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Design of a Web-Based Expert System for Diagnosing Chicken Diseases Using the Forward Chaining Method

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Abstract

This study aims to design and develop a web-based expert system for diagnosing chicken diseases, with a particular focus on *colibacillosis*, in East Sumba Regency. Utilizing forward chaining and certainty factor methods, the system is designed to generate diagnostic results based on user-input symptoms. Farming communities in East Sumba often rely on traditional practices, which can delay decision-making and adversely affect both poultry health and farmers' economic stability. The proposed expert system is intended to enable farmers to quickly and effectively access information on early disease symptoms and preventive measures. Additionally, this research seeks to enhance farmers' knowledge of poultry diseases, thereby reducing chicken mortality rates caused by infections. The integration of information technology into poultry farming is expected to improve efficiency and productivity within the agricultural sector in the region.

Keywords: Expert Systems, Chicken Diseases, *Forward Chaining*, Diagnostics, Web-Based.

1. Introduction

Chicken diseases can cause substantial losses in the livestock industry, adversely affecting poultry health and reducing overall productivity. In East Sumba, chicken farming serves as a significant source of income for the local community. According to data from the East Sumba Regency Livestock Office, the impact of poultry diseases has been considerable. In 2023, chicken mortality reached 428,386. Two major diseases identified were colibacillosis and *chronic respiratory disease* (CRD). By 2024, the recorded poultry population reached 1,573, with three additional diseases documented in East Sumba Regency: *vulnus,* bacterial infections, and arthritis. In other words, there are 5 identified diseases. As noted by Kauffman (2015), these infections can result in significant financial losses, particularly when they lead to sudden mortality and reduced egg production [1]. Farmers in East Sumba face similar challenges, as many still rely on traditional methods to detect and manage livestock diseases. This often results in delays in decision-making, adversely affecting both poultry health and farmers' economic stability. Therefore, a solution is needed to assist farmers in addressing these issues. Information technology, particularly web-based expert systems, offers a promising approach for timely disease diagnosis. Such systems can provide recommendations based on the symptoms exhibited by chickens, enabling farmers to take prompt and appropriate preventive measures.
Digitalization in farming, including the use of expert systems, is a step forward that is in line with current technological developments. (Hossain and Ahsan., 2020) noted that the application of information technology can increase efficiency and productivity in the agriculture and livestock sectors. By utilizing the expert system, farmers in East Sumba are expected to be able to better manage the health of chickens, resulting in quality products and increasing their income [2].

2. Bibliography Review

2.1. Poultry Diseases

Poultry diseases in chickens are a serious problem in the livestock sector because they can cause significant losses, both in terms of economics and productivity. These diseases are caused by various causative agents, such as bacteria, viruses, or parasites, which attack the chicken's immune system. This attack impacts the health, growth, and production of chickens. In addition to affecting infected chickens, poultry diseases are also easily transmitted to other chickens in the same environment. Therefore, implementing appropriate prevention, control, and treatment measures is crucial. Factors such as coop management, environmental cleanliness, feeding, and vaccination also play a crucial role in preventing the spread of poultry diseases. The following are five types of chicken diseases recorded by the East Sumba Regency Animal Husbandry Office:

a. *Colibacillosis* Disease

Colibacillosis is a disease caused by the bacterium *Escherichia coli* (*E.coli*), which generally affects young chickens. Common symptoms include lethargy, diarrhea, dull hair, anorexia, fever and depression, while specific symptoms include yellow or green diarrhea, as well as swelling in the abdominal area. The probability value of the occurrence of *colibasilosis* is 0.8/0.9. *Colibalosis* can cause significant economic losses in farming, especially through decreased hatchability and growth of chickens [3].

b. Chronic *Respirator Disease* (CRD)

