Journal of Research Administration
Society of Research Administrators International

IDENTIFICATION OF HALAL CRITICAL POINT FOOD USING FORWARD CHAINING: A CASE STUDY OF OXTAIL SOUP

Adhi Kusnadi[a*], Yaman Khaeruzzaman[a], Oqke Prawira [a], Marlinda Vasty Overbeek [a], Fenina Fenina Adline Twince Tobing [a], Syarief Gerald Prasetya[b], Alexander Moya Hin[a]

[a] Universitas Multimedia Nusantara, Gading Serpong, Tangerang 15111, Indonesia

[b] Universitas Binaniaga, Bantarjati, Bogor 16153, Indonesia

* corresponding author

ABSTRACT

Halal tourism holds significant economic potential. The MUI has issued a fatwa regarding the fundamental guidelines for implementing halal tourism, which includes regulations for providing halal food and drinks. This guideline is crucial because identifying halal visually is challenging. This work aims to develop a halal critical point (HCP) recognition system utilizing a forward chaining algorithm using food products from SJH LPPOM MUI. This system's development adheres to the stages of the System Development Life Cycle (SDLC). The testing has demonstrated the successful development of the HCP identification system for food ingredients by SJH LPPOM MUI utilizing the forward chaining algorithm. ***The system utilizes black box testing and the comparison testing technique to provide output results by comparing the HCP manual. The comparison results were uniform. This suggests that the operational system has been working efficiently. User satisfaction testing was carried out using the end-user computing satisfaction method, yielding an average satisfaction score of 86.53%.***

Background

Halal tourism is a developing tourism trend with economic potential (Jaelani 2017). In 2019, the halal tourism sector was estimated to be worth 239 billion US dollars, that is, 13% of the total global spending (Muhamad et al. 2019). If Indonesia can utilize this potential, it will certainly serve as one of the drivers behind the country's economic recovery from the coronavirus disease pandemic. Nevertheless, of the 15.8 million tourists in Indonesia, only 22% are Muslim. When compared with Singapore, Malaysia, Thailand, and United Arab Emirates, Indonesia is below them (Siregar 2018). Halal tourism development needs the support of all stakeholders, including universities that will conduct research related to halal. Tourism operators can use research findings from universities and government rules on halal tourism to bridge the gap between higher education and the workforce in the fourth industrial revolution. The investigation is being carried out at Grand Zuri Hotel BSD in Tangerang, Banten Province. The study centers on Banten province because it is recognized as one of the halal tourism zones in Indonesia (V. Paramarta, R. R. V. K. Dewi, F. Rahmanita, S. Hidayati 2021).

The Indonesian Ulema Council (MUI) has issued fatwa number 108/DSN-MUI/X/2016 outlining the key principles of halal tourism. The fatwa prohibits haram activities, requires halal certification for food and beverages, and mandates the availability of worship facilities (Adinugraha et al. 2021). Among the three principles, ensuring the availability of halal food and meeting the

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minimum requirements is a challenging aspect because of the complexity in visually identifying halal products. Additionally, non-Muslim countries still produce halal food ingredients. In Indonesia, there is a consistent disparity between the supply and demand of beef, with national beef production meeting only 45% of the demand. Imports, mainly from Australia (Agus and Widi 2018), cover this deficit, which may create concerns regarding their halal status (Maman, Mahbubi, and Jie 2018).. Another issue is the extensive blending of halal food components with non-halal components (Ramli 2018). Furthermore, fake halal certificates are increasing, many of which are not registered with the MUI (Ridwan 2020). The solution to these problems is to know the travel history of the halal food ingredients used. This travel history is compiled based on the halal critical point (HCP) on the food or drinks consumed. HCP is a point where it is prone to contamination of halal products exposed to non-halal materials (Raheem and Demirci 2018). Identification of food HCPs is important because it forms the basis of a traceability system. The traceability system enhances traceability, ensuring supply assurance, safety, and food quality, and identifies items with imperceptible quality features (Golan et al. 2004). One of the Indonesian specialties that can be offered to world Muslim tourists is oxtail soup (Amelia 2022). This food menu has a high probability of becoming haram because of the ingredients, process, storage, distribution, equipment, and display factors that accompany it.

