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Implementation of AHP Algorithm for Design and Development Halal Food Recommendation System at Cirebon Regional

Erick Abraham Geneva[1], Adhi Kusnadi[2], Fenina Adline Twince Tobing[3]
[1,2,3] Department of Informatics, Universitas Multimedia Nusantara, Tangerang - Indonesia
[1] erick.sanggor@student.umn.ac.id, [2]adhi.kusnadi@umn.ac.id [3]fenina.tobing@umn.ac.id

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***Abstract*— Cirebon is one of the cities in Indonesia that has a variety of unique culinary delights. One of the most famous Cirebonese halal culinary delights is nasi jamblang. However, the many choices of halal Cirebonese food can make tourists struggle to choose food that suits their taste and preferences. This research aims to design and build a halal Cirebonese food recommendation system using the Analytical Hierarchy Process (AHP) method. The AHP method is used to determine the weights of the factors that influence the selection of halal Cirebonese food. This recommendation system is built using PHP and JavaScript programming languages, as well as Laravel, React, and MySQL frameworks. This recommendation system has been tested by distributing questionnaires using End User Computing Satisfaction method with google form to 35 respondents The test results show that this recommendation system produces a user satisfaction value of 87.92%. This value indicates that this recommendation system has met user expectations.**

***Keywords*— Analytical Hierarchy Process, Cirebon, Halal food, Recommendation System**

I. INTRODUCTION

In the midst of diverse local cuisines spread across Indonesia, each region possesses a treasure trove in the form of recipes, spice blends, and narratives behind its culinary offerings. All of these constitute valuable assets contributing to Indonesia's cultural richness. Cirebon City, situated in Indonesia, holds a distinct charm for tourists seeking to explore. The influx of visitors to Cirebon has increased following the opening of a toll road connecting the city to other cities in Java [1]. According to data compiled by the Communication and Information Agency of Cirebon Regency, sourced from the Culture and Tourism Agency of Cirebon Regency, there were 941,435 domestic and international tourists who visited Cirebon Regency during the period of 2021-2022. Iconic foods of Cirebon, such as Empal Gentong, Sega Jamblang, Nasi Lengko, and Tahu Gejrot, contribute to the identity of the region [2].

Halal food encompasses everything that is permissible to eat according to religious requirements, and it should be of Identify applicable funding agency here. If none, delete this. good quality without compromising health [3]. Foods meeting these criteria receive certification and become symbols of high- quality halal food [4]. In addition to halal considerations, the quality of raw materials and how well the food reflects Cirebon's culture and traditions are also crucial factors. In developing a recommendation system, the primary goal is to assist users in finding relevant and interesting items from a vast array of choices. Recommendation systems significantly enhance user experience by providing precise references or suggestions aligned with user preferences. In the context of this research, it is essential to integrate various aspects to deliver recommendations that meet users' expectations.

By combining recommendation technology with a quality assessment of food based on the Analytical Hierarchy Process (AHP), users are expected to enjoy the culinary richness of Cirebon without confusion or doubts about the halal status and quality of their chosen food

II. METHODOLOGY

A. Recommendation System

A recommendation system is a type of system designed to suggest specific products or information to users based on their preferences, characteristics, or behavior. Individuals may seek opinions on books, music, or

movies from others to make decisions. This is the core idea behind the design of recommendation systems [5]. Systems that provide recommendations are crucial for enhancing user experience and assisting platforms or companies in improving user conversion, retention, and sales. Methods that can be applied to recommendation systems include Collaborative Filtering, Content-Based Filtering, and Matrix Factorization.

B. Halal Food

Halal products are products that have been declared permissible according to Islamic law. Therefore, the halal status of a product is a mandatory requirement for every consumer, especially Muslim consumers. Certification and labeling of halal products require special attention from the government, especially for food products, which are primary needs and widely consumed [6]. The criteria for halal food in Islamic perspective include:

1) It does not contain pork and anything derived from pork.
2) It originates from halal animals and is slaughtered ac- cording to Islamic law.
3) It does not contain prohibited or impure substances such as carrion, blood, materials from dirty human organs, and the like.
4) All storage, sales, processing, management, and transportation facilities for halal products must not be used for pork or other non-halal items [3].