Chronic Respiratory Disease (CRD) is caused by *Mycoplasma gallisepticum* and is a common infectious disease in chickens. Common symptoms include cough, lethargy, watery eyes, fever and nasal discharge, while the specific symptom is swelling of the face. The probability value of CRD is 0.7/0.9. It shows that CRD can decrease egg productivity and chicken growth, especially if accompanied by secondary infection with other pathogens [4].

c. *Vulnus* Disease (Viral Arthritis)

Vulnus, or viral *arthritis*, is caused by the *Orthoreovirus* virus and generally affects young chickens. Common symptoms that appear are lameness, lethargy, dull hair, fever and difficulty moving, while specific symptoms include joint swelling. The probability value of vulnus is 0.6/0.7. Viral arthritis can cause significant economic losses, especially in reduced growth and productivity of chickens.

d. Bacterial Infectious Diseases (Avian Cholera)

Bacterial infections, such as avian cholera caused by *Pasteurella multocida*, are highly contagious diseases for chickens and turkeys. Common symptoms seen include fever, lethargy, cough and anorexia, with specific symptoms in the form of swelling in the face and respiratory distress. The probability value of avian cholera is 0.8/0.9. The impact of poultry cholera on high mortality and significant economic losses in livestock [5].

e. Arthritis Disease

Arthritis in poultry, which can be caused by various bacterial or viral infections, is characterized by joint swelling and difficulty moving. Common symptoms include difficulty moving, fever, lethargy and pain, while specific symptoms are damage to the synovial membrane. The value of the probability of *developing Arthritis* is 0.7/0.9. Early treatment and good management are essential to prevent further impacts of the disease [6].

2.2. Expert System Planning

Expert system design is a system development process that utilizes a rule-based inference approach to draw conclusions from existing facts. In this known *forward chaining* method, the system starts with the information (facts) and applies the existing rules to reach a conclusion or diagnosis. *Forward chaining* moves from fact to conclusion, so it is very effective in situations where the initial data is already available and the system needs to make recommendations or decisions based on that data.
The *forward chaining* method in the expert system allows the system to actively seek solutions by utilizing all available information, so as to provide a more accurate and relevant diagnosis." He also added that "this approach is particularly useful in medical and veterinary applications, where quick and precise decision-making is essential for the health of the patient" [7].

2.3. *Forward Chaining*

Forward Chaining is one of the inference techniques used in expert systems and artificial intelligence to draw conclusions from existing facts. This method is known by starting from existing facts and applying existing rules to reach conclusions or solutions [8]. The following are the steps to use production rules in the research of System Design Experts to diagnose diseases in chickens using the *Forward Chaining Method*.
1. Step 1, ask the user questions.
2. Step 2, accommodate input from the user as the premise of rules in short-term memory.
3. Step 3, check the rules based on the inputs stored in short-term memory.
4. Step 4, provide a solution.

3. Research Methods

This research was conducted at the East Sumba Regency Livestock Office. The research flow used is as follows:

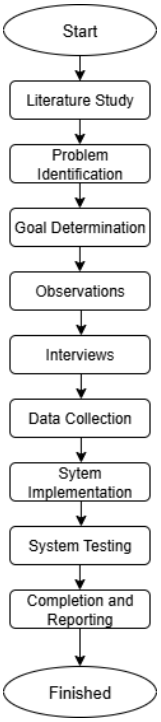

Fig. 1: Research Flow

The stages of this research consist of several key phases, as outlined below:

a. Literature Study: The researcher reviewed materials relevant to the research topic, including papers, journals, theses, conference proceedings, and archival sources.
b. Problem Identification: This stage involved identifying the specific problems to be addressed in the study.
c. Goal Determination: The research objectives and methodological approach were defined to guide the study.
d. Observations: Direct field observations were conducted to understand current practices and challenges in managing chicken diseases.
e. Interviews: Discussions with experts and chicken breeders were carried out to gather in-depth information about disease symptoms and existing diagnostic practices.
f. Data Collection: Data were compiled from various sources, including expert input and literature.
g. System Implementation: This phase involved developing the knowledge base using a programming language, applying the forward chaining method to process user-input symptoms, and incorporating a certainty factor to calculate the confidence level of the diagnostic results.
h. System Testing: Functionality and user testing were performed to ensure all system features operated as intended and to identify potential issues.
i. Completion and Reporting: After testing and refinement, the study was finalized, and a comprehensive report was prepared to present the findings and recommendations.