The oxtail soup is seasoned with shallots, garlic, and Indonesian spices, such as pepper, nutmeg, and cloves. It is made from seasoned pieces of the beef tail then grilled or fried and put in a slightly clear beef broth with sliced potatoes, carrots, tomatoes, scallions, celery, and a sprinkling of fried onions. Identification of the HCP oxtail soup menu is the main factor in identifying the possibility of contaminants that are in contact with something unlawful (Sucipto et al. 2021). The product is evaluated based on its adherence to the HAS 23000 (Mardiyah et al. 2021) rule established by the Halal Assurance System of the Institute for the Assessment of Food, Drugs, and Cosmetics, the Indonesian Ulema Council (SJH LPPOM MUI), in accordance with Islamic law. The product or meal must be free of haram elements, such as pork (Nafis 2019), and must meet halal requirements for other aspects.

Research to identify HCP has been done before. In the study, (Yuniarti et al. 2021) identified HCP for drug manufacture, (Bracewell, Francis, and Smales 2015) identified HCP in chicken slaughter, and other studies for the identification of HCP (Razaly et al. 2018)(Faridah et al. 2022)(SULAIMAN, MAZLAN, and JELANI 2021)(Perdani and Chasanah 2018). Several studies use the Failure Mode Effect Analysis (FMEA) method. Research conducted by Kohivalani et al. identified the HCP in the house Slaughter of Animals (RPH) under Islamic Sharia. Identification is undertaken using the approach Hazard Analysis Critical Control Points decisions (Kohivalani, Yang, T.A., Febrianto, N.A., Abdullah, W.N.W.,&Aris 2012). Hidayati conducted a critical activity study on the food menu in the canteen of Brawijaya University library. The assessment was performed by identifying the grouped materials based on the processing method. From the results of the identification of critical points, there remained ingredients that have not been certified halal (Hidayati 2019). Afterward, Sucipto's research was conducted. This study utilized seven criteria from HAS-23102 to assess the menus, ingredients, production, and servicing at the UB

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canteen. Traceability of Hazard Analysis and Critical Control Points (HACCP) was conducted on 60 menus provided by four food vendors and one beverage vendor (Sucipto et al. 2022). However, these studies are still performed manually and have not used the system; thus, the process takes a long time, and there is the possibility of human identification errors. The development of a system and the application of artificial intelligence technology are the research's innovative solutions to the problem at hand.

An expert system as part of artificial intelligence can be used to solve various kinds of problems. An artificial intelligence component called an expert system can be utilized to solve a variety of issues (Kusnadi et al. 2023a). An expert system is a computer program that simulates and applies expert knowledge in a given field to reasoning in order to solve issues or offer guidance (Elsharif and Abu-Naser 2019). An in-depth understanding of an issue is possessed by a human expert (Lebovitz, Levina, and Lifshitz-Assaf 2021). His experience teaches human professionals how to tackle problems in a more effective and efficient manner. Like a human expert, the expert system must also be able to respond to inquiries regarding the solution it finds and provide justifications for each step taken to accomplish a goal. Better decision quality, cost reduction, consistency, speed, and dependability are the main advantages of expert systems (Leo Kumar 2019). Generally, the speed of expert systems in solving a problem is faster than human experts (Chen et al. 2012). The right algorithm used for the HCP identification system is the forward chaining algorithm because the identification criteria in the LPPOM MUI SJH that are traced forward to determine the next step are the same as the forward chaining algorithm (Sinaga, Riza, and Lazuly 2018). Additionally, the forward chaining algorithm will perform better in determining conclusions derived from the data gathering (Munaiseche, Kaparang, and Rompas 2018). Thus, forward chaining is suitable to be used in dealing with this case compared with other artificial intelligence algorithms. The expected benefit of this research is to provide convenience in identifying HCP in the food according to SJH LPPOM MUI. It is also anticipated to be able to support government initiatives aimed at turning Indonesia into a global hub for halal goods and travel.