The following is the process to obtain halal certification based on an article on the sucofindo.co.id website:

1) Submit a certificate application online at ptsp.halal.go.id.
2) BPJPH (Halal Products Assurance Agency) will check the completeness of the submitted application data. If the documents are complete, BPJPH will immediately send the documents to the Halal Inspection Institution for document verification and calculation of the halal product inspection cost.
3) Generally, the process of calculating the cost of halal product inspection takes a maximum of two working days. However, if the documents are not in order, the Halal Inspection Institution will ask you to correct the document completeness first.
4) The cost calculation for halal product inspection can be seen according to the unit cost multiplied by the established man days by BPJPH. The cost of halal product inspection does not include the cost of testing halal products through accredited laboratories and does not include accommodation and transportation costs in accordance with applicable laws.
5) Subsequently, BPJH will issue a payment invoice to the business owner.
6) Next, businesses must make the payment within a max- imum period of around 10 working days since the first invoice is provided.
7) If the business does not make the payment within the specified deadline, the application will be canceled.
8) After submitting the proof of payment, BPJPH will verify it. If it is correct, BPJPH will immediately issue a document receipt letter as the basis for assigning the Halal Inspection Institution to conduct the halal product testing.
9) The time required for the examination and testing of products is approximately 15 working days.
10) Next, the Halal Inspection Institution will submit the results of the examination and testing of the halal product to MUI (Indonesian Ulema Council) by uploading the documents through the SiHalal application.
11) BPJPH will then issue the halal certificate, and businesses can download the digital halal certificate through the SiHalal application

C. Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) method is commonly used in the process of Multi-Criteria Decision Making (MCDM) to determine the weights of each criterion. In addition, Multi-Attribute Decision Making (MADM) methods such as ELECTRE or PROMETHEE are employed to compare and rank alternatives based on predefined criteria. By combining AHP, MCDM, and MADM, decision-makers can structure criteria, assign weights to each criterion, and then compare alternatives by considering complex preferences. This approach creates a comprehensive and systematic method for decision-making, especially in situations involving a large number of factors and complex preferences.

The AHP method is used to assign weights to each criterion for typical Cirebon halal food and test their consistency. In AHP, the concept of eigenvector is utilized to rank the priority of each criterion based on the pairwise comparison matrix. The fact that, as the number of criteria increases, humans cannot maintain consistent pairwise judgments is addressed. This is why the Consistency Ratio (CR), measuring how

inconsistent a decision-maker is in scoring using a scale, was introduced by Saaty [7].

The reason the author chose the AHP method over other multi-criteria decision-making methods is that AHP introduces the Consistency Ratio (CR) to maintain pairwise criterion scoring consistency. The steps to implement the AHP method are as follows.

1) *Arranging a Hierarchy*
Identify relevant criteria for use in assessing alternatives and then organize them into a hierarchy.

2) *Determining the Pairwise Comparison Matrix*
A pairwise comparison matrix is used to determine values for the criteria. The following is the table of the paired comparison value scale [7].

TABLE I
PAIRWISE COMPARISON VALUE SCALE

Value	Meaning
1	Equal Importance
3	Slightly More Important
5	Moderately More Important
7	Strongly More Important
9	Very Strongly More Important
2, 4, 6, 8	Intermediate values if preferences are not entirely clear.

3) Calculate Relative Weights After the pairwise comparison matrix has been established, calculate the relative weights for each element in the same level. This process involves calculating the geometric mean of the columns in the matrix.

4) *Measuring Consistency*
The steps to measure consistency values are as follows:

a. Multiply the values in the first column by the priorities of the first element, and continue this process until reaching the last element.
b. Sum each row and divide it by the priority value of that element
c. Calculate the Consistency Index (CI) based on the formula.

5) Checking consistency in the hierarchy using IR Values

TABLE II
RANDOM INDEX (RI) VALUES FOR $n = 1$ TO $n = 5$

n	Random Index (RI) Value
1	0
2	0
3	0.58
4	0.90
5	1.12

If the obtained Consistency Ratio (CR) is less than 0.1, it can be stated that the results of the AHP method calculations are consistent, and the priority values can be relied upon [7].