3.1. Development Methods

The research method employed in developing the expert system for diagnosing chicken diseases is the waterfall model. This method is widely used for information system development, starting from requirements analysis and system design. In this model, each phase must be completed before proceeding to the next stage. The implementation of the waterfall model in this study involves several stages, as outlined below:

3.1.1. Needs Analysis

At this stage, several requirements are identified, including the knowledge base, symptom and disease codes, names of disease symptoms, chicken diseases, and decision rules for diagnosing chicken diseases, as outlined below:

a. Knowledge Base

The knowledge base is an important component in an expert system that stores structured information for disease diagnosis containing relevant facts and rules. The knowledge used in this expert system, including the symptoms of diseases and information on the types of chicken diseases, was obtained through direct interviews with experts/veterinarians (drh. Hendrina K.M.Meha) from the East Sumba Regency Animal Husbandry Office. This information is the basis for the preparation of the system's knowledge base, including in determining the premise of symptoms, disease classification, and *Certainty Factor values* that are relevant to the reasoning process. The rules of production are written in the format of IF-THEN (if-then) statements, i.e. IF [Premise] THEN [Conclusion]. In the design of the knowledge base of the specialist system, the premise refers to the symptoms of the disease experienced. Thus, the statement becomes IF [Symptoms] THEN [Disease].

These symptoms are connected by using the *AND logic operator*, so the form of the question is:

IF [Symptom 1 lethargy]

AND [Symptoms of 2 dull furs]

AND [Symptoms of 3 yellow diarrhea]

THEN [Colibacillosis *disease*]

Fig. 2: Logical operators

The *forward chaining* method is known by starting from existing facts and applying existing rules to reach conclusions or solutions. In this context symptoms function as facts, once all the data is fulfilled the information can be used to draw a conclusion about a symptom and disease.

Table. 1: Disease Code

Disease Code	Disease Name
P01	Kolibasilosis
P02	*Chronic Respiratory Disease* (CRD)
P03	Valnus
P04	Bacterial Infections (Avian Cholera)
P05	Arthritis

Table 2: List of Symptoms

Disease Name	Symptom
Kolibasilosis	Lethargy, dull hair, anorexia, fever, depression, yellow or green diarrhea, ,abdominal swelling.
Chronic Respiratory Disease (CRD)	Cough, lethargy, watery eyes, fever, nasal discharge, swelling of the face.
Valnus (Viral Arthritis)	Lameness, lethargy, dull hair, fever, difficulty moving, joint swelling.
Bacterial Infections (Avian Cholera)	Fever, lethargy, cough, anorexia, swelling in the face, respiratory distress.
Arthritis	Difficulty moving, fever, lethargy, pain, damage to the synovial membrane.

Table 3: Symptom Code

Symptom Code	Gejala
G01	Weak
G02	Diarrhea
G03	Dull fur
G04	Anorexia
G05	Fever
G06	Depression
G07	Cough
G08	Watery springs
G09	Nasal secretions
G10	Limp
G11	Difficulty moving
G12	Abdominal swelling
G13	Facial swelling
G14	Respiratory disorders
G15	Nyeri
G16	Swelling of the synovial membrane
G17	Swelling in the Joints