Literature review

There are various essential components of an expert system software (Desnelita, Rukun, and Nasien 2018). Since the component knowledge base represents expert knowledge, it serves as the central component of the expert system program (Abu Al-Qumboz and Abu-Naser 2019). Next, every fact (Cohen, Yang, and Mazaitis 2020)] (Joenväärä et al. 2019) that is received during the system's initial operation as well as the facts discovered throughout the implementation of the conclusion is contained in the database. The user's system reasoning patterns and thought processes are housed in another section of the inference engine. Forward chaining is used by the inference engine, whereas SJH LPPOM MUI is used by the halal knowledge base and database. Forward chaining is a search/conclusion technique that relies on the facts or data that are now available to get the conclusion. Beginning with the known facts, the search proceeds through the premises in order to arrive at a bottom-up conclusion or reasoning. Forward chaining looks for a path from an issue to a fix (Arhami 2005).

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Anything classified as halal is free of haram components or ingredients, meaning that Muslims are not allowed to eat it. Islamic law is not violated by its processing (Waharini 2018). Islamic law has accepted and recommended the qualities, ingredients, handling, processing, and use of different procedures for halal cuisine from beginning to end. HCP is the source of the material, and the manufacturing procedure was carried out after considering Islamic law's regulations about the permissibility of food. It indicates halal if appropriate, and questionable otherwise. This crucial element relates to the established halal rules, which cover the components and manufacturing steps that could impact the product's restriction. A material flow map must be made and confirmed in order to identify essential control points. This is followed by an examination of the steps that are most likely to be subjected to material contamination, which makes it unlawful (Sopa 2019). HCP is employed in traceability procedures.

Traceability refers to the capacity to track and record the lineage and past of a product or food item. Traceability includes documenting and making available all methods and activities that have impacted the life of a specific product for observation by buyers or other players in the supply chain (Bahrudin, Siti Sarah Mohd 2011). Halal traceability may track the halal status of a food product by recording all production activities from the origin of raw ingredients to the final product (Haryono and Dwi Iryaning Handayani 2018)(Kusnadi et al. 2023b). The most widely used method in traceability halal, that is, with halal labeling (Muhammad 2017). Benefits related to the implementation of traceability can be classified into four categories: regulation and supervision, market and consumer response, withdrawal and risk management, and supply chain.

Method

This system's development adheres to the stages of the System Development Life Cycle (SDLC). (Wallin and Land 2001); Figure 1 shows these stages. SDLC is used to build this application so that it can run as expected (Sharma 2017). SDLC consists of requirements analysis, design, implementation, testing, and management stages. However, the management stage is not included in this study. It is an operational stage after the application is used, which was not done in this study. With SDLC, if the system still has shortcomings, the process stages can be started again from the stage of compiling system requirements.

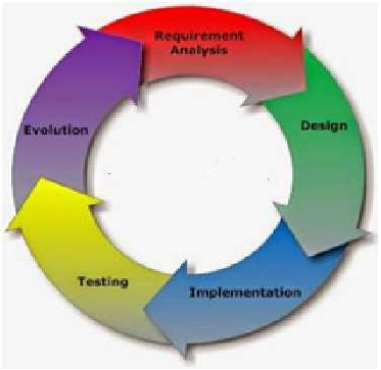

Fig. 1. System development life cycle

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Requirement Analysis

The current phase involves analyzing theories relevant to this research, especially those concerning halal and artificial intelligence. Field studies were conducted through observations at the Grand Zuri Hotel BSD Tangerang Indonesia and interviews with relevant parties and specialists, including the Food and Beverage Manager of Grand Zuri BSD City Serpong, Dimas Purbo Iskandar, to gather information on the necessary materials.

