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Integrating QFD and TRIZ for the Development of a Safe and Sustainable Lunch Box Design

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ABSTRACT

This study addresses the critical need to design a safe and functional food storage solution by re-engineering a lunch box product based on consumer requirements. The research problem centers on the prevalent use of harmful materials like BPA and lead in existing products, which poses health risks to users. Our methodology combines Quality Function Deployment (QFD) and the Theory of Inventive Problem Solving (TRIZ) to tackle this issue. QFD was used to transform detailed customer needs, identified through a Voice of Customer (VOC) survey, into specific technical specifications. The resulting House of Quality (HoQ) revealed two primary contradictions: one between ensuring food-grade material safety and offering a product warranty, and another between using high-quality, safe materials and maintaining an affordable price. To resolve these conflicts, TRIZ principles, specifically Cheap Short-Living Objects and Composite Materials, were applied. This approach led to a product design that is not only robust and practical, with features such as high-density seals and segregated compartments, but also scientifically sound in its use of safe materials. The findings demonstrate a successful integration of market needs and creative problem-solving to develop a product that is both commercially viable and fundamentally safer for consumers.

Keywords: *QFD, TRIZ, Lunch Box, Product Design, Consumer Needs*

A. INTRODUCTION

In line with the rapid evolution of modern society, human activities are increasingly carried out outside the home. This shift toward a dynamic lifestyle, where spending time away from home has become commonplace, has driven individuals to seek practical solutions to daily needs, particularly in terms of food consumption. Carrying home-prepared meals in lunch boxes has become a growing trend among adults since around 2015, stimulated by lifestyle changes and the demand for efficient and portable solutions. This phenomenon has opened a highly competitive market characterized by diverse product designs and continuous innovation.

Reports such as *Business Lunch of the Future? Adult Lunchbox Category Report 2020* highlight that since the spring of 2015, the use of lunch boxes among working adults has steadily increased prior to the disruptions caused by the pandemic, suggesting that this habit has become embedded in modern global lifestyles [1]. Similarly, market surveys by Verified Market Reports indicate consistent growth in demand over the past decade, driven by busier routines and growing awareness of healthy eating, particularly among professionals and working adults [2]. The lunch box market continues to evolve through innovations in design, materials, and functionality, aligning with consumer awareness of food safety and environmental sustainability [3,4].

Despite these advances, a fundamental issue remains: material safety. Many plastic-based lunch box products are still manufactured using hazardous substances such as Polyvinyl Chloride (PVC), lead, and Bisphenol A (BPA). Scientific evidence shows that these materials can pose severe health risks, including endocrine disruption, reproductive complications, and neurotoxicity [5]. These concerns have intensified the urgency for innovation in eco-friendly alternatives, such as biodegradable plastics and natural composites, which offer safer and more sustainable solutions without compromising aesthetics or functionality [6]. Furthermore, modern consumers increasingly demand products that not only ensure material safety but also deliver multifunctionality, user convenience, and attractive design. Research has shown that user-centered design approaches enhance consumer satisfaction while improving the competitiveness of lunch box products in the market [7].

Previous studies on lunch box development have often focused on material substitution and isolated design improvements but have not fully addressed the integration of consumer needs into systematic product design processes while resolving inherent technical contradictions. This research gap highlights the necessity for methods that can simultaneously capture consumer expectations, translate them into technical specifications, and resolve conflicts between safety, cost, and functionality. To address this challenge, the present study employs Quality Function Deployment (QFD) to systematically translate consumer needs into measurable technical attributes and applies the Theory of Inventive Problem Solving (TRIZ) to overcome technical contradictions with logical and creative solutions. Through this holistic approach, the study aims to develop a lunch box design that is not only efficient and practical but also fundamentally safer for consumer health and environmentally sustainable.

B. LITERATURE

Research on lunch box product design over the past five years has demonstrated a significant trend in the application of Quality Function Deployment (QFD) and the Theory of Inventive Problem Solving (TRIZ) to enhance product safety, functionality, and sustainability [7]. QFD has been widely employed to translate consumer needs and preferences into measurable technical parameters, thereby ensuring that products are designed in alignment with market demands [8]. Meanwhile, TRIZ has been applied to resolve technical contradictions that typically arise during the design process, such as balancing the use of safe, food-grade materials with the requirement for cost-effective production [11,12]. Several studies confirm that integrating these two methods produces lunch box designs that are more innovative, safe, and environmentally friendly, while simultaneously improving efficiency in both production and distribution processes [13]. The central focus of these studies lies in demonstrating how QFD and TRIZ can be used complementarily to address the demands of the modern market, which prioritizes products that are practical, aesthetically appealing, and free from harmful chemicals.

