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Designing a Simple QR Code-Based Digital Traceability System for Halal Product Transparency

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Abstract

The halal product industry in Indonesia continues to grow rapidly, but consumers still face limitations in independently verifying a product's halal status solely from packaging labels. This study aims to design a simple QR Code-based digital traceability system to transparently convey halal product information and evaluate the system's acceptance based on consumer perceptions. The study used a sequential, exploratory, mixed-methods approach, with a case study of the Wafello Chocolate Gellato Style wafer product (PT Mayora Indah Tbk). The system was designed in three stages: product information content development, QR Code creation using a QR Code generator, and system finalization. Testing was conducted with 30 respondents using a questionnaire based on the Technology Acceptance Model (TAM) theory, expanded with trust and perceived risk dimensions. The results showed that the system was very well received, with an average positive dimension score of 4.24 on a scale of 5.00. Perceived benefits and perceived system needs received the highest scores (4.36 each), followed by ease of use (4.30), trust (4.15), and intention to use (4.03). However, respondents expressed serious concerns about the risk perception related to potential data manipulation and reliance on an internet connection (mean = 4.17). This study concluded that a QR code-based digital traceability system is technically feasible, low-cost, and relevant for halal product consumers. Further development is recommended, including real-time integration with the BPJPH/BPOM database, the addition of digital encryption, and the exploration of blockchain technology to enhance system security and reliability.

Keywords: *Digital traceability, QR code, halal products, information transparency, TAM, UMKM.*

1. Introduction

This The halal product industry in Indonesia has grown into one of the most dynamic economic sectors over the past decade. According to the 2023 State of the Global Islamic Economy (SGIE) report, Indonesia ranks third in the world as the country with the largest consumption of halal products, with a market value reaching over US$184 billion [7]. This figure reflects the significant demand among Indonesians for halal assurance of products, ranging from food and beverages, cosmetics, pharmaceuticals, to household products.

Behind these large figures, there is a fundamental problem that has not been optimally resolved: how can consumers truly verify a product's halal status independently, quickly, and reliably? Halal certification issued by the Halal Product Assurance Agency (BPJPH) is indeed the primary instrument in the national halal assurance system, but the label printed on product packaging is often insufficient to provide a comprehensive overview of the production process, raw materials, supply chain, and certification validity period [5].

Advances in digital technology have opened up vast opportunities for the development of innovative solutions in the areas of food safety and product transparency. One technology that is relatively easy to implement yet has a significant impact is the Quick Response Code, or QR Code. This technology allows for the storage and transmission of much larger amounts of data than conventional barcodes, while also being easily accessible using a smartphone camera without the need for special devices [6]. This ease of access makes the QR Code an excellent candidate for integration into a halal product traceability system.
The application of QR codes in food and halal product traceability systems has begun to be explored by several researchers and industry players. However, most existing implementations are partial, expensive, and require complex technological infrastructure, making them difficult for UMKM to access. There is limited research specifically designing a simple, affordable, and directly effective halal traceability system that can be tested through the perceptions of end users, namely consumers.

This research gap is the starting point for this research. Most existing studies focus on the technical aspects of platform development or halal regulatory policy analysis, but very few directly connect system design with consumer perception-based testing within a single

research framework. After all, a technological system, no matter how sophisticated, will have no real impact if it is not accepted and used by its target users.

Based on the above background, this study formulates two main questions: (1) How can a simple QR code-based digital traceability system be designed that can transparently convey halal product information to consumers? (2) What is the level of acceptance and ease of use of this system based on consumer perceptions, particularly in terms of ease of use, trust, perceived benefits, and intention to use?

The specific objectives of this research are: (1) to design a prototype QR Code-based digital traceability system that contains complete and easily accessible halal product information; (2) to evaluate the effectiveness and acceptability of the system through questionnaire based testing with general respondents.

2. Literature Review

2.1. The Concept of Digital Traceability in the Halal Product Supply Chain

Traceability in the supply chain is defined as the ability to track the movement of a product through all stages of production, processing, and distribution, from upstream to downstream [10]. In the context of halal products, this definition is expanded to include the ability to verify that each stage of the supply chain meets Islamic sharia requirements, from raw material sourcing and production, packaging, storage, and distribution to consumers.

