that combining anthropometric measurements with QFD could improve the design suitability of industrial tools (Nugroho et al., 2019). Caesaron also applied ergonomic principles to redesign a manually operated tool in order to improve productivity and user comfort (Caesaron et al., 2024). In a small-business context, Leony integrated anthropometric data and QFD to develop an ergonomic workstation for a home-based service provider (Leony et al., 2025). Further showed that anthropometric adjustments could be applied to the design of processing machinery to improve its compatibility with operator dimensions. However, limited studies have simultaneously combined customer requirements, QFD priorities, anthropometric dimensions, mechanical design, and manufacturing-cost considerations in the development of shallot-peeling equipment for MSMEs.

Based on these gaps, this study aims to design and develop an appropriate-technology shallot-peeling machine that meets the operational requirements of EA Kitchen. The study identifies user needs through the VoC approach and translates them into prioritized engineering characteristics using QFD and the House of Quality. Anthropometric measurements are used to establish appropriate machine dimensions, while manufacturing-cost analysis is conducted to evaluate whether the proposed design is economically feasible for a micro-scale enterprise. Specifically, this study seeks to determine the priority customer attributes, formulate the corresponding technical responses, establish ergonomic machine dimensions, develop a peeling-machine design suitable for a 3–5 kg production requirement, and estimate the cost of manufacturing the proposed equipment.

This study argues that a shallot-peeling machine developed through the integration of VoC, QFD, anthropometric analysis, mechanical design, and cost evaluation will provide better operational suitability than equipment designed solely according to mechanical considerations. The VoC and QFD approaches are expected to produce measurable priorities regarding capacity, peeling uniformity, corrosion resistance, operational simplicity, safety, maintenance, and ease of cleaning. The incorporation of anthropometric data is expected to produce machine dimensions that support a safer and more comfortable working posture. Manufacturing-cost analysis is also expected to ensure that the design remains affordable and technically realistic for implementation by EA Kitchen. Accordingly, the proposed integrated design approach is expected to produce a shallot-peeling machine that is efficient, ergonomic, safe, hygienic, maintainable, and economically suitable for food-processing MSMEs.

RESEARCH METHOD

This study employed a product design and development approach to design a shallot peeling machine based on user requirements, ergonomic considerations, and economic feasibility. The research was conducted systematically through several stages, including literature review, identification of customer needs, product design, application of *Quality Function Deployment* (QFD), anthropometric analysis, and cost analysis. The overall research procedure is presented in Figure 1.

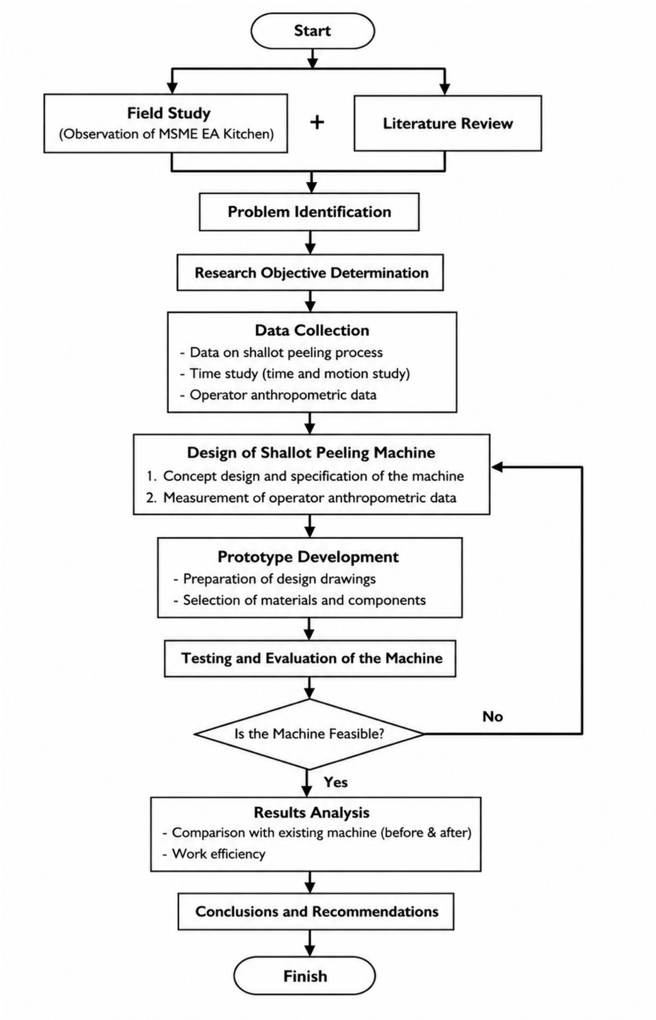

Figure 1. Research Flowchart

The research began with a literature review to establish the theoretical and methodological basis for the development of the shallot peeling machine. The literature review focused on product design, *Voice of Customer* (VoC), QFD, *House of Quality* (HoQ), anthropometry, and cost analysis. The results of this stage were used as guidelines for determining the research variables, data collection methods, and product design procedures.

