Research Article

Expert System to Determine the Fermentation Quality of Sheep Feed Using Forward Chaining Method

[1*]Farida Yunita, [2]Siwi Bi'arfina Sadya, [2]Fatih Syariful Mubarrok, [2]Ragil Widiarto, [2]Setyo Pamungkas

[1] D3 Study Program in Informatics Management, STMIK Bina Patria, Magelang City, Central Java, Indonesia
[2] Bachelor of Information Systems Study Program, STMIK Bina Patria, Magelang City, Central Java, Indonesia

* Corresponding Author: frida_diajeng@stmikbinapatria.ac.id

Abstract: Livestock productivity is strongly influenced by three main pillars: breeding, feeding, and management. The quality of animal feed, especially for sheep, is highly dependent on the raw materials used, which must have a balanced nutritional content and quality. Grass as the main feed is becoming increasingly difficult to obtain due to land conversion, so the use of concentrates and feed fermentation techniques is a promising solution. This research focuses on the development of an expert system to determine the quality of fermented sheep diets using the forward chaining method. The forward chaining method is used to organize the facts and data collected to arrive at the optimal solution. Feed quality is classified into three grades (G1, G2, G3) based on the ingredients used and certain criteria. Through observation, interviews, problem identification, understanding, analysis, and literature study, this system is designed to assist farmers in choosing the right and efficient feed ingredients. The results show that this expert system is effective in identifying and classifying the quality of fermented sheep diets and provides clear guidance to feed manufacturers in selecting suitable ingredients. The system is also expected to be developed into a mobile application to help users obtain information quickly and accurately, thereby increasing the efficiency and effectiveness of sheep feed management.

Keywords: Fermented Feed; Forward Chaining; Sheep; Expert system; Sheep feed management

Citation: F.Yunita, S.B.Sadya, F.S.Mubarrok, R.Widiarto, S.Pamungkas, "Expert System to Determine the Fermentation Quality of Sheep Feed Using Forward Chaining Method", *Iota*, **2024**, ISSN 2774-4353, Vol.04, 03. https://doi.org/10.31763/iota.v4i3.780

Academic Editor : Adi, P.D.P

Received : July, 13 2024

Accepted : July, 21 2024

Published : August, 20 2024

1. Introduction

Livestock productivity is influenced by the three pillars of livestock production: breeding, feeding, and management. Raw materials are very important to produce high-quality feed with a balanced nutrient content. Grass as a raw material for sheep feed has a wide range of nutritional content, and as Angonan and agricultural land have been converted for housing and industrial purposes, the quality of grass is declining. Therefore, the use of concentrates can be a promising alternative. Compared to forage, concentrates promote growth, conversion efficiency, protein, and energy. They also digest and ferment more quickly.

Green fodder and concentrates are very important to meet the nutritional needs of livestock. Farmers in some areas, such as Magelang, Salatiga, Temanggung, and Wonosobo, have easy access to fodder, but in other areas, they can only use local fodder, which is deficient in nutrients, especially protein. The health and productivity of livestock, especially sheep, are affected by the availability of adequate nutrients in animal feed. It also affects the overall efficiency of the livestock enterprise. Fermentation techniques are emerging as a promising solution to overcome this problem and improve the nutritional quality of forage and local feed. The fermentation process uses microorganisms that can increase the protein content of the feed, allowing the conversion of organic compounds into simpler forms. The composition, dosage, and processing of the fermented feed determine the quality of the feed.

From the description, it can be concluded that the production of quality sheep feed is not just a matter of high-quality ingredients. The selection of the right material for sheep, and the process of mixing, blending, and storage of the feed are also factors that determine the quality of the feed. Therefore, the author discusses the topic of an expert system to determine the quality of fermentation of sheep feed using the forward chaining method [21]. The aim is to help those who want to start sheep farming to save grazing time, have more flocks to use during the long dry season, and increase the nutritional value of the feed.