D. End User Computing Satisfaction (EUCS)

Information systems can be reliable if they have good quality and can provide satisfaction to their users [8]. End User Computing Satisfaction (EUCS) is a term used to describe how satisfied end users are with the software or system they use regularly. It is a metric used to determine how satisfied or dissatisfied customers are with the use of computer technology or specific software. Evaluation using this method emphasizes end-user satisfaction with technology, assessing five variables: Content, Accuracy, Format, Ease of Use, and Timeliness [9].

E. Likert Scale

Likert Scale is a scale used to measure an individual's or a group's perception, attitude, or opinion about an event or social phenomenon [10]. A sequence of statements or questions is typically presented to respondents, who are then asked to indicate how much they agree or disagree. Likert Scale is quite simple to design and yields reliable scale values [11]. Likert scales usually consist of 5 response options such as strongly agree, agree, neutral, disagree, and strongly disagree. The following is a table of weights for each category.

$$P = \frac{\Sigma \text{ each category} \times \text{weight}}{5+n} \times 100\% \quad (3)$$

TABLE III
LIKERT SCALE

Category	Weight
Strongly Agree	5
Agree	4
Neutral	3
Disagree	2
Strongly Disagree	1

P: total number of respondents choosing

n: Number of respondents

Research Methodology

1) Problem Identification

In the context of developing a halal food recommendation system for Cirebon, several issues arise that impact user experience in finding Cirebon's halal food. First, limited information about Cirebon's halal food can make it challenging for users to find options that match their preferences. Time constraints lead users to seek quick and efficient solutions in

determining Cirebon's halal food, while high expectations for technology drive them to look for smart and innovative applications.

2) Source of Knowledge Determination

In a recommendation system using AHP, criteria are a crucial part of the AHP method. In this study, criteria will be determined by experts. Determining knowledge about Cirebon's halal food will be obtained through websites providing related food data. Collecting data on Cirebon's local food for research purposes.

3) Knowledge Acquisition

Collecting data from tourists and halal Cirebon food, and values for each criterion obtained from websites such as tripadvisor.com for finding alternative values based on user reviews, cookpad.com, opendata.cirebonkab.go.id, data.cirebonkota.go.id, and fatsecret.co.id for nutritional values. Halal certificates data is obtained from the bpjph.halal.go.id website. Here are some example im- ages for collecting food data, references for determining alternative values, and halal certificates.

4) Knowledge Representation

The AHP representation in the Cirebon halal food recommendation system takes the form of a hierarchy containing criteria, sub-criteria, and alternatives.

5) Inference Engine Development

Designing the AHP model for the system structure, such as Data Flow Diagram, Sitemap, Flowchart, database design, and wireframe for the Cirebon halal food recommendation website. This method aims to facilitate the system implementation process.

6) System Implementation

Implementing all designs made in the previous stages. This process aims to build the system from the interface to the recommendation process using the AHP method

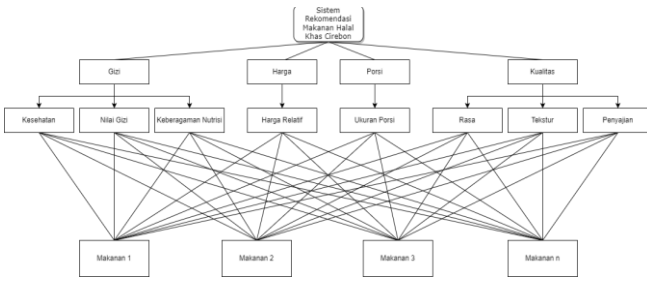

Fig. 1. AHP Method Hierarchy

7) Testing and Evaluation

In this process, the built recommendation system will undergo testing, where the recommendation system web- site will be tested using the EUCS method. Users will fill out a survey to obtain satisfaction scores for the built recommendation system. Reconsideration of the implemented recommendation system.