Product Design

Product design was carried out as a structured process to transform user needs and design ideas into a technically feasible product. The design process focused on developing a shallot peeling machine that could support the operational requirements of the target MSME. The main design considerations included machine capacity, ease of operation, ease of maintenance, material selection, safety, ergonomic dimensions, and manufacturing cost. The proposed product specifications were determined by integrating customer requirements obtained through VoC analysis with the technical responses developed using the QFD method. Anthropometric data were subsequently used to determine appropriate machine dimensions, while cost analysis was conducted to estimate the financial requirements for machine fabrication.

Voice of Customer (VoC) Identification

The *Voice of Customer* (VoC) method was used to identify the needs, expectations, and preferences of the intended user. In QFD, VoC serves as the initial input for translating customer requirements (*WHATs*) into measurable technical characteristics (*HOWs*) through the HoQ matrix (Hakim et al., 2022). VoC data were collected using interviews, direct observation, and questionnaires.

Interviews were conducted to obtain detailed information regarding user requirements and problems encountered during the existing shallot peeling process. Direct observation was used to understand the actual production process and operating conditions, while questionnaires were used to confirm and quantify the importance of the identified requirements. The collected customer requirements were subsequently grouped into relevant product attributes, including design, quality, and safety. VoC analysis was intended to reduce the possibility of design errors, improve product suitability, and support the prioritization of user requirements. The results were then used as the primary input for the QFD analysis (Hakim et al., 2022; Sabilah & Daonil, 2023; Wahyuningsih, 2023).

Quality Function Deployment (QFD)

The QFD method was applied to systematically translate customer requirements into technical design responses. The analysis began with the identification of customer needs obtained from the VoC stage. These requirements were then converted into technical characteristics representing engineering responses to user expectations.

The QFD procedure consisted of several stages: identifying customer requirements, determining the importance level of each attribute, conducting product benchmarking, establishing target values, calculating improvement priorities, formulating technical responses, and developing the *House of Quality* matrix. The relationships between customer requirements and technical responses were classified into three levels: strong, medium, and weak, with respective numerical values of 9, 3, and 1.

The technical priority of each response was determined based on the weighted relationship between customer requirements and technical characteristics. The resulting priority values were used to identify the most important technical aspects to be considered in the final machine design. This approach was expected to improve design quality, increase development efficiency, and reduce the possibility of costly design changes (Widiasih & Murnawan, 2016).

Anthropometric Analysis

Anthropometric analysis was conducted to ensure that the dimensions of the shallot peeling machine were compatible with the physical characteristics of the user. The analysis focused on determining an appropriate machine working height to improve operator comfort and reduce physical fatigue during operation.

The main anthropometric parameter used was the user's standing elbow height. The machine height was determined by subtracting 5 cm from the standing elbow height to provide a comfortable working position. The design equation was expressed as follows:

$$H_m = H_e - 5$$

where:

H_m= machine height, and

H_e= user's standing elbow height.

The resulting anthropometric dimension was then used as one of the main references in determining the physical configuration of the proposed machine.

Cost Analysis

Cost analysis was conducted to estimate the total expenditure required to manufacture the proposed shallot peeling machine. The analysis included the identification and calculation of costs associated with raw materials, mechanical components, transmission components, fabrication processes, and other supporting components required for machine assembly.

The total fabrication cost was calculated by multiplying the quantity of each component by its respective unit price and subsequently summing all cost components. The general calculation can be expressed as:

$$C_T = \sum_{i=1}^{n} Q_i \, P_i$$

where:

C_T= total fabrication cost,

Q_i= quantity of component i,

P_i= unit price of component i, and

n= total number of cost components.

The cost analysis was used to determine the financial requirements for machine fabrication and to provide an initial assessment of the economic feasibility of implementing the machine in the MSME production process.