This stage produces a research scope; problem analysis; physical architecture and logical architecture, which are used to create data structures; business processes; and data flows. The results of the literature study of the LPPOM MUI SJH Manual found that there was a decision tree in identifying HCP (Sucipto et al. 2022); however, in this study, only the identification of HCP for material criteria was performed as the object of research because the principle was the same for other criteria. The criteria for materials are categorized into HCP, vegetable materials, animal materials, and microbial materials. An example of a decision tree to identify plant-based HCPs based on the 2008 LPPOM MUI SJH general guidelines (LPPOM - MUI 2008) (Figure 2).

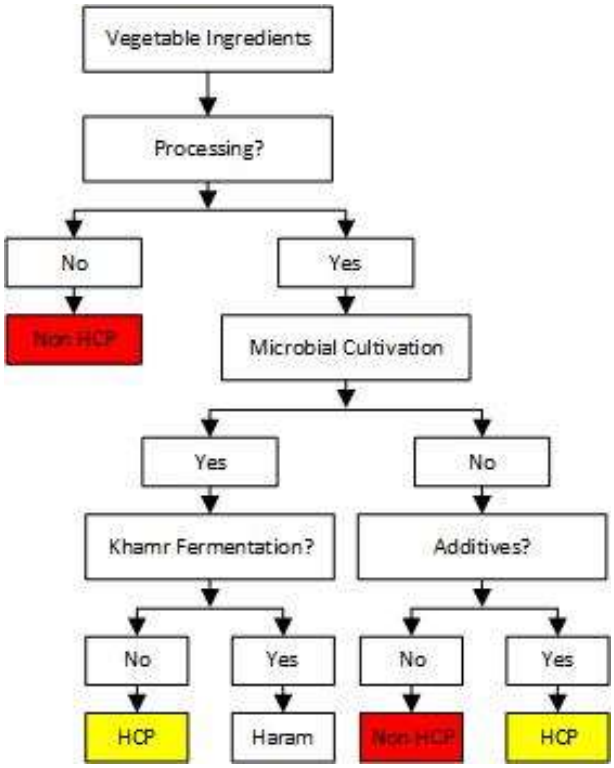

Fig. 2. Decision tree to identify plant-based HCPs based on the SJH LPPOM MUI 2008

The vegetable materials discovered in the critical point determination are initially halal. However, if they are treated with non-halal additives and auxiliary materials, they become non-halal. Therefore, for the identification of HCP, it is necessary to know the flow of the production process along with additional and auxiliary materials used in processing a vegetable material and other factors. The decision tree is then translated into rules using an expert system with a forward

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chaining algorithm. The algorithm starts by getting information that is then checked (IF) to conclude (THEN) (Gusman and Hendri 2019). An illustration of the process is shown in Figure 3.

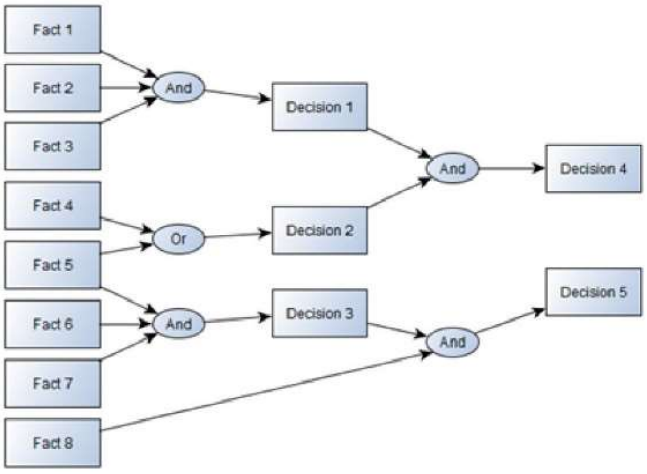

Fig. 3. Illustration of the decision tree process

An example of the implementation of the SJH LPPOM tree to forward chaining can be seen in Figure 4.