According to Firtawaty, et al (2022)[4] the research on Improving the Quality of Animal Feed with Perforation Techniques in the Goat Livestock Business Group in Patumbak I Deli Serdang Village, aims to overcome the obstacles faced by business partners in managing agricultural products to be used as fermented feed. It was concluded that improving the quality of animal feed had an impact on the quality and quantity of livestock, so it was necessary to develop a livestock system to a fattening system that required a relatively short time and increased insight for business partners about the fermentation process.

According to Budi Purwo Widiarso, et al (2023)[2] from the study The Effect of Addition of Lactobacillus plantarum with Different Levels on Organoleptic Quality, pH and Nutrient Content of Kol Vegetable Waste Silage (Brassica oleracea L. var. Capitata L.), aims to determine the effect of treatment on the physical quality variable of cabbage vegetable waste silage using Lactobacillus plantarum, knowing the effect of treatment on the variables of crude fiber content, moisture content, dry matter, and crude protein of cabbage vegetable waste silage using Lactobacillus plantarum, knowing the effect of treatment on the pH value variable of cabbage vegetable waste silage using Lactobacillus plantarum, as well as knowing the optimal level of Lactobacillus plantarum needed to improve organoleptic quality, pH, and nutrient content of fermented cabbage waste silage using Lactobacillus plantarum. It was concluded that the results of organoleptic testing showed that the physical quality of cabbage waste silage using Lactobacillus plantarum was brownish yellow to green boiled leaves, moderately acidic to pungent acidic, and moderately textured to not easily destroyed, Silage using Lactobacillus plantarum had a significant effect on changing the pH value from 3.8 to 4.34, then Silage using Lactobacillus plantarum had a significant effect on changing silage nutrients including water content from 86.71% to 89.03%, dry matter from 10.97% to 13.29%, crude protein from 12.77% to 18.87%, and crude fiber from 8.73% to 13.56%. Based on organoleptic, pH, and nutrient content, the best results were obtained in the treatment of the addition of 2% Lactobacillus plantarum.

According to Salsa Billah Lilia Dewi, et al (2024)[3] the research on Rice Straw Fermentation Innovation as Animal Feed to Create Livestock Welfare in Musir Lor Village, aims to educate villagers so that harvest waste can be given or sold or will be further managed by farmers to be used as additional food for livestock. It was concluded that the great potential of rice straw as an alternative livestock feed source was proven, with various fermentation methods such as the use of probiotics or ammonia. The main components of fermented animal feed include rice straw, brown sugar/molasses, and EM-4, with necessary equipment such as plastic sheeting, scales, stirrers, and large storage containers.

2. Theory

2.1 Feed

Feed is food or food given to animals (pets). This term has been adopted from the Javanese language. Feed is a source of energy and material for the growth and life of living things. The most important substance in feed is protein.

2.2 Fermentation

Fermentation is a process of chemical change, from complex compounds to simpler ones with the help of enzymes produced by microbes. Enzyme activities involved in the fermentation process include amylase, protease, and lipase.

2.3 Forward Chaining

The forward chaining method is a forward search that starts with several facts and looks for guidelines that are consistent with the assertions or hypotheses that lead to a result or conclusion [7-12].

3. Method

3.1 Research Stages

The stages of research used in this study include:

1. Observation
   The collection of data through systematic and directed observation and recording of the symptoms of the research subject is called observation. Observing the process of making fermented sheep feed is an example of observation.
2. Interviews
   Interviews are a data collection technique used to find problems that need to be researched by debriefing the interviewee. By asking the interviewee questions, the interview is used to collect data to identify problems that need to be researched. Mr. Susilo and Mrs Endriyaningsing Yunita, restaurant entrepreneurs who use fermented food processing, were the subjects of the interviews.
3. Identification
   Identification of problems based on their scope; in this study, the problem was to determine the composition of good fermented feed to produce superior sheep; in this study, the problem was to determine the composition of good fermented feed to produce superior sheep.
4. Understanding and Analysis
   Understanding and analysis were carried out on the data obtained from the interview results.
5. Literature Review
   A literature study is an activity to collect information that is relevant to the topic or object of research. This information can be obtained from scientific papers, literature, and the internet.