RESULT

Overview of the Research Object

This study was conducted at EA Kitchen, a micro, small, and medium enterprise (MSME) located in Driyorejo, Gresik, Indonesia. EA Kitchen is a small-scale food industry that produces various food products, including *risoles* and boxed meals. In its production process, shallots are one of the main raw materials used as filling ingredients and seasonings, with a consumption of approximately 3–5 kg per production cycle.

Before processing, the shallots undergo an initial sorting process to separate damaged or unsuitable materials. Manual shallot peeling requires a considerable amount of time and labor, particularly when production volume increases. Therefore, the implementation of a shallot peeling machine with a capacity of 5 kg is expected to accelerate the production process, improve operational efficiency, reduce manual workload, and provide more consistent peeling results.

Identification of the Voice of Customer

User needs were identified through interviews and questionnaire completion involving the owner of EA Kitchen. This stage aimed to collect information regarding user requirements, expectations, and preferences for the proposed shallot peeling machine. The results of the *Voice of Customer* (VoC) identification are presented in Table 1.

Table 1. Voice of Customer Questionnaire

No.	Question	Yes	No
1	Should the machine have a capacity that meets the user's production needs?	✓	
2	Should the machine be designed with proportional dimensions?		✓
3	Should the machine be easy to operate?	✓	
4	Should the machine produce uniform peeling results?	✓	
5	Should the machine be manufactured using corrosion-resistant materials?	✓	
6	Should the machine have an ergonomic design?	✓	
7	Should the machine be equipped with safety features during operation?	✓	
8	Should the machine components be easy to clean and maintain independently?	✓	

Based on the identified user needs, the next stage involved translating these requirements into product design attributes. The main attributes considered in this study were design, quality, and safety. The classification of user requirements into product attributes is presented in Table 2.

Table 2. Statements and Product Attributes

Statement	Attribute
Large capacity	Design
Proportional design	Design
Easy to operate	Design
Uniform peeling results	Quality
Corrosion-resistant material	Quality
Ergonomic	Safety
Operational safety features	Safety
Easy to clean and maintain	Design

The importance level of each formulated attribute was subsequently assessed using a five-point Likert scale. A score of 1 represented *not important*, 2 represented *less* *important*, 3 represented *moderately important*, 4 represented *important*, and 5 represented *very important*. The results of the attribute importance assessment are presented in Table 3.

Table 3. Importance Level of Product Attributes

Attribute	Importance Level
Quality	4
Design	3
Safety	4

The results indicate that quality and safety received the highest importance scores of 4, while design obtained a score of 3. The quality attribute is associated with the selection of corrosion-resistant materials and the ability of the machine to produce uniform peeling results. The design attribute is related to the physical configuration, capacity, ease of maintenance, and dimensional suitability of the machine. Meanwhile, the safety attribute is associated with ergonomic considerations and user safety during machine operation.

Quality Function Deployment (QFD)

The *Quality Function Deployment* (QFD) method was applied to translate user requirements into technical characteristics of the product. The QFD stages in this study included product evaluation and objective determination, formulation of technical responses, development of the interaction matrix between customer requirements and technical responses, analysis of relationships among technical responses, and construction of the *House of Quality* (HoQ).

Product evaluation was conducted through a benchmarking process by comparing the existing product with the proposed design. This evaluation aimed to determine which attributes should receive the highest priority based on the calculated *Improvement Ratio* (Caesaron et al.), *Relative Importance Index* (RII), weight, and percentage weight. The results of the product evaluation and objective determination are presented in Table 4.

Table 4. Product Evaluation and Objectives

Atribute	Benchmarking				Evaluation Score	Target Value	IR	RII	Weight	%Weight
	1	2	3	4						
Quality					2	3	1,5	4	6	31,5
Design					1	3	3	3	9	47,3
Safety					3	3	1	4	4	21,0
	←	Weak	Strong	→					19	100

Existing Product
Designing Product

Benchmarking note: the evaluation scale ranges from weak to strong. The comparison was conducted between the existing product and the proposed product design.

The evaluation results indicate that the design attribute had the highest priority weight of 47.3%, followed by quality at 31.5% and safety at 21.0%. Therefore, the design aspect became the primary consideration in the development of the shallot peeling machine. Nevertheless, quality and safety remained essential because they directly influence machine performance and operator safety.

The next stage involved formulating the technical responses. Technical responses represent the *voice of the developer* and constitute engineering solutions to address the user requirements previously identified through the VoC. The formulated technical responses are presented in Table 5.