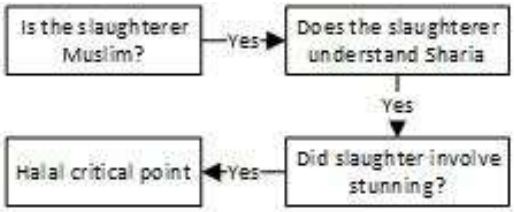

Fig. 4. Example of SJH LPPOM in forward chaining

Design

At this point, theories relevant to the research, particularly those pertaining to the decision tree in Figure 2, are examined and transformed into user-friendly questions for easier utilization of the system by non-experts. Some of the questions are shown as follows:

1. Which group is suitable to describe the type of material used (vegetable, animal, microbial, other)?
2. Has the vegetable material used been processed?
3. Do the unprocessed vegetable materials pass through the microbial cultivation stage?
4. Do vegetable materials that pass through the microbial cultivation stage pass through the Khamr fermentation stage?
5. Are vegetable ingredients that have not passed the microbial cultivation stage mixed with additives?
6. Is the animal material derived from milk, eggs, or fish, or is it meat and its by-products (fat, bone, skin, etc.)?
7. Has the milk/eggs/fish been processed?

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8. Do meat and by-products come from halal animals?
9. Is the animal slaughtered in accordance with Islamic Sharia and has an MUI Halal Certificate or an institution recognized by LPPOM
10. Does the slaughtered animal have any further processing?
11. Which group is suitable for describing other types of materials (Mining materials, Synthetics, mixtures)?
12. Are the synthetic materials used organic?
13. Does the synthetic inorganic material used contain additives?

These questions are converted into rules so that they can be coded using a programming language, for example, rules:

- IF The vegetable materials used undergo processing THEN Do the unprocessed vegetable materials pass through the microbial cultivation stage
- IF The vegetable materials used are not processed THEN Non-TK

Implementation

Implementation of the design into application form used Xampp Control Panel v3.2.4 software, Visual Studio Code Version 1.64.1, and Google Chrome Version 98.0.4758.82 (Official Build) (64-bit). For example, Figures 5, 6, and 7 are the implementation of the HCP identification system in the form of questions based on the decision tree in the LPPOM MUI SJH. The system is hosted on the 000webhost platform. With the application url as follows: https://criticalpointidentification.000webhostapp.com/

Testing

The system is tested using the black box testing approach to determine if it aligns with its intended purpose and is practical for use (Guidotti et al. 2018). Black box testing is a method where the program is tested based on its output from test data without examining its internal structure. The black box testing method employed is comparison testing (Irawan et al. 2018), where each version is tested using identical data to verify that they all yield the same results. Another conducted test is the user happiness assessment utilizing the end-user computing satisfaction (EUCS) methodology method (Abdinnour-Helm, Chaparro, and Farmer 2005). The EUCS technique measures five primary dimensions. The five dimensions include content, accuracy, presentation, simplicity of use, and timeliness.

Results

In the first rule, because vegetable materials are processed, the next question will appear according to the forward chaining algorithm, which is traced forward until it concludes. In the second rule, because vegetable materials have not undergone processing, it can be ascertained that the material does not have an HCP or has reached a conclusion. This research was conducted from January to May 2022 at the Grand Zuri Hotel BSD Tangerang Banten Indonesia. The object of research is the menu of oxtail soup, starting from the preparation of the raw materials used until the presentation; however, in this publication, it is only up to the stage of providing the ingredients. Figure 5 shows the page view for starting HCP identification. The user is asked to enter the name of the menu that will be identified so that it can be recorded in the database.