Beyond functional aspects, the literature also emphasizes the importance of material safety and sustainable innovation in lunch box design. A number of studies highlight the substitution of hazardous plastics, such as BPA, with eco-friendly alternatives through the structured application of QFD and TRIZ [14]. These material innovations are often combined with considerations of product aesthetics, such as color durability and visual appeal, which have been identified as key factors in enhancing consumer satisfaction [15]. By integrating these two methods, the development of lunch box products extends beyond their basic role as food containers to encompass dimensions of safety, efficiency, aesthetics, and sustainability. This body of work underscores that QFD and TRIZ are not merely technical tools, but strategic frameworks that can guide product design toward more comprehensive innovations that are aligned with market needs while supporting public health and environmental sustainability objectives.

The conceptual framework of this study is grounded in the integration of Quality Function Deployment (QFD) and the Theory of Inventive Problem Solving (TRIZ) to address consumer needs in the design of safe and sustainable lunch boxes. Consumer expectations, identified through the *Voice of Customer* (VOC), include functionality, practicality, safety, aesthetics, and environmental sustainability. QFD translates these consumer requirements into measurable technical specifications through the development of the House of Quality (HoQ), which provides structured insights into product attributes and design priorities. However, the translation of consumer needs often reveals technical contradictions, such as balancing the use of food-grade and eco-friendly materials with the pressure to maintain affordable production costs.

To resolve these contradictions, TRIZ is employed as a complementary method. By applying inventive principles and systematic problem-solving strategies, TRIZ enables the identification of innovative solutions that overcome design conflicts without compromising product performance. The integration of QFD and TRIZ thus provides a comprehensive framework that links consumer needs, technical specifications, and innovative solutions. This framework ultimately guides the development of lunch box designs that are not only functional and aesthetically appealing, but also fundamentally safer for consumer health and more environmentally sustainable.

Figure 1. Research's Conceptual Framework

C. RESEARCH METHOD

This study applies a combination of qualitative and quantitative approaches, involving 45 respondents who are users of lunch boxes as the research subjects, while the object of the study is the development of a lunch box product design.