The concept of digital traceability emerged as an evolution of manual traceability, which previously relied on physical documents and paper-based records. By utilizing digital technology, all traceability information can be stored, updated, and accessed in real time through various platforms. A study conducted by [9] showed that adopting digital traceability for food products can reduce food safety incident investigation time by up to 80% compared to manual systems, while significantly increasing consumer trust.

In the halal ecosystem, traceability challenges become more complex because they involve spiritual aspects that are not only technical but also ethical and religious. [10] state that an effective halal traceability system must be able to guarantee product integrity end-to-end, not just at the final stage or on the packaging label. This means the system needs to record and store data from every critical point in the supply chain that could potentially impact a product's halal status.

In Indonesia, the regulatory framework for halal product traceability is strengthening with the implementation of Law Number 33 of 2014 concerning Halal Product Assurance (JPH) and its derivatives. Government Regulation Number 39 of 2021 requires all products entering, circulating, and traded within Indonesia to be halal certified in stages. However, monitoring and verification mechanisms that are directly accessible to consumers still require further development [8].

2.2. QR Code as a Medium for Delivering Product Information

QR codes were first developed by the Japanese company Denso Wave in 1994 and, over the past two decades, have become one of the most widely used product identification technologies globally. Unlike one-dimensional barcodes, which can only store around 20 numeric characters, two dimensional QR codes can accommodate up to 7,089 numeric characters or 4,296 alphanumeric characters in a single code (ISO/IEC 18004:2015). This significantly larger storage capacity allows QR codes to store URL links, descriptive text, and even encrypted data that can be redirected to dynamic web pages containing complete product information [2].

From a usability perspective, QR codes have several advantages that make them a primary choice for consumer information applications. First, scanning can be performed on almost any modern smartphone without the need to download additional applications, given that most current operating systems already have built-in QR code reader capabilities [11]. Second, the scanning process is very fast, usually taking less than a second, so it doesn't disrupt the consumer's shopping experience. Third, QR codes are very low-cost; they can be printed on packaging without the need for special ink or materials [1]. These advantages position QR codes as an accessible, affordable, and actionable technology for all business segments.

Several empirical studies have confirmed the effectiveness of QR codes in the context of food and health product information. Research by [13] found that the use of QR codes on food product packaging significantly increased consumer trust, with the greatest effect among the 25-40 age group, active smartphone users.

2.3. Information Transparency as a Factor of Consumer Trust

Transparency in the supply chain context can be defined as a company's willingness and ability to disclose relevant and material information to stakeholders, particularly end consumers [12]. This concept is rooted in agency theory and asymmetric information theory, which state that information imbalances between sellers and buyers tend to create distrust and reduce market efficiency. In the context of halal products, transparency has a deeper meaning because it touches on the beliefs and religious values of Muslim consumers.

Research conducted by [4] identified four dimensions of transparency that directly influence Muslim consumers' trust in halal products: (1) transparency of raw material information, (2) transparency of the production process, (3) transparency of certification and testing, and (4) transparency of distribution and handling. These four dimensions interact with each other and collectively shape a comprehensive

perception of halalness in the minds of consumers. Interestingly, the study found that the certification transparency dimension had the highest influence on trust, followed by raw material transparency.

From a consumer psychology perspective, trust in halal products is a multidimensional construct encompassing cognitive trust (based on knowledge and facts), affective trust (based on feelings and emotions), and behavioral trust (reflected in purchasing decisions). An effective digital traceability system needs to be designed to balance these three dimensions of trust by presenting accurate factual data, communicating it in an empathetic and easy-to-understand manner, and encouraging concrete action in the form of more confident purchasing decisions

3. Research Method

3.1. Research Approach

This research employed a mixed-methods approach that combined two main strategies. First, a prototype-based system development approach was used to design and build a digital QR Code traceability system as the object to be tested. Second, a descriptive quantitative approach was used to analyze questionnaire data reflecting consumer perceptions and acceptance of the developed system. The research design was exploratory sequential, where the system was built first, followed by user perception testing using.