F. Application Design

Flowchart: A Flowchart is a visual representation that il- lustrates the flow or logical sequence in a system or process. In a flowchart, standard symbols are used to represent activities, conditions, and the logical sequence of the described process. Flowcharts have various applications in different fields, including software development, project management, and business planning. The use of flowcharts helps establish the sequence of steps in a process, identify errors or shortcomings in the system, and improve the overall efficiency of a process. The following is the main flowchart that explains the entire website system

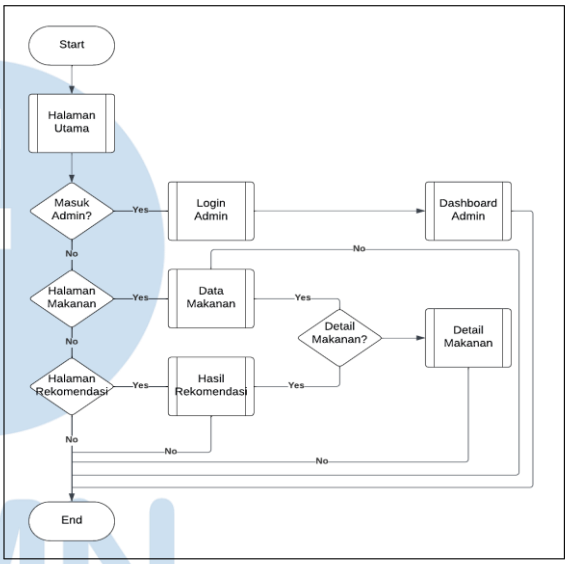

Fig. 2. *Main Flowchart*

G. User Interface Design

1. Main Page

Figure 3 represents the initial page when users access the website for the first time. There is navigation for users to switch to the food page and to the admin login page. There is a navigation button in the middle of the page that will redirect users to the recommendation system page.

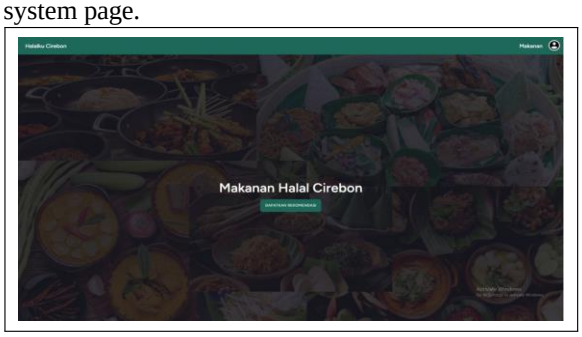

Fig. 3. Main Page

2. Food Page

Figure 4 is the food page when users access the website using the food button in the navigation. The food page will display all food data and brief information such as name, description, image, and food type in the form of cards. On the food card, there are navigation buttons for users to switch to the detailed page of the selected food. There is also navigation for users to switch to the recommendation page

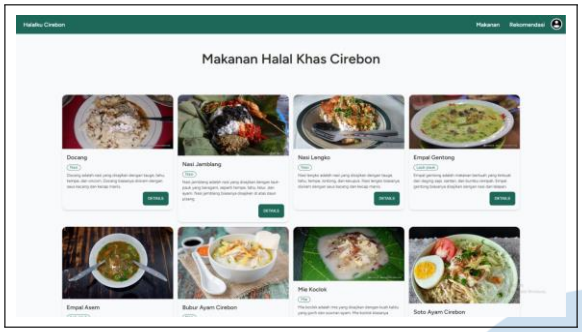

Fig 4. Food Page

3. Food Detail Page

Showing the food detail page for users. On the detail page, it will display all the information about the food data, such as name, description, image, food type, price, and even a button for users to switch to Google Maps for the restaurant that provides the selected food

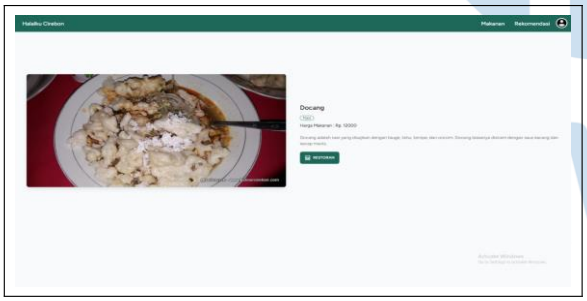

Fig. 5. Food Detail Page

4. System Recommendation Page

In Figure 6, there is a slider to receive ratings from users for each importance value, which will then be used to recommend suitable foods based on user preferences.