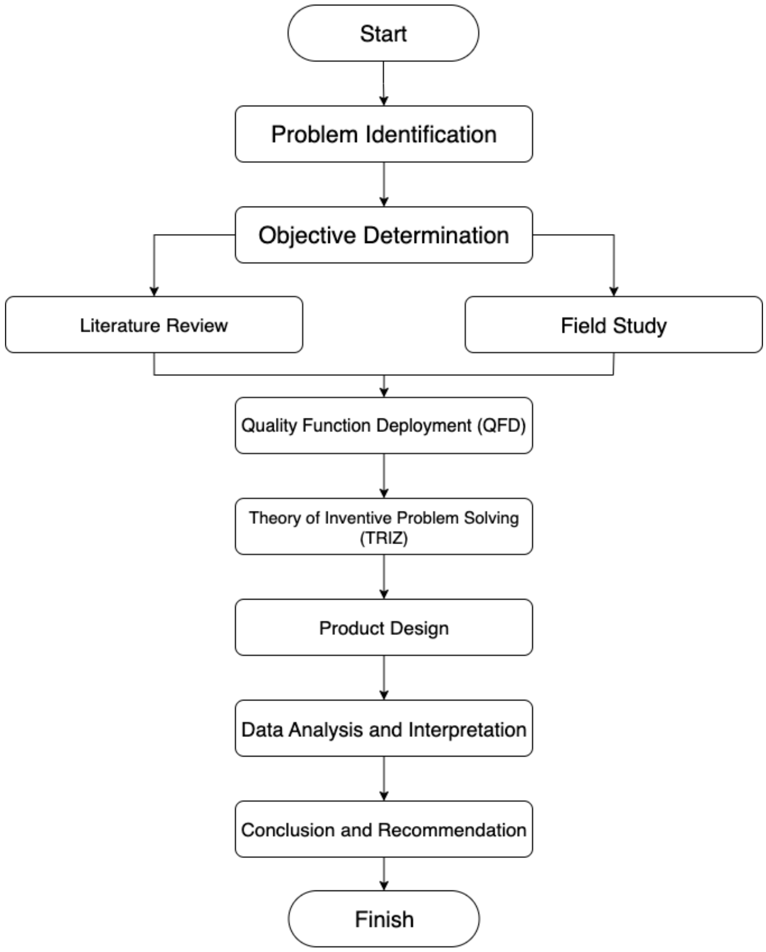

Figure 2. Research Workflow Diagram

The research begins with problem identification and objective formulation, followed by a literature review and field study. The literature review focuses on collecting references related to product design, lunch boxes, Quality Function Deployment (QFD), and Theory of Inventive Problem Solving (TRIZ). Meanwhile, the field study is conducted through the distribution of questionnaires to capture the Voice of Customer (VOC) and product benchmarking. The data obtained are then processed using the QFD method through the construction of the House of Quality (HoQ), which generates product attributes, technical responses, interaction matrices, priorities, and target specifications.

Based on the results of the HoQ, contradictions are identified and addressed through the TRIZ method. The process begins with defining specific problems derived from the technical responses in the HoQ, which are then translated into general technical contradictions and further developed into physical contradictions. These contradictions are resolved by employing general solutions derived from separation principles and the 40 inventive principles, followed by determining the most suitable specific solutions. The solutions obtained from TRIZ then serve as the basis for product design, which is further refined through data analysis and interpretation. The final stage of the research concludes with the formulation of conclusions and recommendations to ensure that the designed lunch box product is not only functional and efficient but also safe and aligned with consumer needs.

D. RESULT AND DISCUSSION

D.1. Result

Data processing in this study was carried out using the Quality Function Deployment (QFD) method, with a particular focus on the construction of the House of Quality (HoQ). This matrix serves as a tool to enhance the potential and usability of the product in alignment with customer needs. Based on the distribution of the customer satisfaction questionnaire regarding lunch box usage, a benchmark product was identified from the Tupperware brand. The findings from the Voice of Customer (VoC) survey revealed 13 attribute categories, which represented an integration of the subjective assessments of both the researcher and respondents. A summary of the questionnaire results is presented in Table 1.

Table 1. Recapitulation of Questionnaire Results

No	Attributes	Importance Rating	Satisfaction Rating
1	Lid Tightness	4.76	4.73
2	Attractive Design	3.93	4.01
3	Practicality	4.60	4.51
4	Eating Utensils	4.11	4.12
5	Partition	4.18	4.30
6	Air Circulation Regulator	4.11	4.20
7	Eco-friendly Material	4.53	4.53
8	Temperature Retention	4.62	4.53
9	Durable Material	4.62	4.60
10	Safe Material	4.84	4.81
11	Product Warranty	4.16	4.12
12	Affordable Price	4.07	4.37
13	Ideal Size	4.30	4.40

From the VOC data, a planning matrix was developed to record the level of importance assigned to each product need or benefit. The components of this planning matrix include benchmarking, sales points, improvement ratios, new weights (raw weights), and recommended actions for the product.

Table 2. Planning Matrix

No	*Customer Requirements*	Competitor Evaluation from Consumers					*Goals*	*Sales Point*	*Improvement Ratio*	Row Weight	Action
		1	2	3	4	5					
1	Lid Tightness					▲●	4,5	◉	3,06	3,67	A
2	Attractive Design				●▲		4,8	◉	1,22	1,47	B
3	Practicality					▲●	3,7	◉	0,80	0,97	A
4	Eating Utensils					▲●	4,2	○	1,02	1,02	C
5	Partition				●	▲	4,5	○	1,08	1,08	B
6	Air Circulation Regulator					●▲	4	◉	0,97	1,17	C
7	Eco-friendly Material					▲●	3,8	○	0,84	0,84	C
8	Temperature Retention					▲●	4	◉	0,87	1,04	B
9	Durable Material					●▲	4,7	◉	1,02	1,22	A
10	Safe Material					▲●	4,4	◉	0,98	1,18	B
11	Product Warranty					▲●	3,5	◉	0,84	1,01	B
12	Affordable Price					▲●	3,5	○	0,80	0,80	C
13	Ideal Size				●	▲	4	○	0,91	0,91	C

The next stage involved determining the technical responses, which constitute the technical specifications required to meet each attribute. These technical responses are expressed as consumer-driven solutions, consisting of specific metrics and their corresponding values.