3.2. Data Sources and Product Samples

This study uses one wafer product as a case study sample, namely Wafello Chocolate Gellato Style produced by PT Mayora Indah Tbk. The selection of this product is based on the availability of complete and officially verified product information, not on the basis of relationships with producers. Product information used as content in the QR Code system includes: (1) product name; (2) producer name; (3) ingredient composition (wheat flour, sugar, vegetable oil containing the antioxidant TBHQ, vegetable creamer, cocoa powder, cocoa mass, soy lecithin emulsifier, salt, ammonium/sodium bicarbonate leavening agent, and synthetic flavor); (4) MUI halal certification number: ID00410000045791119; (5) BPOM registration number: MD 273139002300079; and (6) expiration date: October 2026.

It should be emphasized that this product sampling was conducted independently by the researchers as ordinary consumers and was not an official collaboration with the manufacturer. This approach aligns with the spirit of consumer research, which examines the accessibility of product information from the end-user perspective.

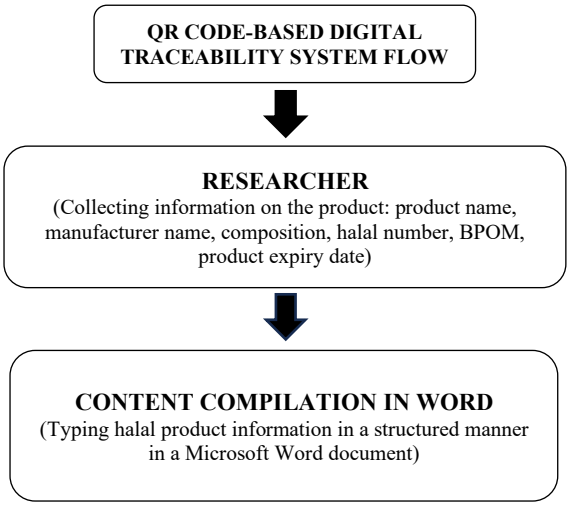
3.3. QR Code System Design

The digital traceability system designed in this research is a structured text-based system encoded directly into QR codes, allowing product information to be read directly by scanners without requiring external links. The system design process consists of three main stages:

The first stage is the preparation of product information content. At this stage, all relevant halal information is collected, verified, and compiled into written form using a word processing application (Microsoft Word). The compiled information includes the product name, manufacturer name, ingredient composition, halal certification number, BPOM registration number, and expiration date. This text is designed to be concise, clear, and easy to read when displayed through QR code scanning.

The second stage is QR code creation. The product information text compiled in a Word document is then copied and entered into a QR code generator. The text is encoded directly into a QR code without using a URL link, so that when scanned, the product information is displayed directly as text on the smartphone screen. The resulting QR code is then tested on several smartphone devices to ensure all information is read correctly and completely.

The third stage is finalizing and presenting the QR Code. The successfully tested QR Code is then saved in image format and inserted into a Word document as part of the product information label. At this stage, attention is paid to the size and legibility of the QR Code to ensure it remains scannable, as well as the neatness of the overall appearance of the document as a simple representation of the product label equipped with a digital traceability system.