Fig. 6. System Recommendation Page

5. Recommended Food Page

In Figure 7, it shows the page displaying recommended food results for users. On this page, the recommended food data for users will be presented

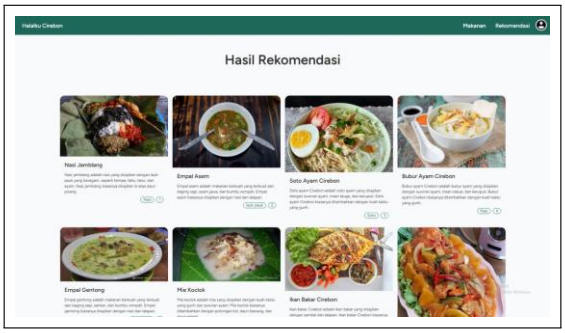

Fig. 7. Recommended Food Page

6. Login Page

Illustrated in Figure 8 is the admin login page. On this page, the admin needs to fill out the login form, and upon completion, the admin will be redirected to the dashboard

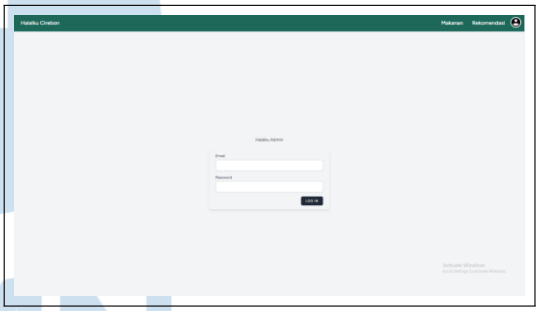

Fig. 8. Login Page

7. Dashboard Page

Depicted in Figure 9 is the admin dashboard page for managing food data and ratings. On this page, there are two navigation buttons: one leading to the food data page and the other to the food rating data page.

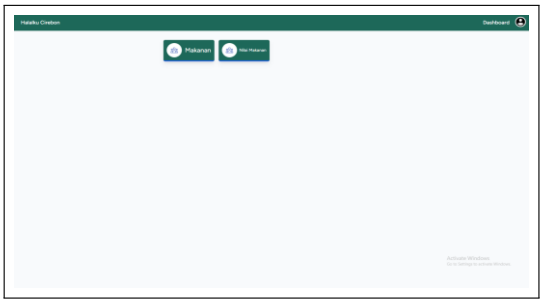

Fig. 9. Dashboard Page

8. Food Dashboard Page

Depicted in Figure 10 is a page displaying all food data and information in the form of a table. On this page, there are three navigation buttons for the admin:the ”Add Data” button, the ”Edit” button, and the ”Delete” button. The ”Add Data” button will redirect the admin to the add food data page, the ”Edit” button to the edit food data page, and the ”Delete” button to delete the selected food, as shown in Figure 11.

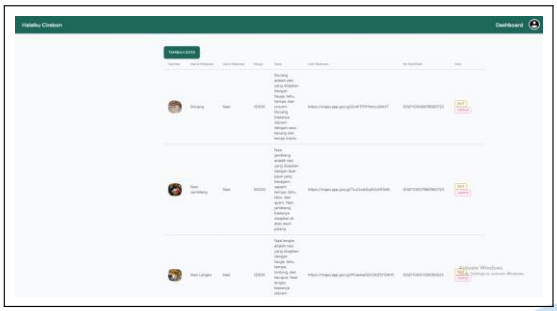

Fig. 10. Food Dashboard Page

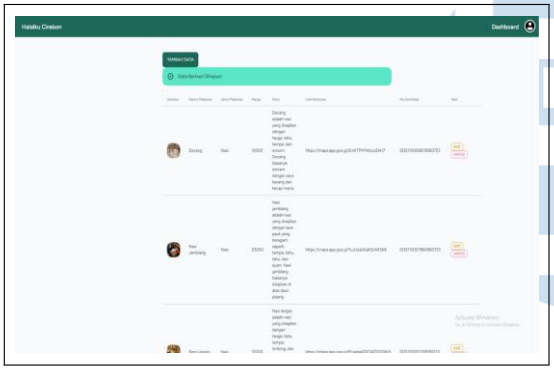

Fig. 11. Delete Food Data

III. Result and Discussion

A. Validation and Evaluation Test

This test is conducted to find out whether the results of the recommendation system calculations match the results of manual calculations. The goal of this test is to ensure that the recommendation system is functioning correctly. In the manual calculation, four criteria are used: price, quality, portion, and nutritional value of the food, as shown in Table 4.