3.2 Forward Chaining Method

An Expert System or expert system is a system designed to mimic the ability and knowledge of humans to computers so that computers can solve problems as experts usually do [4]. Expert systems can use several methods, including the Certainty Factor, Backward Chaining, and Forward Chaining [5].

In this study, the forward chaining method as an approach was chosen because it allows the search process to begin by selecting a collection of data and facts, which are then compiled based on the selected facts.

The Forward Chaining method is a method that begins the process of searching for a set of data or facts. From these data, a conclusion is sought that is the solution to the problem at hand. Forward Chaining starts the search process with data so this strategy is also called data-driven [6,13,14,15].

The application of the Forward Chaining Method is to check each rule on a knowledge base and collect appropriate facts in each rule examined [16-20]. Then, these facts are used to activate other rules and are continuously processed until a final solution is obtained to overcome the problems faced. Figure 1 shows how the forward chaining process runs, where a set of action-condition rules is used.

In this study, an expert system was used for the procedure of handling the knowledge base on the fermentation quality of sheep feed. According to Nukman, et al (2023) [7] there are 3 stages carried out to conduct expert system research, namely the scaling stage, the search stage, and the decision tree stage. The process of implementing an expert system to determine the quality of fermentation of sheep feed is as follows:

1. *Tracking Method*
   In the process of fermentation of animal feed, the tracking method used is the forward chaining method. Using the tracking method, a trace will be carried out

to detect all data regarding feed ingredients and rules to obtain feed fermentation results for quality sheep.

2. *Search methods*
In the fermentation process of animal feed, the search method used is the best first search method. This search method will check all fermented feed ingredients that have been collected. By using this method, the search process will be more effective to get quality results without having to do more testing.

3. *Decision Tree Method*
To determine the quality of sheep feed fermentation, binary trees are used, namely the formation of decision trees in the design of expert systems. The decision tree that can be seen in Figure 1 is combined with the best first search method.

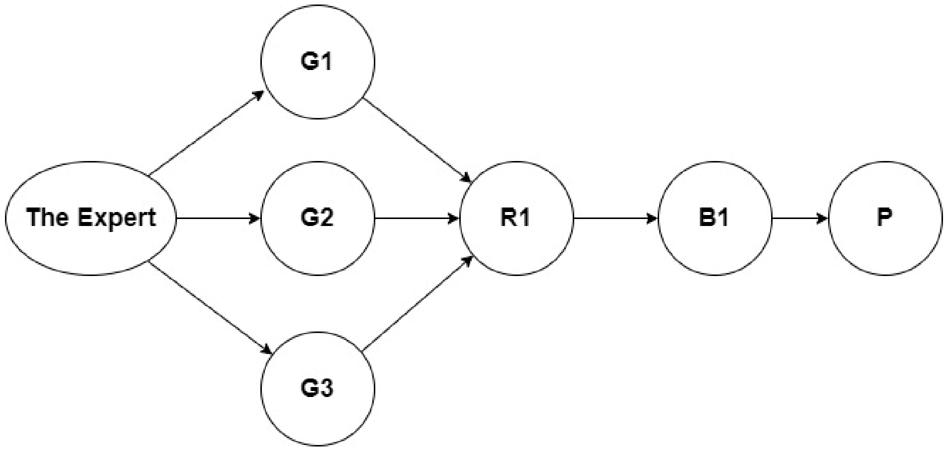

Figure 1. Best First Search Decision Tree

Notes
G1-G3: Feed fermentation mixture quality grade
R1: Rules
B1: Feed fermentation material
P: Conclusion

4. *Decision Tree Designing*
A decision tree diagram is a design in the form of a tree that is used to build an expert system, the decision tree diagram will provide convenience in compiling the necessary set of rules as can be seen in Figure 2.