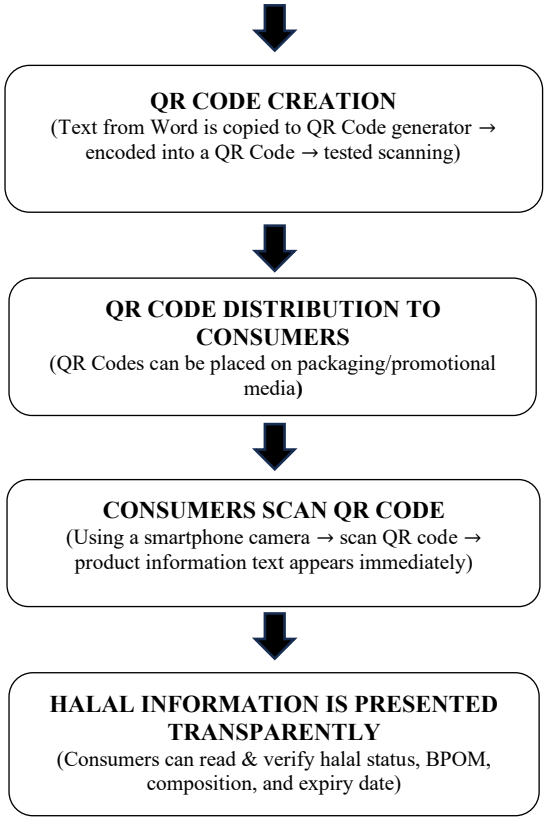


Figure 1: QR Code-Based Digital Traceability System Flow

3.4. Research Instruments

The data collection instrument used in this study was a structured questionnaire developed based on the TAM theory (Davis, 1989) which was expanded with the dimensions of trust and risk perception. The questionnaire consisted of six measurement dimensions, namely: (A) Perceived System Needs, (B) Ease of Use (Usability), (C) Trust, (D) Behavioral Intention, (E) Perceived Benefit, and (F) Perceived Risk. Each dimension was measured with several statements using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

3.5. Respondents and Sampling Techniques

Respondents in this study were members of the general public without specific selection criteria regarding educational background, occupation, age, or religious affiliation. The sampling technique used was convenience sampling, where questionnaires were distributed online via the Google Forms platform to respondents who agreed to participate. Although there were no strict demographic restrictions, all respondents were assumed to have access to a smartphone capable of scanning QR codes, as this capability is a minimum requirement for operating the tested system. A total of 30 respondents were collected.

The choice of convenience sampling was based on the consideration that the purpose of this study was more exploratory and descriptive, namely to obtain an initial picture of system acceptance, rather than to produce broad statistical generalizations. The results of this study are expected to serve as a basis for further research using more representative samples and more rigorous sampling techniques.

4. Results and Discussion

4.1. QR Code System Design Results

The digital traceability system successfully designed in this research is a QR Code-based system that stores product information text directly within the code, without requiring a URL link or external web page. The design process produces a QR Code that can be scanned using a regular smartphone camera without requiring additional applications or an internet connection. When scanned, the QR Code displays product information text directly on the device screen, containing the following information in a structured and easy-to-read format:

Table 1. Product Information Contained in the QR Code System

Information Component	Information Details
Product name	Wafello Chocolate Gellato Style
Manufacturer	PT Mayora Indah Tbk

Material Composition	Wheat flour, sugar, vegetable oil (antioxidant TBHQ), vegetable creamer, cocoa powder, cocoa mass, emulsifier (soy lecithin), salt, raising agent (ammonium/sodium bicarbonate), synthetic flavor.
MUI Halal Number	ID00410000045791119
BPOM Registration Number	MD 273139002300079
Expiration Date	October 2026

The MUI halal certification number and BPOM registration number are crucial components of this system. Both numbers are unique and officially verified by government agencies, allowing consumers to cross-check their information through the official BPJPH website (halal.go.id) and the BPOM website (cekbpom.pom.go.id). This independent verification capability is at the heart of the transparency concept this system seeks to achieve.
QR codes have an error correction level of M (medium), which allows the code to remain scannable even if a small area is physically damaged. Product information appears on the smartphone screen within seconds of scanning, making this system highly practical and usable anywhere.

4.2. Respondent Characteristics

Of the 30 questionnaires distributed, all were returned completely completed, resulting in a 100% response rate. Respondents consisted of active consumers who were accustomed to purchasing halal labeled products. Based on their age profile, most respondents were in the 18–25 age range, belonging to the millennial and Gen Z generations, who are typically active smartphone users. The majority of respondents stated they were familiar with the use of QR Codes, particularly in the context of digital payment applications and restaurant menus. This demonstrates the high penetration of QR Codes among Indonesians, which is an important prerequisite for the adoption of the system designed in this study

4.3. Results Per Item and Per Section of the Questionnaire

The following presents the complete analysis results for each statement item based on real data from 30 respondents. The mean value is calculated by converting the percentage of responses to a Likert score (STS=1, TS=2, KS=3, S=4, SS=5).