Table 5. Attributes and Technical Responses

Attribute	Technical Response
Design	The product is designed with a large capacity and is easy to maintain
Quality	Selection of appropriate raw materials or construction materials
Safety	The product is easy to operate

After the technical responses were formulated, an interaction matrix was developed to determine the relationship between user requirement attributes and technical responses. The relationship levels were classified into three categories: strong, medium, and weak, with numerical values of 9, 3, and 1, respectively. The interaction matrix is presented in Table 6.

Table 6. Interaction Matrix between Attributes and Technical Responses

No	Attribute	Technical Responses: Material Selection	Large Capacity	Easy Maintenance	Easy Operation	Weight
1	Quality	● 54	▲ 6			6
2	Design		● 81	● 81	■ 27	9
3	Safety		▲ 4		● 36	4
Sum Score		54	91	81	63	289
Priority (%)		18.68512	31.48789	28.02768	21.79931	100

● : strong relationship (9)
■ : medium relationship (3)
▲ : weak relationship (1)

Based on the interaction matrix calculations, the technical response with the highest priority was large capacity, with a value of 31.49%, followed by ease of maintenance at 28.03%, ease of operation at 21.80%, and material selection at 18.69%. These results indicate that machine capacity is the most dominant technical characteristic in meeting user requirements.

The interaction results between customer requirements and technical responses were subsequently arranged into a *House of Quality* (HoQ) matrix, as shown in Figure 2.

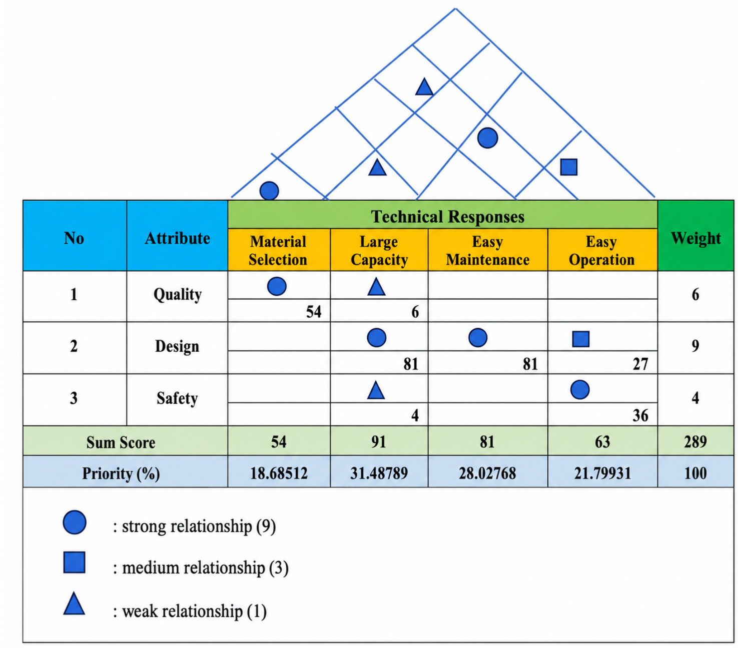

Figure 2. House of Quality (HoQ) Matrix

The HoQ matrix illustrates the relationships between user requirements and technical responses that serve as the basis for the development of the shallot peeling machine. The technical response related to large capacity has a strong relationship with the design attribute because the machine is intended to accommodate the relatively high volume of shallots required by EA Kitchen. In contrast, machine capacity does not have a dominant relationship with the quality attribute. The results of the HoQ analysis were subsequently used as the basis for determining the technical specifications and developing the conceptual design of the shallot peeling machine.

Anthropometric Data Analysis

Anthropometric principles were applied in the design of the shallot peeling machine to ensure that the machine dimensions were compatible with the physical characteristics of the user. This approach aimed to improve working comfort and reduce the risk of fatigue and musculoskeletal disorders during machine operation.

One of the anthropometric parameters used was the user's standing elbow height. The machine height was designed to be slightly lower than the user's elbow height to provide a more ergonomic working posture and reduce shoulder fatigue. The machine height was determined using the following equation:

$$H_m = H_e - 5$$

$$H_m = 88 - 5 = 83 \text{ cm}$$

where:

H_m= machine height
H_e= user's standing elbow height

Based on the calculation, the proposed machine height was determined to be 83 cm. This dimension is expected to provide a more ergonomic working posture for the operator during machine operation.

Cost Analysis

Cost analysis was conducted to determine the expenditure required for machine fabrication and to provide an initial basis for assessing its economic feasibility before production or implementation in the MSME production process. The identified cost components included the main construction material and components of the transmission system. The machine fabrication costs are presented in Table 7.