TABLE IV Criteria Table

Code	Description
H	Price
K	Quality
G	Nutrition
P	Portion

Table 5 is a criteria comparison matrix table that has been converted from user input as in the example in Figure 16. The values entered by the user will be calculated manually and using the system. Table 6 is the result of matrix normalization in the criteria comparison matrix table.

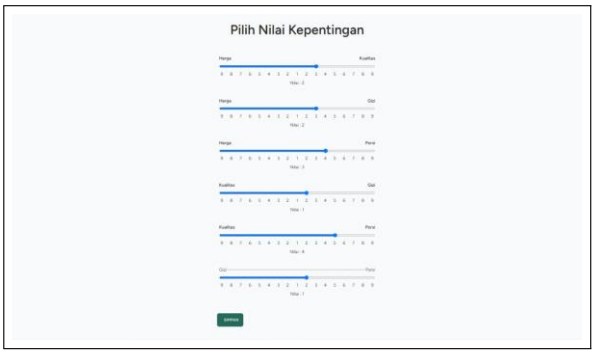

Fig. 16. Value Form User Input

TABLE V
Comparison Matrix Table

Column 1	H	K	G	P
H	1	0,333	0,333	0,25
K	3	1	0,5	0,2
G	3	2	1	0,5
P	4	5	2	1
Total	11	8,333	3,833	1,95

TABLE VI
Matrix Normalization

Column 1	H	K	G	P
H	0,09090	0,04	0,08695	0,12820
K	0,27272	0,12	0,13043	0,10256
G	0,27272	0,24	0,26087	0,25641
P	0,363636	0,6	0,52173	0,51282
Total	1	1	1	1

TABLE VII
Criteria Code

Criteria	Total	Average/Criterion Weight
H	0,34607	0,08651
K	0,62572	0,15643
G	1,03000	0,25702
P	1,99819	0,49954

$$\text{Criteria Weight}_K = \frac{0.27272 + 0.12 + 0.13043 + 0.102564}{4} = 0.15643 \quad (5)$$

$$\text{Criteria Weight}_G = \frac{0.27272 + 0.24 + 0.26086 + 0.25641}{4} = 0.25702 \quad (6)$$

$$\text{Criteria Weight}_P = \frac{0.36363 + 0.6 + 0.52173 + 0.51282}{4} = 0.49954 \quad (7)$$

Then, finding the maximum eigenvalue (lambda max) by summing each criterion weight, which is multiplied by the total of each criterion in the previous comparison matrix

$$\lambda_{Max} = (0.08651 \cdot 11) + (0.15643 \cdot 8.33333) + (0.25702 \cdot 3.83333) + (0.49954 \cdot 1.95) = 4.21650$$

The obtained value of lambda max is used to find the consistency index (CI) or consistency index. The CI value can be calculated by subtracting lambda max from the number of criteria and dividing by the number of criteria minus 1. The calculation can be seen as follows

$$CI = \frac{4.21650 - 4}{4 - 1} = 0.07226 \quad (8)$$

$$CR = \frac{0.07226}{0,9} = 0.08029 \quad (9)$$

TABLE VIII
FOOD VALUE

Criteria	Value Weight
Price	0.08651
Quality	0.15643
Nutrition	0.2575
Portion	0.49954

TABLE IX
FOOD VALUE WEIGHT TABLE

Food Name	H	K	G	P
Nasi Lengko	0.19376	0.10558	0.13243	0.14198
Empal Gentong	0.21407	0.15057	0.11447	0.19111
Nasi Jamblang	0.11489	0.15189	0.17708	0.1190
Mie Koclok	0.14280	0.12021	0.14490	0.14698
Empal Asem	0.09896	0.18080	0.19286	0.18548
Ikan Bakar Cirebon	0.11430	0.19891	0.09544	0.07673
Ikan Asam Manis Cirebon	0.07824	0.07437	0.10469	0.08553
Tahu Gejrot	0.04294	0.07375	0.07513	0.08219