Table 2: Analysis Results per Questionnaire Statement Item (N=30)

Code	Statement	STS%	TS%	KS%	S%	SS%	Mean
	SECTION A – Perception of System Needs						
A1	I need clear information about the halal status of the product before purchasing.	0	0	0	23,3	76,7	4,77
A2	Halal information on product packaging is currently still less transparent.	3,3	0	26,7	53,3	16,7	3,80
A3	I feel it is important to know the raw materials of the products I consume.	0	0	0	46,7	53,3	4,53
A4	Digital systems can help increase transparency of halal products.	0	0	0	66,7	33,3	4,33
	Average Section A						***4,36***
	SECTION B – Ease of Use (Usability)						
B1	I find it easy to use QR Codes to access product information.	3,3	0	3,3	46,7	46,7	4,33
B2	I am used to using my smartphone to scan QR Codes.	0	0	3,3	40,0	56,7	4,53
B3	Accessing information via QR Code is more practical than reading regular labels.	0	0	23,3	50,0	26,7	4,03
	Average Section B						***4,30***
	SECTION C – Trust						
C1	I have more confidence in products that provide halal information digitally.	0	0	26,7	53,3	20,0	3,93
C2	Information from the QR Code system increases my confidence in the halal nature of the product.	0	0	10,0	66,7	23,3	4,13
C3	Transparency of information can reduce doubts about the product.	0	0	3,3	53,3	43,3	4,40
	Average Section C						***4,15***
	SECTION D – Behavioral Intention						
D1	I am interested in using QR Code to check halal product information.	0	0	3,3	73,3	23,3	4,20
D2	I would use this system if it was available on the product I purchased.	0	0	6,7	76,7	16,7	4,10
D3	I prefer products that have a QR Code feature over those that don't.	0	3,3	26,7	56,7	13,3	3,80
	Averge Section D						***4,03***
	SECTION E – Perceived Benefits						
E1	This system helps me make better purchasing decisions.	0	0	3,3	76,7	20,0	4,17
E2	This system increases the sense of security in consuming the product.	0	0	3,3	63,3	33,3	4,30
E3	Complete information makes me more confident about the product.	0	0	0	40,0	60,0	4,60
E4	This system provides added value for halal products.	0	0	6,7	50,0	43,3	4,37
	Average Section E						***4,36***
	SECTION F – Risk Perception						

F1	I am concerned that the information in the QR Code can be manipulated.	0	3,3	16,7	50,0	30,0	4,07
F2	I feel that the use of this system depends on the internet connection.	0	3,3	10,0	43,3	43,3	4,26
	Average Section F						***4,17***

Source: Primary data from questionnaires processed by researchers (2026)

4.4. Discussion by Dimension

4.4.1. Section A – Perception of System Needs (Mean = 4,36)

Section A received the highest average score along with Section E, namely 4.36 (very high category). Item A1 "I need clear information regarding the halal status of a product before purchasing" achieved the highest score in the entire instrument (mean = 4.77), with 76.7% of respondents answering Strongly Agree and 23.3% answering Agree. Not a single respondent stated Disagree or Strongly Disagree. This finding empirically confirms that consumer demand for transparent halal information is at a very high level.

Item A3 regarding the importance of knowing the raw materials also received a high score (4.53), with 53.3% of respondents strongly agreeing and 46.7% agreeing, indicating that consumers are not satisfied with just a halal label; they want to know what is actually in the products they consume. Item A2 received the lowest score in this section (3.80), with 26.7% of respondents stating they somewhat disagree that halal information on current packaging is still insufficiently transparent. This indicates a difference in perception among respondents: some feel that current packaging is already sufficiently informative, while the majority still consider it insufficient. Despite this difference, Section A as a whole still shows that respondents view a digital traceability system as necessary and relevant.

4.4.2. Section B – (Mean = 4,30)

The average score for Section B of 4.30 (very high) indicates that the designed system successfully overcomes one of the main barriers to technology adoption: usability. Item B2 regarding the habit of using a smartphone to scan QR codes received the highest score in this section (4.53), confirming that respondents already possess basic literacy in using QR codes. Item B3 received the lowest score (4.03), with 23.3% of respondents stating they "Disagree" that access via QR codes is more practical than standard labels. This is an important note: although the majority consider QR codes more practical, there is still a segment that feels the conventional method is sufficient or even easier. A more intuitive and visual design of the information page could be a solution to increase acceptance among this segment.