Table 7. Machine Fabrication Cost Components

Component	Quantity	Unit Price (IDR)	Total Cost (IDR)
Stainless Steel 304	5 kg	150,000	750,000
V-belt Pulley	1 unit	150,000	150,000

Based on the available cost components, the preliminary total cost for Stainless Steel 304 and the V-belt pulley was IDR 900,000. This value does not represent the total machine fabrication cost if additional components are required, such as the electric motor, shaft, bearings, V-belt, electrical components, machining processes, welding, and assembly costs. Therefore, the final cost analysis should be conducted after all machine components and manufacturing processes have been comprehensively identified.

DISCUSSION

The findings indicate that the development of the shallot peeling machine should consider not only mechanical performance but also user requirements, ergonomics, and economic feasibility. The VoC analysis identified quality, design, and safety as the main customer attributes. Although quality and safety received the highest importance scores, the QFD analysis showed that design had the highest priority weight of 47.3%, followed by quality at 31.5% and safety at 21.0%. This difference indicates that customer importance ratings should be combined with technical evaluation to determine appropriate product-development priorities.

The House of Quality analysis identified large capacity as the highest technical priority at 31.49%, followed by ease of maintenance at 28.03%, ease of operation at 21.80%, and material selection at 18.69%. The high priority of capacity reflects the operational requirement of EA Kitchen, which processes approximately 3–5 kg of shallots per production cycle. This finding is consistent with previous peeling-machine studies that considered processing capacity as an important performance indicator ((El-Ghobashy, 2012 #5;Fadeyibi, 2020 #7). However, this study differs by determining the technical priorities directly from user requirements through the integration of VoC and QFD.

Ease of maintenance and operation also emerged as important technical requirements. These characteristics are particularly relevant to MSMEs because complex maintenance and operating procedures may increase production interruptions and dependence on skilled technicians. Therefore, the proposed machine should be simple to operate, easy to clean, and maintainable by the user. This supports the principle that product development should consider actual operating conditions and user expectations rather than technical performance alone (Ulrich & Eppinger, 2016).

The anthropometric analysis resulted in a proposed machine height of 83 cm based on the operator's standing elbow height. This dimension is expected to provide a more comfortable working posture and reduce unnecessary physical strain. The result supports previous studies showing that anthropometric considerations can improve the ergonomic suitability of tools and processing equipment (Nugroho et al., 2019). Nevertheless, the proposed dimension is based on the current operator and should be further validated during prototype testing.

The preliminary cost of Stainless Steel 304 and the V-belt pulley was IDR 900,000. Although this value does not yet represent the total manufacturing cost, it demonstrates that economic considerations were incorporated from the early design stage. A complete cost analysis should include the motor, shaft, bearings, transmission components, electrical system, fabrication, and assembly costs.

Overall, the main contribution of this study lies in integrating VoC, QFD, anthropometric analysis, and cost evaluation in the design of a shallot peeling machine for a micro-scale food-processing enterprise. Future work should focus on prototype fabrication and performance testing, including peeling efficiency, processing capacity, shallot damage, operating time, ease of cleaning, and comparison with the existing manual peeling process.

CONCLUSION

This study developed a user-oriented design framework for a shallot peeling machine intended for EA Kitchen. The results showed that design was the highest-priority customer attribute, with a weight of 47.3%, while large capacity became the most important technical response at 31.49%, followed by ease of maintenance, ease of operation, and material selection. Anthropometric analysis produced a proposed machine height of 83 cm, while the preliminary cost of the identified main components was IDR 900,000.

The main scientific contribution of this study lies in the integration of Voice of Customer (VoC), Quality Function Deployment (QFD), anthropometric analysis, and cost evaluation within the development of appropriate technology for a micro-scale food-processing enterprise. This integrated approach provides a systematic basis for translating user needs into measurable technical priorities while considering ergonomic and economic aspects.

This study is limited by the use of data from a single MSME and by the absence of comprehensive prototype-performance testing. Future studies should therefore validate the proposed design through experimental testing, including peeling efficiency, processing capacity, product damage, energy consumption, operator comfort, maintenance requirements, and comparison with the existing manual peeling process.