Table 3. Technical Requirements

Metric #	Need #s	Metric	Units
1	1,8	Lid tightness	Cm
2	3,4	Addition of spoon and fork	Cm
3	2,5	Partitioning	Cm
4	3,7,9,10	Food grade symbol	Binary
5	6	Ventilator	Cm
6	11	Product size	Cm
7	12	Unit price	Rupiah
8	13	Product warranty	Year
9	2.3	Addition of bag	Cm

The identified product metrics reflect consumer needs and expectations for a practical, safe, and high-quality lunch box design. Lid tightness is essential to prevent food or liquid leakage, especially for meals with sauces or oils, while the addition of spoon and fork addresses consumer demand for convenience by integrating eating utensils into the product. Partitioning ensures different types of food remain separated, preserving both appearance and taste, and the presence of a food grade symbol provides assurance that the material is safe for food use. A ventilator supports air circulation and reduces pressure build-up when storing hot meals, whereas product size needs to balance compactness for portability with sufficient capacity for larger portions. The unit price strongly influences purchasing decisions, as consumers seek affordable products without compromising quality, and the inclusion of a product warranty enhances trust by guaranteeing durability and reliability. Finally, the addition of a bag improves practicality, comfort, and aesthetics, offering consumers a more complete and user-friendly solution.

Within the correlation matrix, which forms part of the HoQ, relationships are established between customer-desired attributes ("What's") and the technical responses to be implemented ("How's"). This matrix is instrumental in identifying conflicts or contradictions that need to be addressed. In this study, nine technical characteristics were identified. The HoQ matrix, illustrated in the figure below, highlights the presence of technical contradictions, represented by the symbol (x).

Figure 3. Contradictions Resolved Using TRIZ

In the roof of the House of Quality, the symbols represent the correlation between different technical requirements. A circle (○) generally indicates a positive correlation, meaning that improving one requirement will also improve the other. For example, an increase in lid tightness may positively influence food-grade compliance or product durability. On the other hand, a cross (×) shows a negative correlation, suggesting that improving one requirement may negatively affect the other. For instance, enhancing ventilation might reduce lid tightness, since adding air circulation features could compromise sealing strength.

These correlations are important because they help designers anticipate potential trade-offs or synergies in the product development process. By analyzing the roof matrix, the design team can prioritize features that provide mutual benefits, while carefully addressing areas where technical contradictions exist. Such contradictions can later be resolved using the TRIZ method, which offers inventive principles to overcome conflicts without sacrificing overall product performance.

Following analysis of the matrix, two major contradictions were identified that required resolution through the TRIZ method. The first contradiction occurs between the food-grade symbol and product warranty, where improvements in material safety features (food-grade) may conflict with extended product warranty provisions. The second contradiction arises between the food-grade symbol and product affordability, as the use of high-quality and safe materials tends to increase production costs, which in turn conflicts with the goal of maintaining a competitive product price.

D.2. Discussion

The contradictions identified in the House of Quality (HoQ) matrix illustrate the inherent challenges in balancing consumer expectations with technical feasibility and cost considerations. The first contradiction, between the food-grade symbol and product warranty, reflects the tension between prioritizing material safety and ensuring long-term durability. Food-grade materials, while essential for consumer health, do not always provide the robustness required to justify extended warranty coverage. TRIZ was applied to resolve this issue by combining inventive principles. Principle #27 (*Cheap Short-Living Objects*) offers a practical solution by designing a product with a predetermined lifespan, supported by a warranty period of up to one year to ensure quality assurance and consumer confidence. Complementing this, Principle #40 (*Composite Materials*) suggests the use of material composites that combine different substances to achieve improved properties. This approach allows the product to meet food safety standards while maintaining sufficient durability to justify warranty provisions.

The second contradiction, between the food-grade symbol and affordable pricing, represents a classic trade-off between safety and cost efficiency. High-quality, food-safe materials often increase production expenses, which conflicts with the need for competitive pricing. To address this, TRIZ inventive principles were again applied. Principle #27 (*Cheap Short-Living Objects*) helps to maintain affordability by balancing material choices with intended product lifespan, while Principle #3 (*Local Quality*) proposes modifying the product structure from uniform to non-uniform. In this case, the design integrates partitions tailored for different types of food carbohydrates, proteins, vegetables, and fruits enhancing functional value without substantially increasing overall production costs. These principles collectively provide a pathway to designing products that remain safe, functional, and competitively priced.

Based on the integration of QFD and TRIZ, the final product design was developed with detailed technical specifications. These include lid tightness supported by a locking clip, the addition of a spoon and fork, partitions for different food categories, and a 3.5 cm ventilator for air circulation control. The lunch box is designed with an optimal size ($13 \times 4.5 \times 22$ cm^3) and constructed using durable, food-grade materials. Furthermore, it includes a warranty covering replacement and repair for up to one year, ensuring both product reliability and consumer trust. The prototype illustration of this design demonstrates the practical realization of solutions derived from the systematic integration of QFD and TRIZ. This outcome underscores the strength of combining consumer-driven specifications with structured problem-solving methodologies to create products that are safe, sustainable, functional, and market-competitive.