4.4.3 Section C – Trust (Mean = 4,15)

Section C yielded an average score of 4.15, which remains in the high category. Item C3, "Transparency of information can reduce doubts about a product," received the highest score (4.40), with 96.6% of respondents (agree + strongly agree) acknowledging that, in principle, transparency of information is indeed effective in reducing doubts. Item C2 indicates that 90% of respondents (66.7% agree + 23.3% strongly agree) stated that information from the QR Code system increases their confidence in the halal status of the product. This is a critical finding the direct effect of the system on trust is proven to be positive for 9 out of 10 respondents.

Item C1 received the lowest score in this section (3.93), with 26.7% of respondents stating they "Disagree." This suggests that not all consumers automatically associate the presence of digital halal information with a higher level of trust. There may be moderating factors, such as perceptions of system security or prior experience with digital technology, that influence this response, which aligns with the findings in Section F regarding risk perception.

4.4.4 Section D – Behavioral Intention (Mean = 4,03)

Section D received the lowest average score among all positive dimensions (4.03), though it still falls within the high category. The highest interest was observed in item D2, which measures conditional usage intention ("if available on the product I purchase"), where 93.4% of respondents agreed or strongly agreed. This indicates that the barrier to usage intention does not lie in a reluctance to use the system, but rather in the system's availability on the products they purchase. This means that the responsibility for adoption lies more with manufacturers to implement the system, rather than with consumers.

Item D3 received the lowest score (3.80), with 26.7% of respondents stating they "Disagree" and 3.3% stating they "Strongly Disagree" that they prefer products with a QR Code over those without. This finding is realistic; consumer preferences in actual purchases are influenced by many factors, including price, brand, and product availability, so the presence of a QR Code alone is not necessarily a deciding factor. However, if the presence of a QR Code is accompanied by competitive pricing and good product quality, it has the potential to be a significant differentiator.

4.4.5 Section E – Perceived Benefits (Mean = 4,36)

Along with Section A, Section E received the highest average score (4.36). Item E3, "Complete information makes me more confident in the product," received the second-highest score in the entire instrument (4.60), with 60% of respondents answering "Strongly Agree" and 40% answering "Agree." Not a single respondent expressed any hesitation, disagreement, or strong disagreement. This is a very strong confirmation that the completeness of product information directly has a positive impact on consumer confidence the strongest argument for promoting the implementation of a traceability system.

Item E4 regarding the added value of the system for halal products scored 4.37, with 93.3% of respondents agreeing or strongly agreeing. This finding has important business implications: from the consumer's perspective, the QR Code system is not merely a technical feature, but a tangible added value that distinguishes a product from its competitors. Manufacturers who adopt this system have the potential to build a meaningful competitive advantage in the halal product market.

4.4.6 Section F – Risk Perception (Mean = 4,17)

It should be noted that Section F measures risk perception, where a high score actually indicates a high level of concern or acknowledgment of risk, unlike other sections where a high score signifies a positive perception. With an average of 4.17, these findings reveal that the

majority of respondents acknowledge the presence of risks in this system; 80% agreed or strongly agreed that information within the QR Code could potentially be manipulated (F1 = 4.07), and 86.6% acknowledged that the system relies on an internet connection (F2 = 4.26).

These high risk perception scores represent the most critical finding in this study. Although the system received positive responses in other dimensions, consumers remain aware of the system's potential vulnerabilities. This awareness must be addressed through the development of more transparent and verifiable data security mechanisms, such as direct integration with the BPJPH database or the addition of cryptographic authentication layers. At the same time, reliance on the internet must also be addressed by developing features that can function partially in offline conditions.

4.5. Summary and Overall Analysis

Table 3: Summary of Average Scores by Dimension (N=30)

Section	Dimension	Mean	Category
A	Perceived System Need	4,36	Very High
B	Usability	4,30	Very High
C	Trust)	4,15	High
D	Behavioral Intention	4,03	Tinggi
E	Perceived Benefit	4,36	Very High
F	Perceived Risk *)	4,17	High (need attention)
	Rata-rata dimensi positif (A–E)	**4,24**	**Very High**

For Section F, a high score reflects a high level of risk awareness, not a positive perception.