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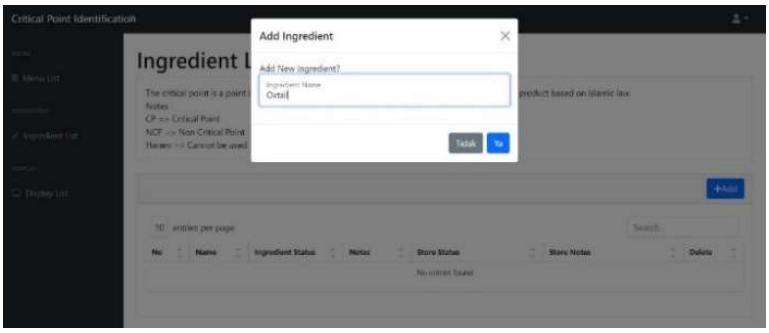

Fig. 5. Input menu screen

If the menu input has been done, the user will be asked several questions until they conclude; an example of a question screen display can be seen in Figure 6.

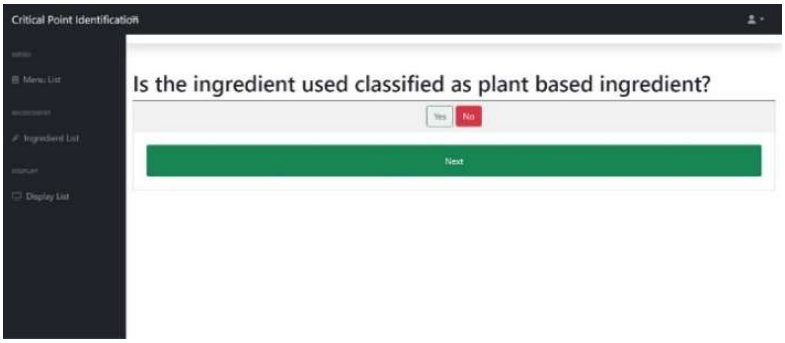

Fig. 6. Implementation of Figure 2 in the application

The answers given will generate conclusions from the HCP from the material in question; an example of HCP material for the oxtail soup menu is shown in Figure 7.

Fig. 7. Result screen

Identification of HCP ingredients for making oxtail soup manually can be seen in Table 1. The results will be compared with HCP identification based on the system. In the manual identification in Table 1, apart from listing the results of the HCP identification, the place of purchase or the producer of the material because they have HCP must also be identified. The table also includes precautions so that users can avoid HCP and get ingredients that are truly guaranteed to be halal.

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The identification results in Table 1 are then compared with the identification results from the system. Some of the results are shown in Figure 7. The results of both identifications resulted in the same HCP identification, namely, oxtail soup, which had HCP in beef tail ingredients and sugar. This proves that functionality and system development are correct. Other criteria such as storage, distribution, and display can be done in the same way.

Table 1. ANALYSIS OF CRITICAL POINTS FOR OXTAIL SOUP

No.	Material	In production	Halal	HCP	Preventive
1	Oxtail	Supplier/market	Not clear	Slaughter process	Choose oxtail that is clearly
2	Shallot	–	–	–	–
3	Garlic	–	–	–	–
4	Pepper	–	–	–	–
5	Carrot	–	–	–	–
6	Potato	–	–	–	–
7	Leek	–	–	–	–
8	Celery	–	–	–	–
9	Tomato	–	–	–	–
10	Clove	–	–	–	–
11	Lawang	–	–	–	–
12	Cinnamon	–	–	–	–
13	Cardamom	–	–	–	–
14	Salt	–	–	–	–
15	Sugar	Buy at the	Not clear	–	–
16	Oil fry	PT Global	Halal	–	–
17	MSG	PT Ajijomoto Indonesia	Halal	–	Buying sugar that is clearly
18	Water	–	–	–	–

Following the completion of black box system testing, the system undergoes acceptability testing utilizing the EUCS. Forty-one individuals interested in the halal status of food products participated in the survey, with questionnaires distributed randomly. The content dimension assesses if the system has delivered suitable content, whereas the accuracy dimension evaluates the precision of input received by the system. The format dimension assesses the layout of the information presented by the system. The ease of use dimension assesses the degree of convenience users encounter while utilizing the technology. The timeliness factor assesses user satisfaction based on how promptly the system delivers information to users.