Table 4: Disease Knowledge Base

No.	Disease Rules
1.	IF lethargy AND diarrhea is yellow or green THEN the possibility *of Colibasilosis*.
2.	IF Dull hair AND Anorexia THEN *Colibasilosis is possible.*
3.	IF Cough AND Lethargy THEN Chronic *Respiratory Disease* (CRD) is possible.
4.	IF watery eyes AND fever THEN it is possible *Chronic Respiratory Disease* (CRD).
5.	IF Lame AND Lethargic THEN possibly *Vulnus* (*Viral Arthritis*).
6.	IF dull fur AND difficulty moving THEN possibly *Vulnus* (*Viral Arthritis*).
7.	IF Fever AND Lethargy THEN it is likely Avian Cholera.
8.	IF Cough AND Swelling on the face THEN possible Avian Cholera.
9.	IF Difficulty Moving AND Pain THEN Arthritis Is Likely.
10.	IF fever and lethargy THEN it is possible *Arthritis*.

Table 5: Decision Rules

Type Code Disease (Awards)	**Disease Rules**				
	RP1	**RP2**	**RP3**	**RP4**	**RP5**
G01	✓	✓	✓	✓	✓
G02	✓				
G03	✓		✓		
G04				✓	
G05	✓	✓	✓	✓	✓
G06	✓				
G07		✓		✓	
G08	✓	✓			
G09		✓			
G10			✓		
G11			✓		✓
G12	✓				
G13		✓		✓	
G14				✓	
G15					✓
G16					✓
G17			✓		
Conclusion (Action)			✓		
P01	✓				
P02		✓			
P03			✓		
P04				✓	
P05					✓

Based on table 5 the *decision rules used by the* system to determine the type of chicken disease based on the symptoms that appear, the data in this table was obtained through interviews with experts or veterinarians at the East Sumba Regency Livestock Office, this table consists of the symptom code column (G01–G17) and the disease rule column (RP1–RP5) which represents five types of diseases, namely P01–P05. The checkmark () indicates the relationship between a specific symptom and rule. At the bottom, the conclusion (✓ *action*) shows the results of the diagnosis set by the system based on the compatibility of symptoms with existing rules. This table serves as the basis for decision-making in the expert system when matching user input.

3.2. Certainty Factor + Forward Chaining *Algorithm Workflow*

Forward Chaining is an inference method used in expert systems to draw conclusions based on available data. When combined with *the Certainty Factor* (CF), this method can produce a more precise diagnosis in conditions of uncertainty because it also obtains certainty from the data. Here are the steps in the workflow of this algorithm:

Forward Chaining:

a) The process begins by checking for existing symptoms. If the symptoms are in accordance with the rules, CF is calculated and added.
b) For each symptom, if the relevant rules are met, calculate the CF using the formula.

CF Calculation:

A *Certainty Factor* (CF) value of 0-1 is as follows:

Table 6 : CF Calculation

Nilai Certainty Factor	Categories of each certainty value
1	Very confident
0,6 - 0,9	Believe
0,1 - 0,5	Lack of confidence
0	Not Yakit

Description 1 :

Rumus *Certainty Factor*:

CF [H,E]= MB[H,E] – MD[H,E]

CF[H,E] = *Certainty Factor* for hypothesis H, based on evidence E shows how much confidence in the hypothesis is after considering the existing evidence.

MB[H,E] = *Measure of belief* (measure of belief) is obtained by hypothesis H, if evidence E is given (between 0 and 1).

MD[H,E] = *Measure of disbelief* towards *evidence* H, if given *evidence* E (between 0 and 1)

3.3. *Use Case Diagram*

Use Case Diagram is a type of diagram in *Unified Modeling Language* (UML) that functions to describe the relationship between *actors* (users) and systems based on available functions or services. *This diagram* shows the interactions that users can have with the system, without explaining the details of how the system works technically. The following is a *use case diagram* for *admins* and *users* which can be seen in figure 2 and figure 3:

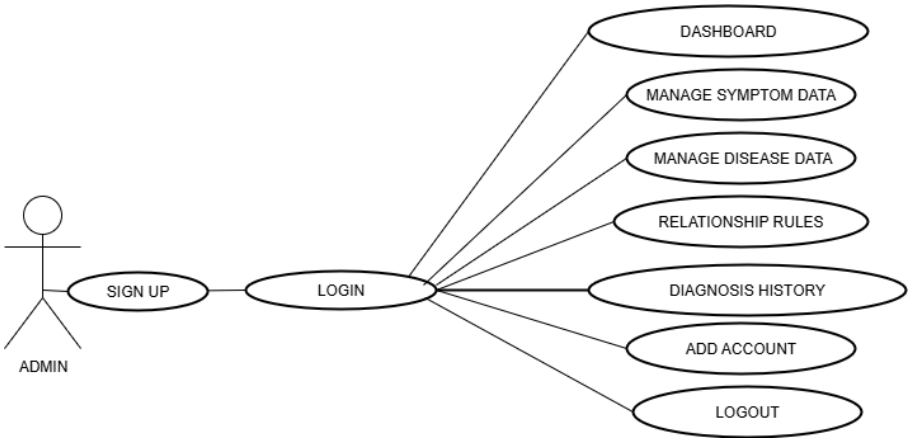

Fig. 3 : *Use Case Diagram Admin*

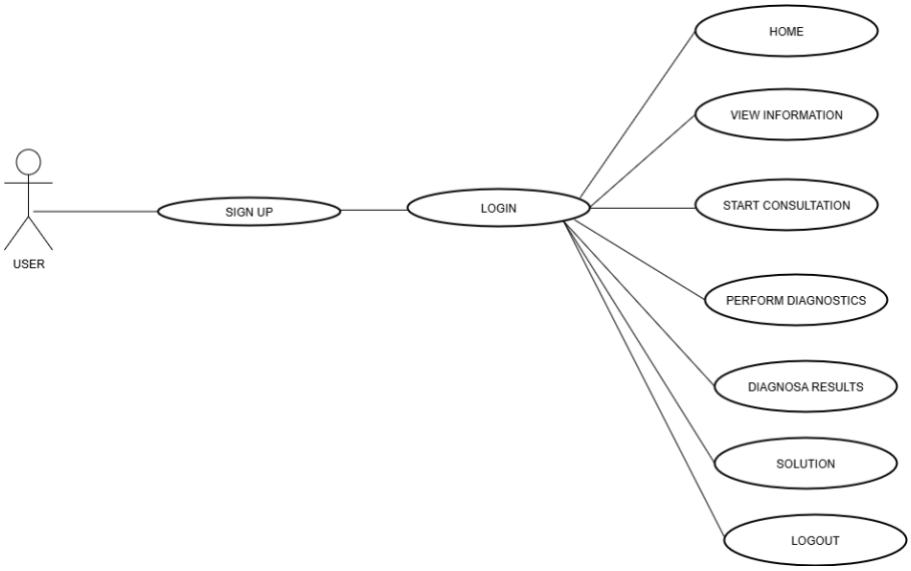

Fig. 4 : *Use Case Diagram User*

4. System Implementation and Testing

4.1. System Implementation

The specialist system that has been designed is then implemented into the form of a system that functions to diagnose diseases in chickens. The following is a view of the results of the system implementation:

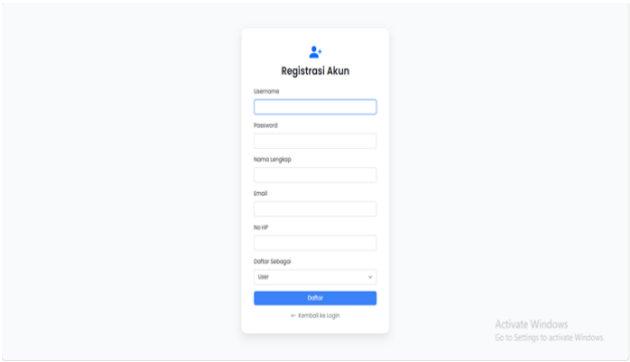

Fig. 5 : Account Registration Page

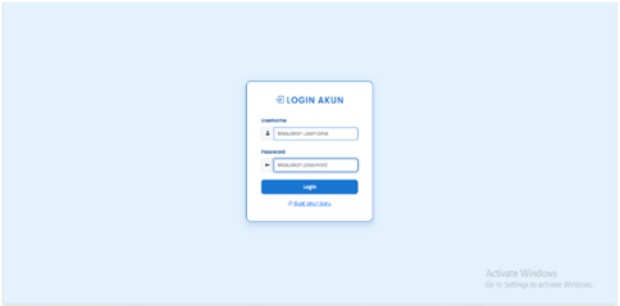

Fig. 6: Account Login Page

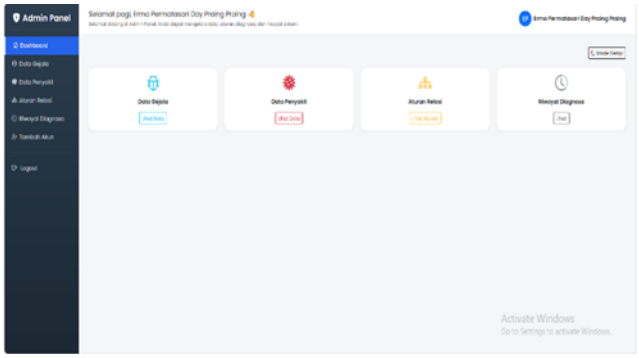

Fig. 7 : Admin *Dashboard Page*

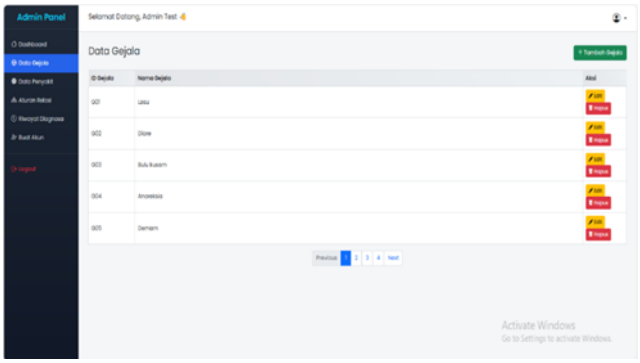

Fig. 8 : Admin Symptom Data Page

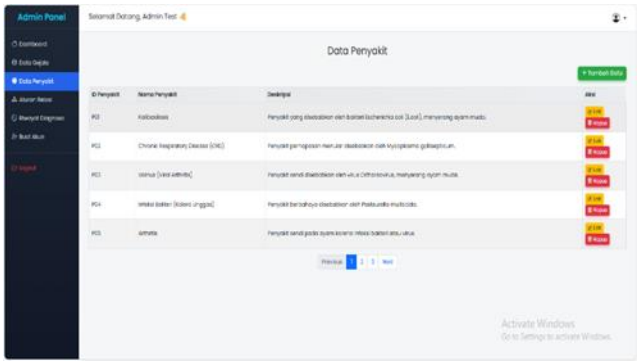

Fig. 9 : Admin *Disease Data Page*

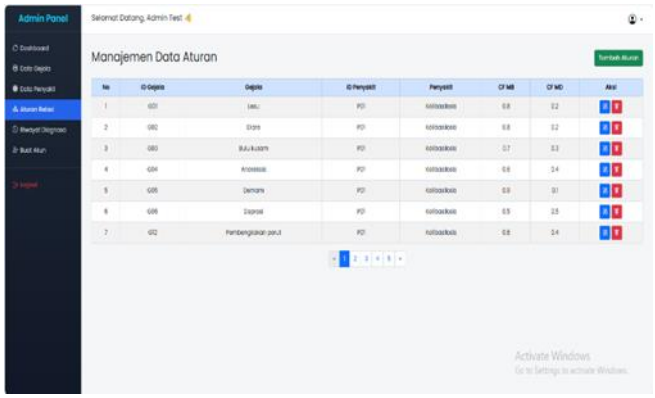

Fig. 10 : Admin Relationship Rules Page

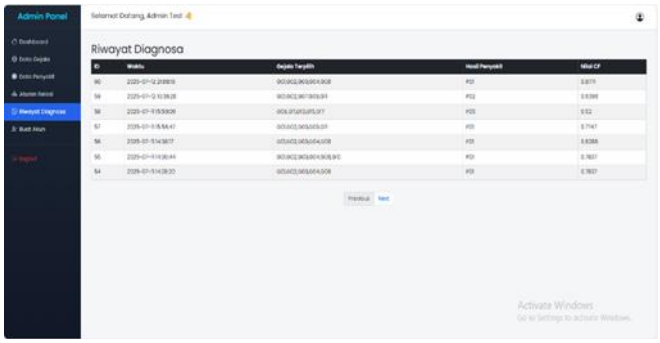

Fig. 11 : Admin Diagnosis History Page

Fig. 12 : Home *User Page*

Fig. 13 : User *Information Page*

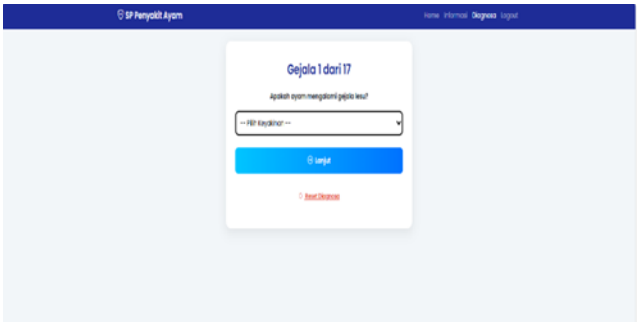

Fig. 14 : User *Diagnosis Page*

Fig. 15 : User Diagnosis Results Page

4.2. System Testing

At this stage, black box testing is carried out to evaluate the extent to which the system can meet the desired commands. If an error is found, it can be identified and corrected by going back to the initial stage.

Table 7 : Black *Box Testing*

No.	Test Scenarios	Input	Output yang Expected	Status
1.	Log in with valid credentials	Correct username and password	Access to the user dashboard	✓
2.	Log in with invalid credentials	Incorrect username or password	Error message: "Username or password is wrong"	✓
3.	View symptom list	-	List of available symptoms	✓
4.	View a list of diseases	-	List of available diseases	✓
5.	Seeing solutions to diseases	Select diseases	Selected disease-related solutions	✓
6.	Filling in the symptoms for diagnosis	Selected list of symptoms	Results of the diagnosis of the disease	✓
7.	Consultation with an expert	Questions or symptoms	Response from experts	✓
8.	Register as a *new* user	Complete registration data	Successful registration confirmation message	✓
9.	Change *user profiles*	New data for profiles	Successful profile change confirmation message	✓
10.	Log out of the system	-	Return to the login page	✓

Based on Table 7 above, it is a *black box testing* test for *users* and *admins* that shows that the results of this system test are successful.

5. Conclusion

The results of the system's research and development demonstrate that the web-based expert system successfully diagnoses chicken diseases, which remain a critical issue in East Sumba Regency. By integrating the forward chaining and Certainty Factor (CF) methods, the system provides accurate diagnoses based on user-input symptoms. The findings indicate that this system not only assists farmers in identifying diseases more efficiently but also enhances their understanding of early symptoms that threaten poultry health. Designed to address the limitations of traditional diagnostic practices, the expert system enables farmers to access timely and reliable information, allowing them to implement appropriate preventive measures. As a result, the system has the potential to reduce chicken mortality rates and improve overall productivity. Moreover, by supporting better poultry health management, the system can contribute to increased economic efficiency for farmers, positively impacting production yields in both meat and egg output.

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