Source: Primary questionnaire data processed by the researcher (2026)

The average score for the positive dimensions (A through E) of 4.24 indicates that the system as a whole was very well received by respondents. The dimensions with the highest scores were perceived need for the system and perceived benefits (both 4.36), which together confirm that consumers not only feel a need for this type of system but also experience tangible benefits after using it directly. This is the most ideal combination in technology acceptance testing.

What is interesting to note is the scoring pattern among the TAM dimensions. The higher score for ease of use (4.30) compared to trust (4.15) and usage interest (4.03) suggests that technical barriers have been successfully minimized by the system design, yet consumer trust still requires further effort. This suggests that in the context of halal products, trust is a more challenging variable to build compared to ease of use, as it relates to dimensions of belief that are more personal and layered.

4.6. Advantages and Limitations of the System

Based on the design process and test results, the QR Code-based digital traceability system developed has several notable advantages. First, this system can be implemented at very minimal cost because it does not require specialized technological infrastructure, expensive servers, or additional applications for users. Second, it is highly scalable because QR Codes can be easily generated for each different product. Third, the system is compatible with almost all modern smartphones without requiring special configuration. Fourth, the information presented is verifiable, meaning its accuracy can be confirmed through official government sources.

On the other hand, this system has several limitations that must be honestly acknowledged as part of responsible scientific analysis. First, the system in its current form is static, meaning that the information stored in the QR code cannot be updated in real time without creating a new QR code. This differs from blockchain-based systems, which are dynamic and can record every change in the supply chain. Second, this system is unable to track the supply chain comprehensively; rather, it only conveys information that has been curated by the producer or researcher. Third, there is no authentication mechanism to prevent malicious parties from creating fake QR codes that mimic this system. Fourth, the text capacity that can be stored in a single QR Code is limited, so very long or complex information needs to be summarized to remain readable with high accuracy.

These limitations do not mean the system is useless; rather, they open the door for further development. The addition of digital encryption features, real-time integration with the BPJPH database, and development into a blockchain-based system are natural steps that can be taken in the next development iteration.

5. Conclusions and Recommendations

5.1. Conclusions

This study successfully designed and tested a simple QR code-based digital traceability system to transparently convey halal product information to consumers. The case study used was the Wafello Chocolate Gellato Style wafer product (PT Mayora Indah), where key product information including ingredient composition, MUI halal certification number, BPOM registration number, and expiration date was successfully encapsulated in a single QR Code that can be easily scanned using a smartphone.

First, the designed system proved to be technically feasible and implementable at low cost using open-source technology. The system successfully integrated three functional layers: manufacturer data input, QR code processing and generation, and a responsive, fast loading consumer information interface.

Second, the system was very well received by respondents, with an average score of 4.24 on a 5.00-point scale for the positive dimensions. The dimensions of perceived benefits and perceived need for the system received the highest scores (4.36 each), confirming that the system is relevant and provides tangible benefits to consumers. A total of 96.7% of respondents acknowledged needing clear halal information before purchasing (item A1, mean = 4.77), and 100% of respondents on item E3 stated that the completeness of information increased their confidence (mean = 4.60).

Third, although overall acceptance of the system is very positive, perceptions of risk particularly concerns about data manipulation (F1) and reliance on the internet (F2) need to be seriously addressed in future system development. High scores on these risk dimensions do not mean that respondents reject the system, but rather indicate that they are critical users who are aware of the technology's potential vulnerabilities.

5.2. Recommendations

Based on the findings and limitations of this study, several recommendations are proposed for future research and development. First, future research should evolve the system from a static format into a dynamic system integrated in real-time with the BPJPH and BPOM databases, so that updates to certification status are immediately reflected in the information presented to consumers. Second, security mechanisms such as digital encryption or digital signatures should be added to prevent the creation of fake QR codes that could mislead consumers. Third, future research is advised to use a larger and more representative sample with probabilistic sampling techniques, as well as involve respondents from diverse demographic and geographic backgrounds to enhance the generalizability of the findings. Fourth, exploring the integration of this system with blockchain or distributed ledger technology (DLT) is highly recommended as a long term development step to enhance the reliability and tamper-proof nature of halal supply chain data. Fifth, the government, through the BPJPH, is advised to consider developing national standards for a digital traceability system for halal products that can serve as a reference for all industry stakeholders.

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