The Likert scale is utilized to gauge the attitudes, views, and perceptions of individuals or groups about social phenomena. The Likert scale is utilized to gauge user satisfaction levels by detailing the options available on the scale (Joshi et al. 2015).. Survey answers in Table 2 are derived by multiplying the Likert scale value.

Table 2. QUESTIONNAIRE RESULTS

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Dimension	Question	Likert				
		1	2	3	4	5
Content	In your opinion, does the critical point identification system created provide information that is appropriate to the system's usefulness?	0	1	4	20	16
	In your opinion, what is the identification system critical point made easy to understand?	0	1	3	18	19
Accuracy	In your opinion, does the critical point identification system created display accurate information?	0	0	2	19	20
Format	In your opinion, are you satisfied with the appearance of the critical point identification system made?	0	0	7	19	15
Ease of use	In your opinion, is the critical point identification system made easy to use?	0	1	2	21	17
Timeliness	In your opinion, is the critical point identification system fast in identifying critical points?	0	0	3	19	19

- OF THE USERS, 85.85% ARE SATISFIED WITH THE CONTENT DIMENSION.
- Of the users, 88.78% are satisfied with the accuracy dimension.
- Of the users, 83.9% are satisfied with the format dimension.
- Of the users, 86.34% are satisfied with the dimensions of ease of use.
- Of the users, 87.8% are satisfied with the dimensions of timeliness in the designed system.

Discussion

In Table 1, it can be seen that the ingredients that already have halal certification are cooking oil produced by PT Global Digital Niaga and MSG sold by PT Ajijomoto Indonesia. Meanwhile, what is not clear about the halal status is oxtail and granulated sugar. Additional ingredients such as shallots, garlic, pepper, carrots, potatoes, scallions, celery, tomatoes, cloves, star anise, cinnamon, cardamom, water, and salt are halal foodstuffs. Although the results of the identification system development are correct, the system has not yet covered all the factors that influence HCP because in the SJH LPPOM manual, there are only decision trees for HCP materials, HCP for animal materials, HCP for microbial products, HCP for other materials (mining, synthetic), HCP for storage, and production lines and HCP distribution critical points. There are other factors in identifying the oxtail soup menu, namely, HCP in the manufacturing process and HCP using tools. These factors need to make a decision tree diagram and include SJH LPPOM MUI because they greatly affect the halalness of food. Tables 3 and 4 show the results of manual HCP identification

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for the manufacturing process and use of the equipment.

Previous HCP research uses the FMEA method to analyze by calculating the highest risk priority. The results of the study found several risks that could cause the occurrence of an HCP at the risk of changing the formula, which results in a new product (80%). There are no permanent suppliers who are halal-certified (60%) and a good working environment close to contamination (50%). There is no halal logo on the raw materials used (40%) (B. A. Kinanti n.d.). Several studies have proven that there are still risks that can be an HCP causes a decrease in the halal status of the product (M. K. S. A. V. I. F. L. &. S. W. Anwar 2018)(Atma 2018). The results of this previous study have an analysis similar to this research, that the process and use of tools have the opportunity to change the halalness of food

Table 3. ANALYSIS OF CRITICAL POINTS FOR THE OXTAIL SOUP PROCESS

No.	Process stage	Critical point of haram
1	Food supply	The raw material used has a haram critical point, on the oxtail used. Then, in the procurement of granulated sugar, there is also a critical point of haram. Both of these food ingredients can be obtained from producers who may not have a halal certificate.
2	Smoothing spices	This process is a critical point of haram because, during the refining process, the ingredients may be mixed due to the proximity of the material even though the human hand has worn gloves and headgear.
3	Sauteing spices	The process of sauteing this spice is done by human hands. This process is a critical point of haram because during the refining process using human hands that do not wear gloves and headgear.