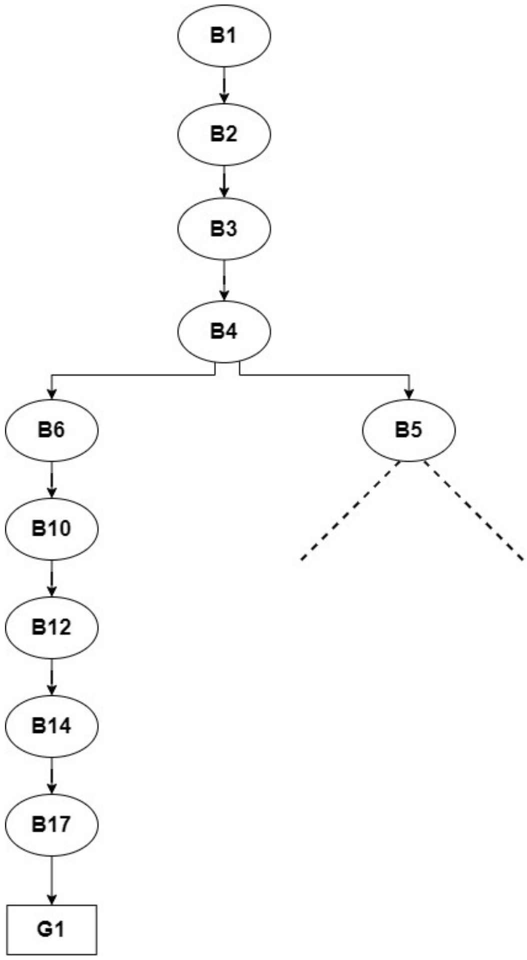

Figure 2. Decision Tree Determines Quality Feed Fermentation For Sheep

Notes: B1-B15: Fermented Feed Ingredients

4. Result and Discussion

4.1 Knowledge Base

A knowledge base is a representation of the knowledge of an expert. The knowledge base possessed by an expert in determining the quality of fermentation of sheep feed is an acquisition from a source of knowledge.

4.1.1 Feed quality or grade.

Feed quantity is divided into three, i.e.:
G1: Grade 1
G2: Grade 2
G3: Grade 3

4.1.2 Criteria

Here are some criteria for fermenting sheep feed ingredients that can be used to determine the quality of fermented feed:

B1 : Kleci
B2 : Salt
B3: Copra Bungkil
B4: Fine Bran
B5: Rough Bran
B6: Fine Wheat Dregs
B7: Coarse Wheat Dregs
B8 : Pongkol Tela Smooth

B9 : Pongkol Tela Rough
B10: Smooth Coffee Skin
B11: Rough Coffee Skin
B12: Rendeng Kangkung halus
B13 : Rendeng Kangkung Kasar
B14 : Pollared Cilacap
B15: Pollared Golden Stick
B16: Pollared Goose Cap
B17 : Nutrified BC1314
B18 : Nutrified BC133
B19 : Nutrifieed BC132
B20 : Nutrified BC131

Furthermore, Grade 1 (G1) in this context refers to the highest classification for the fermentation quality of sheep feed. Grade 1 ingredients meet the optimum standards for the fermentation process, resulting in a feed with the best nutritional value and fermentation characteristics.

Grade 2 represents good quality fermentation of sheep feed, but is below the optimal standard of grade 1. Ingredients in this category produce fermented feeds of adequate quality for sheep nutrition but may have some minor limitations. In the decision tree, Grade 2 is achieved via the right path after node B4. Ingredients are classified as Grade 2 if they meet all the evaluation criteria with a 'yes' answer along the path.

Grade 3 indicates acceptable fermentation quality of sheep diets, but falls below the standards of grades 1 and 2. Ingredients in this category produce fermented feed that can still be used but may require additional treatment or blending with other ingredients to improve their quality. In the decision tree, Grade 3 is achieved via the right path after node B4, where at least one evaluation criterion is answered with "NO".