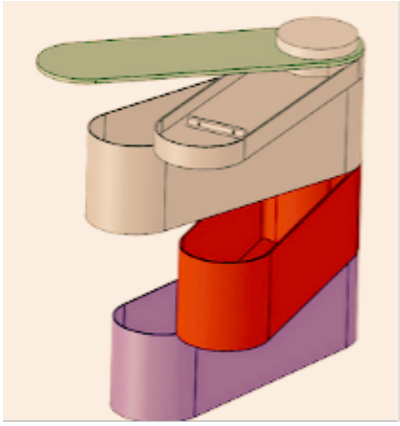

Figure 4. Product illustration, diagonal view

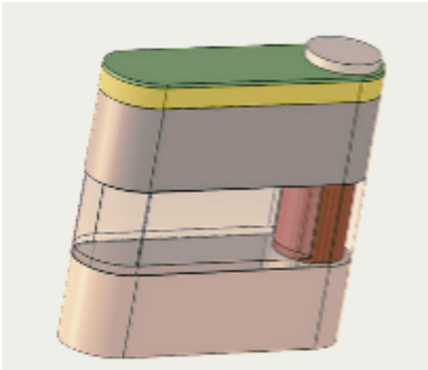

Figure 5. Product illustration, side view

E. CONCLUSION

Based on the research conducted, it can be concluded that the design of the lunch box product successfully achieved the research objectives and addressed the identified problems. The Quality Function Deployment (QFD) method proved effective in identifying and translating consumer needs such as lid tightness, safe materials, and affordability into detailed technical specifications. Furthermore, the Theory of Inventive Problem Solving (TRIZ) provided innovative solutions to the two main contradictions revealed in the HoQ matrix, namely the trade-off between material safety and warranty, and between material quality and product price. By applying TRIZ principles such as *Cheap Short-Living Objects*, *Composite Materials*, and *Local Quality*, the resulting product prototype not only met user expectations but also fundamentally resolved technical challenges, producing a design that is efficient, functional, and safe for consumer health.

The findings of this study carry several practical implications for both consumers and the food container industry. For consumers, the proposed lunch box design demonstrates how safety, functionality, and affordability can be achieved simultaneously without sacrificing product quality. The incorporation of food-grade materials and partitioned compartments not only ensures health protection but also enhances convenience and usability in everyday contexts. For industry stakeholders, this research illustrates the value of systematically integrating QFD and TRIZ in the product development process. The use of QFD ensures that consumer needs are accurately translated into technical requirements, while TRIZ offers structured pathways to resolve design contradictions that typically hinder innovation.

Manufacturers can adopt this dual-method approach to create competitive products that meet evolving market demands for health, sustainability, and practicality. Moreover, the methodological framework established in this study can be replicated and adapted for the development of other consumer products facing similar challenges in material safety, cost efficiency, and user-centered design.

Despite the success in designing an innovative lunch box product, several implications and opportunities remain for future research. A key limitation of this study is the lack of direct testing of the proposed prototype. Therefore, subsequent studies should focus on product testing to optimize its alignment with user needs and to validate the effectiveness of the solutions generated through TRIZ. In addition, the literature review could be expanded not only through academic references but also by incorporating direct observations of industry practices or product developers to gain deeper insights into real-world design processes. Such future work would provide more substantial contributions to the development of similar products and to the industry as a whole.

Bibliography

[1] R. Brown, “Business lunch of the future? Adult lunchbox category report 2020 | Category Report | The Grocer.” Accessed: Sep. 06, 2025. [Online]. Available: https://www.thegrocer.co.uk/category-reports/business-lunch-of-the-future-adult-lunchbox-category-report-2020/646011.article

[2] Verified Market Reports, “Lunch Box Market Size, Demand, Research & Forecast 2033.” Accessed: Sep. 06, 2025. [Online]. Available: https://www.verifiedmarketreports.com/product/lunch-box-market/

[3] Markwide Research Report, “Lunch Box market Analysis- Industry Size, Share, Research Report, Insights, Covid-19 Impact, Statistics, Trends, Growth and Forecast 2025-2034 2025-2034 | Size,Share, Growth,” Markwide Research Report. Accessed: Sep. 06, 2025. [Online]. Available: https://markwideresearch.com/lunch-box-market/

[4] C. Caner, M. Yüceer, and B. Harte, “Trends in Sustainability and Innovative Food Packaging Materials: An Overview,” *Akademik Gida*, pp. SI65–SI77, 2024, doi: 10.24323/AKADEMIK-GIDA.1554476.