Table of food value weights based on each criterion.

$$\text{Nasi Lengko} = (0.19376 \times 0.08651) + (0.10558 \times 0.15643) + (0.13243 \times 0.25702) + (0.14198 \times 0.49954) = 0.13830$$

$$\text{Empal Gentong} = (0.21407 \times 0.08651) + (0.15057 \times 0.15643) + (0.11447 \times 0.25702) + (0.19111 \times 0.49954) = 0.16702 \quad (11)$$

$$\text{Nasi Jamblang} = (0.11489 \times 0.08651) + (0.15189 \times 0.15643) + (0.17708 \times 0.25702) + (0.1190 \times 0.49954) = 0.138754 \quad (12)$$

$$\text{Mie Koclok} = (0.14280 \times 0.08651) + (0.12021 \times 0.15643) + (0.14490 \times 0.25702) + (0.14698 \times 0.49954) = 0.14189 \quad (13)$$

$$\text{Empal Asem} = (0.09896 \times 0.08651) + (0.18080 \times 0.15643) + (0.19286 \times 0.25702) + (0.18548 \times 0.49954) = 0.17916 \quad (14)$$

$$\text{Ikan Bakar Cirebon} = (0.11430 \times 0.08651) + (0.19891 \times 0.15643) + (0.09544 \times 0.25702) + (0.07673 \times 0.49954) = 0.10391 \quad (15)$$

$$\text{Ikan Asam Manis Cirebon} = (0.07824 \times 0.08651) + (0.07437 \times 0.15643) + (0.10469 \times 0.25702) + (0.08553 \times 0.49954) = 0.08809 \quad (16)$$

$$\text{Tahu Gejrot} = (0.04294 \times 0.08651) + (0.07375 \times 0.15643) + (0.07513 \times 0.25702) + (0.08219 \times 0.49954) = 0.07566 \quad (17)$$

The product of the criteria weights and the obtained food values will be sorted from the highest to the lowest. The top 6 values will be selected and displayed as food recommendations for the user

TABLE X
FINAL VALUE TABLE

Food Name	Final Value	Rank
Empal Asem	0,17916	1
Empal Gentong	0,16702	2
Mie Koclok	0,14189	3
Nasi Jamblang	0,138754	4
Nasi Lengko	0,13830	5
Ikan Bakar Cirebon	0,10391	6
Ikan Asam Manis Cirebon	0,08809	7
Tahu Gejrot	0,07566	8

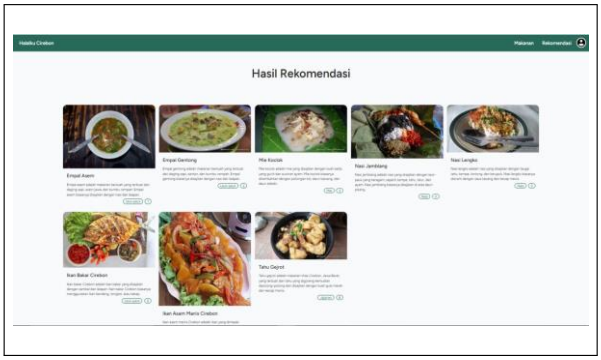

Fig. 17. System Recommendation Results

B. User Satisfaction Test

The second test was conducted by distributing a questionnaire to assess user satisfaction and ease of use of the recommendation system. The questionnaire consisted of 5 questions covering aspects of content, accuracy, format, ease of use, and timeliness. The distributed questionnaire received a total of 35 responses.

1. *Content:* From the results of the first question, the majority of respondents, 34 respondents, agreed or strongly agreed with the statement. Specifically, 12 respondents agreed, 22 respondents strongly agreed, and only 1 respondent answered neutrally

((0×1) + (0×2) + (1×3) + (12×4) + (22×5)) / 5*35 = 91,71%

From the results of the second question, the majority of respondents, 31 respondents, agreed or strongly agreed with the statement. Specifically, 15 respondents agreed, 16 respondents strongly agreed, and only 4 respondents answered neutrally.