Moreover, the decision tree shows the sheep feed fermentation quality classification process, focusing on Grade 1 which is the highest quality. Ingredients included in Grade 1 are:

1. B1 (Material 1)
2. B2 (Material 2)
3. B3 (Material 3)
4. B4 (Material 4)
5. B6 (Material 6)
6. B8 (Material 8)
7. B10 (Material 10)
8. B12 (Material 12)
9. B14 (Material 14)
10. B17 (Material 17)

From the knowledge of the fermentation criteria of sheep feed that has been presented, the knowledge base can be made as follows Table 1.

Table 1. Knowledge-Based

Materials code	**Grade Code**		
	G1	**G2**	**G3**
B1	x	x	x
B2	x	x	x
B3	x	x	x
B4	x		

Materials code	**Grade Code**		
	G1	**G2**	**G3**
B5		x	x
B6	x		
B7		x	x
B8	x		
B9		x	x
B10	x		
B11		x	x
B12	x		
B13		x	x
B14	x		
B15		x	
B16			x
B17	x		
B18		x	
B19		x	
B20			x

Testing for the classification of sheep feed fermentation quality including Grade 1 (G1), Grade 2 (G2), and Grade 3 (G3) can help farmers or feed manufacturers quickly identify ingredients that will produce the best quality sheep feed fermentation, improve efficiency in the material selection process and potentially improve the quality of the feed nutrients produced.

Table 2. Quality Classification Testing

Evaluation Criteria	Grade 1 (G1)	Grade 2 (G2)	Grade 3 (G3)
Materials	B1,B2,B3,B4,B6,B8,B10 B12,B14,B17	All Ingredients other than those in G1	All Ingredients other than those in G2
High Quality	Consistently Meets the Highest Standards	Meets intermediate standards	Meets minimum quality standards
Flexibility	Optimal Choice for best fermentation	Alternative Viable If Grade 1 is not available/expensive	May require modification /mixing.
Potential Upgrades	-	Can be upgraded with Minor adjustments	May require additional treatment for improvement
Economy	High quality may cost more	More economical options when grade 1 is not available	Economical choice with trade-offs on quality.
Example of use	Production of the highest quality feed	Production of feed with medium quality materials	Production of feed with minimum quality ingredients

Notes:
R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1
R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2
R3: IF B3 AND B9 AND B13 AND B20 THEN G3
R4: IF B3 AND B1 THEN FAIL
R5: IF B4 THEN FAIL

Table 3. Developed Testing

Number	Fact	R1	R2	R3	R4	R5	Results
1	B1,B3,B8,B6,B14,B17,B10	✓					G1
2	B1,B16,B17,B9,B11		✓				G2
3	B14,B8,B10,B3			✓			G3
4	B3,B1				✓		FAILED
5	B4					✓	FAILED
6	B1,B3,B8,B6,B14,B17,B10						unknown
7	B14,B8,B10,B3			✓			G3
8	B1,B16,B17,B9,B11		✓				G2
9	B3,B1,B4				✓	✓	FAILED
10	B1,B3,B8,B6,B14,B17,B10	✓					G1

Explanation for additional testing:

a) This combination is similar to R1, but lacking B6. Because no rule fully matches, the result is UNKNOWN.
b) This is a combination of R3 with an additional B1. Since all R3 requirements are met, the result is still G3.
c) This is a combination of R2 with an additional B14. Since all the conditions of R2 are met, the result is still G2.
d) This combination meets R4 and R5, but because R4 is more specific (requires two ingredients), R4 is used, so the results FAIL.
e) This is a combination of R1 with an additional B16. Since all the conditions of R2 are met, the result is still G2.

In this test, we see that:

a) Some combinations of ingredients produce a certain grade despite the presence of additional ingredients (7, 8, 10).
b) A combination that does not meet all the conditions of the existing rule results in UNKNOWN (6).
c) When there is a conflict between rules, a more specific rule takes precedence (9).