[5] O. I. Triswindyaningrum, S. Sulistiyani, and Y. H. Darundiati, “SYSTEMATIC REVIEW: IMPACT OF BISPHENOL-A (BPA) EXPOSURE ON HUMAN HEALTH,” Jan. 31, 2025, *Airlangga University Faculty of Public Health*. doi: 10.20473/jkl.v17i1.2025.85-98.

[6] M. Thangamuniyandi, T. Prabhu, S. Shenbagavalli, N. R. Kennady, and R. V. Sundarrajan, “Plastics in Food Packaging: Trends, Innovations and Environmental Impact,” *Annu Res Rev Biol*, vol. 40, no. 6, pp. 60–71, Jun. 2025, doi: 10.9734/ARRB/2025/V40I62254.

[7] J. Kramer, S. Noronha, and J. Vergo, “A User-Centered Design Approach To Personalization,” *Commun ACM*, vol. 43, no. 8, pp. 44–48, Aug. 2000, doi: 10.1145/345124.345139.

[8] K. Dhalmahapatra, A. Verma, and J. Maiti, "An integrated TRIZ coupled safety function deployment and capital budgeting methodology for occupational safety improvement: A case of manufacturing industry," *Process Safety and Environmental Protection*, vol. 165, pp. 31–45, Sep. 2022, doi: 10.1016/J.PSEP.2022.06.067.

[9] J. Prasetiyo, F. Debora, M. Pupung, and A. Widodo, "Perbaikan Desain Kemasan Makanan Ringan Menggunakan Metode Quality Function Deployment (QFD)," *Jurnal Optimalisasi*, vol. 8, no. 1, pp. 96–105, Apr. 2022, doi: 10.35308/JOPT.V8I1.5334.

[10] S. Zetli, E. Paskaria Loyda Tarigan, and N. Fajrah, "Perancangan Desain Kemasan Keripik dengan Menggunakan Metode Quality Function Deployment (QFD)," vol. 11, no. 1, pp. 19–28, 2024.

[11] D. A. Susanti, S. Ma'arif, E. Nurhayati, D. Zulmarihana, and A. R. Dharu, "Perancangan Desain Kemasan Gudeg Jogja dengan Menggunakan Metode Quality Function Deployment (QFD)," *Jurnal Engine: Energi, Manufaktur, dan Material*, vol. 6, no. 2, pp. 64–69, Jan. 2022, doi: 10.30588/JEEMM.V6I2.1359.

[12] B. Anwar, A. Romadin, F. Anwar, I. Indra Putra, and J. Pendidikan Teknik Mesin, "Usulan Desain Kemasan Songkok Recca Menggunakan Metode Kano," *Integrasi: Jurnal Ilmiah Teknik Industri* , vol. 10, no. 1, pp. 55–64, Apr. 2025, doi: 10.32502/INTEGRASI.V10I1.497.

[13] A. A. Mubarok and R. M. Sasongko, "MENERJEMAHAN VOICES OF THE CUSTOMER (VoC) KEDALAM INOVASI PRODUK MELALUI QUALITY FUNCTION DEPLOYMENT (QFD) PADA UMKM KULINER," *Journal of Economic, Business and Engineering (JEBE)*, vol. 4, no. 2, 2023.

[14] F. Yuamita *et al.*, "PERANCANGAN KEMASAN PRODUK DENGAN METODE QUALITY FUNCTION DEPLOYMENT (QFD) & BUSINESS MODEL CANVAS (BMC) PADA UMKM 'PM' PUTRA MANDIRI," *Jurnal Kajian Ilmiah Interdisiplinier*, vol. 9, no. 1, pp. 2118–7303, 2025.

[15] A. A. Niha, G. Sidik, C. Wahyuni, and N. Khuriyati, "Redesain Kemasan Produk Wedang Uwuh Menggunakan Metode Creative Brief dan Quality Function Deployment (QFD) Packaging Redesign Wedang Uwuh Products Using Creative Brief and Quality Function Deployment (QFD)," *TEKNOTAN*, vol. 18, no. 2, doi: 10.24198/jt.vol18n2.2.