REFERENCES

Badan Pusat, S. (2024). *Statistik Penyediaan Makanan Minuman 2023*. https://www.bps.go.id/

Badan Pusat, S. (2025). *Statistik Penyediaan Makanan Minuman 2024*. https://www.bps.go.id/id/publication/2025/12/31/e46a55af756331ede8016b91/statistik-penyediaan-makanan-minuman-2024.html

Boothroyd, G., Dewhurst, P., & Knight, W. A. (2011). *Product Design for Manufacture and Assembly* (3 ed.). CRC Press.

Caesaron, D., Ardani, F., Yudistira, Y., & Mufidah, I. (2024). Ergonomic Design of Shovel to Improve Productivity in Sorghum Silage Industry. *Industria: Jurnal Teknologi dan Manajemen Agroindustri*, *13*(2). https://industria.ub.ac.id/index.php/industri/article/view/5590

Cohen, L. (1995). *Quality Function Deployment: How to Make QFD Work for You*. Addison-Wesley.

El-Ghobashy, H., Bhansawi, A., Ali, S. A., Afify, M. T., & Emara, Z. (2012). Development and Evaluation of an Onion Peeling Machine. *Misr Journal of Agricultural Engineering*, *29*(2), 663-682. https://doi.org/10.21608/MJAE.2012.102323

Fadeyibi, A., & Ajao, O. F. (2020). Design and Performance Evaluation of a Multi-Tuber Peeling Machine. *AgriEngineering*, *2*(1), 55-71. https://doi.org/10.3390/agriengineering2010004

Gustafsson, A., Ekdahl, F., & Edvardsson, B. (1999). Customer Focused Service Development in Practice: A Case Study at Scandinavian Airlines System. *International Journal of Service Industry Management*, *10*(4), 344-358.

Hakim, A., Rahdiana, N., & Suhara, A. (2022). Perancangan Produk Softener Pakaian dengan Metode Quality Function Deployment pada UMKM Suci Laundry. *Buana Ilmu*, *7*(1), 96-105. https://doi.org/10.36805/bi.v7i1.3020

Leony, F., Halim, W., Suhada, K., & Tjahjadi, K. (2025). Design of an Ergonomic Ironing Station for Home-Based Laundry Service Providers Using an Anthropometric and Quality Function Deployment Approach. *Jurnal Rekayasa Sistem Industri*, *14*(1), 60-75. https://doi.org/10.26593/jrsi.v14i1.7912.60-75

Maghfurah, F., Effendi, R., & Aini, M. N. (2020). Design of Onion Epidermis Peeling and Onion Smoothing Machine with Rubber Friction Method Application. *Jurnal Polimesin*, *18*(1), 39-46. https://doi.org/10.30811/jpl.v18i1.1459

Nugroho, A. J., Kusumaningsih, E., Yuamita, F., & Pradana, A. Y. (2019). Redesign N Metal Casting Tools Using Anthropometry and QFD. *International Journal of Engineering Technology and Natural Sciences*, *1*(2), 16-23. https://doi.org/10.46923/ijets.v1i2.46

Pheasant, S., & Haslegrave, C. M. (2006). *Bodyspace: Anthropometry, Ergonomics and the Design of Work* (3 ed.). CRC Press.

Sabilah, A. I., & Daonil, D. (2023). Analisis Promosi Penjualan dan Kualitas Pelayanan di CV SAU dengan Metode Quality Function Deployment (QFD). *Blend Sains Jurnal Teknik*, *2*(1), 84-93. https://doi.org/10.56211/blendsains.v2i1.292

Shi, J. (2024). An Entropy-Based Fuzzy QFD Model on Used Product Remanufacturing Design. *Green Manufacturing Open*. https://www.oaepublish.com/articles/gmo.2023.103101

Ulrich, K. T., & Eppinger, S. D. (2016). *Product Design and Development* (6 ed.). McGraw-Hill Education.

Ulum, B. (2023). Design and Manufacturing Process of an Onion Peeling, Cutting, and Grinding Machine. *Jurnal Mesin dan Pembelajaran Mekanika*, *7*(1). https://doi.org/10.18196/JMPM.V7I1.18481

Wahyuningsih, U. (2023). Pengembangan Desain Produk Sepeda Motor Listrik Menggunakan Metode Pengintegrasian Kano Model dalam Quality Function Deployment (QFD). *KILAT*, *12*(1), 49-63. https://doi.org/10.33322/kilat.v12i1.1893

Widiasih, W., & Murnawan, H. (2016). Penyusunan Konsep untuk Perancangan Produk Pot Portable dengan Pendekatan Quality Function Deployment (QFD). Seminar Internasional dan Konferensi Nasional IDEC 2016, Surakarta.