((0×1) + (0×2) + (4×3) + (15×4) + (16×5)) / 5*35 = 86,86%

$$\text{Final Score Index} = \frac{91,71\% + 86,86\%}{2} = 89.29 \quad (18)$$

2. *Accuracy:* From the results of the first question, the majority of respondents, 33 respondents, agreed or strongly agreed with the statement

((0×1) + (0×2) + (2×3) + (20×4) + (13×5)) / 5*35 = 86,29%

Based on the results of the second question, no respondents answered strongly disagree or disagree. Two respondents answered neutrally, 15 respondents answered agree, and 18 answered strongly agree.

((0×1) + (0×2) + (2×3) + (15×4) + (18×5)) / 5*35 = 89,14%

$$\text{Final Score Index} = \frac{86,29\% + 89,14\%}{2} = 87,715\% \quad (19)$$

3. *Format:* From the results of the first question, the majority of respondents, 32 respondents, agreed or strongly agreed with the statement. Specifically, 17 respondents agreed, 15 respondents strongly agreed, and only 3 respondents answered neutrally

((0×1) + (0×2) + (3×3) + (17×4) + (15×5)) / 5*35 = 86,86%

From the results of the second question, the majority of respondents, 32 respondents, agreed or strongly agreed with the statement. Specifically, 12 respondents agreed, 20 respondents strongly agreed, and only 3 respondents answered neutrally.

((0×1) + (0×2) + (3×3) + (12×4) + (20×5)) / 5*35 = 89,71%

$$\text{Final Score Index} = \frac{86,86\% + 89,71\%}{2} = 88,285\% \quad (20)$$

4. Easy of Use: From the results of the first question, the majority of respondents, 34 respondents, agreed or strongly agreed with the statement. Specifically, 20 respondents agreed, 14 respondents strongly agreed, and only 1 respondent answered neutrally.
((0×1) + (0×2) + (1×3) + (20×4) + (14×5)) / 5*35 = 87,43%

From the results of the second question, the majority of respondents, 33 respondents, agreed or strongly agreed with the statement. Specifically, 14 respondents agreed, 19 respondents strongly agreed, and only 2 respondents answered neutrally.

((0×1) + (0×2) + (2×3) + (14×4) + (19×5)) / 5*35 = 85,14%

$$\text{Final Score Index} = \frac{87,43\% + 85,14\%}{2} = 86,285\% \quad (21)$$

5. Timeliness: From the results of the first question, the majority of respondents, 32 respondents, agreed or strongly agreed with the statement. Specifically, 22 respondents agreed, 10 respondents strongly agreed, and only 3 respondents answered neutrally.
((0×1) + (0×2) + (3×3) + (22×4) + (10×5)) / 5*35 = 84%

From the results of the second question, the majority of respondents, 34 respondents, agreed or strongly agreed with the statement. Specifically, 14 respondents

agreed, 20 respondents strongly agreed, and only 1 respondent answered neutrally.

((0×1) + (0×2) + (1×3) + (14×4) + (20×5)) / 5*35 = 90,86%

$$\text{Final Score Index} = \frac{84\% + 90,86\%}{2} = 87,43\% \quad (22)$$

C. Final Score

After calculating all the questions, an average calculation is performed to determine the final score. The calculation results can be seen as follows

$$\text{Final Score} = \frac{89,9\% + 87,71\% + 88,28\% + 86,28\% + 87,43\%}{5} = 87,92\% \quad (23)$$

The result of the final percentage calculation is 87.628%, indicating that the respondents strongly agree with the use of the website from the Cirebon typical halal food recommendation system.

IV. CONCLUSION

The halal food recommendation system for the Cirebon region has been designed and built using the Analytical Hierarchy Process method. This system is developed using PHP and JavaScript programming languages, as well as Laravel, React, and MySQL frameworks. The recommendation values generated by this system are consistent with manual calculations. The user satisfaction level is measured by distributing a Google Form questionnaire consisting of 10 questions, filled out by 35 respondents. The measurement of user satisfaction using the End User Computing Satisfaction method resulted in a percentage of 87.92%. After conducting the research, the following suggestions can be implemented for future system development: implementing Collaborative Filtering methods based on ratings and experiences of visitors who have dined in specific local eateries and adding features from applications or websites based on existing research gaps.

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