In the critical point analysis of the process of making oxtail soup of food supplies, the raw materials, or the tails, have a critical point, which is haram. Raw materials are the main ingredients of a product (S. Prawirosentono 2012). The raw material used to make oxtail soup is oxtail. In this main raw material, there is a HCP. Especially in the aspect of animals slaughtered by mentioning names other than Allah, animals are slaughtered to be sacrificed to idols or other worship. This practice violates the most basic principle of Islam, namely, the oneness of Allah (Rumyiyah 2021). Granulated sugar is made from sap, which can come from various sources, such as sugar cane, coconut, siwalan and palm. Because it comes from plants, the main raw material for granulated sugar is halal. The process of making granulated sugar consists of several stages, starting from the extraction process, purification, evaporation, and crystallization to drying. In the stages of this process, it may become haram for materials to enter and contaminate granulated sugar. For example, if it involves a purification process, then the activated carbon used must be confirmed to have a halal status (A. Roswiem 2012).

The next step is to grind the spices. Based on observations, the process of grinding this spice is done by human hands. This process becomes a critical point of haram because, at the time of the

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refining process, human hands are not used without gloves and headgear. Likewise, the clothes used are not clean. The process of sauteing this spice is done by human hands. This process becomes a critical point of haram because, at the time of the refining process, human hands are not used without gloves and headgear. Likewise, the clothes used are not clean.

Table 4. ANALYSIS OF CRITICAL POINTS FOR OXTAIL SOUP EQUIPMENT

No.	Equipment	Equipment state	Control effort
1	Container	The container used is not clean	Cleaning before, after, and during the process
2	Knife	The knife used is not clean	Cleaning before, after, and during the process
3	Wooden vegetable spoon	The wooden ruses used look rarely cleaned	Cleaning before, after, and during the process
4	Wok	The skillet used is not clean	Cleaning before, after, and during the process

The utensil used for cooking consists of the first container. Containers must use clean containers. It must be ensured the container by clean hands before and during the cooking process. The second and subsequent tools are a knife, a wedge, and a frying pan. Similar to the container, the three tools must be cleaned using clean hands.

Tables 2 and 3 show the stages of containing HCP that need to be considered in keeping food halal until it reaches consumers. The critical point of oxtail soup for raw materials is oxtail and granulated sugar. The critical point of the production process is to grind the spices and saute the spices. The critical points of equipment are containers, knives, ruses, and pans. Control efforts on food ingredients are to buy ingredients with halal labels. Then, the equipment is cleaned before, after, and during the process, as well as cleaned with clean hands.

Conclusion

The HCP identification system for food ingredient from SJH LPPOM MUI using the forward chaining algorithm has been successfully created. The system was tested using the black box testing method with the comparison testing technique where the system output results with manual HCP identification were compared. The comparison results have the same results; this indicates the functional system has been running well. Although the system has been running well, it does not cover all potential identification of HCPs, because the decision tree listed in the LPPOM MUI SJH does not include the manufacturing process and equipment used in making food menus, in this case, oxtail soup. Therefore, for further research, a decision tree can be made by involving experts and LPPOM MUI. Additionally, it is necessary to test user satisfaction so that the system can be used by ordinary people who do not understand the concept of halal.

Another test is the user acceptance test using the EUCS method with 41 respondents and getting

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an average for the content dimension of 85.85%. The accuracy dimension is 88.78%, the format dimension is 83.9%, the ease of use dimension is 86.34%, and the timeliness dimension is 87.8%. The average value of the level of user satisfaction is taken from the average value of each dimension of 86.53%. Thus, the system is running as it should, and the user is satisfied with the critical point identification feature designed.

Acknowledgments

This research has been partially supported by Universitas Multimedia Nusantara, Indonesia, under LPDP (Research Fund Management) Research Grant contact no 089/E4.1/AK.04.RA/2021. Thanks to The Hotel Grand Zuri BSD Tangerang Indonesia for the research place. Thanks to the students of the Informatics Department of Universitas Multimedia Nusantara for contributing to the research.

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