Rules:
R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1
R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2
R3: IF B3 AND B9 AND B13 AND B20 THEN G3
R4: IF B3 AND B1 THEN FAIL
R5: IF B4 THEN FAIL

Iteration 1

DATABASE

B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B16 B17 B18 B19 B20

DATABASE
B1,B3,B8,B6,B14,B17,B10

NEW FACTS
G1

KNOWLEDGE BASE

R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1

R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2

R3: IF B3 AND B9 AND B13 AND B20 THEN G3

R4: IF B3 AND B1 THEN FAIL

R5: IF B4 THEN FAIL

KNOWLEDGE BASE
R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1
R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2
R3: IF B3 AND B9 AND B13 AND B20 THEN G3
R4: IF B3 AND B1 THEN FAIL
R5: IF B4 THEN FAIL

Iteration 2

DATABASE
B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B16 B17 B18 B19 B20

DATABASE
B1, B2, B13, B9, B11, B18, B19

NEW FACTS
G2

KNOWLEDGE BASE

~~R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1~~

R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2

R3: IF B3 AND B9 AND B13 AND B20 THEN G3

R4: IF B3 AND B1 THEN FAIL

R5: IF B4 THEN FAIL

KNOWLEDGE BASE
R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1
R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2
R3: IF B3 AND B9 AND B13 AND B20 THEN G3
R4: IF B3 AND B1 THEN FAIL
R5: IF B4 THEN FAIL

Iteration 3

DATABASE

B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B11 B12 B13 B14 B16 B17 B18 B19 B20

DATABASE
B3, B9, B13, B1, B7, B20

NEW FACTS
G3

KNOWLEDGE BASE

~~R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1~~

~~R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2~~

R3: IF B3 AND B9 AND B13 AND B20 THEN G3

R4: IF B3 AND B1 THEN FAIL

R5: IF B4 THEN FAIL

KNOWLEDGE BASE

R1: IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1

R2: IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2

R3: IF B3 AND B9 AND B13 AND B20 THEN G3

R4: IF B3 AND B1 THEN FAIL

R5: IF B4 THEN FAIL

Notes :

Iteration 1: The initial facts are B1, B2, B3, B4, B8, B6, B14, B17, B10. The rules applied are "IF B1 AND B3 AND B8 AND B6 AND B14 AND B17 AND B10 THEN G1", resulting in G1 in the form of new facts.

Iteration 2: Initial facts B1, B2, B13, B9, B11, B18, B19. The rules applied are "IF B1 AND B13 AND B18 AND B9 AND B11 THEN G2", resulting in G2 in the form of new facts.

Iteration 3: The initial facts are B3, B9, B13, B1, B7, B20. The rules applied are "IF B3 AND B9 AND B13 AND B20 THEN G3", resulting in G3 in the form of new facts.

The user interface for this application is shown in Figure 3 and Figure 4.

Figure 3. Consultation Page

Figure 4. Consultation Result Page

5. Conclusion

The resulting system has a simple display to determine the quality of sheep feed fermentation and three main categories have been identified, namely Grade 1 (G1), Grade 2 (G2), and Grade 3 (G3). Each category has a different definition, classification method, and meaning, allowing a clear differentiation of quality and providing guidance in the selection of the right feed ingredients. This three-level classification system provides a comprehensive framework for the evaluation and selection of ingredients in the production of fermented sheep diets. With this system, feed manufacturers can make more informed and strategic decisions, balancing nutritional quality, ingredient availability, and economic considerations to improve the efficiency and effectiveness of sheep feed management and potentially improve the quality of the feed nutrients produced, providing long-term benefits to the livestock industry. It is hoped that this system can help users to identify quality fermented feed ingredients for sheep feed. For further research, it is expected that the knowledge base representation system can be developed with a frame representation so that the result can be expected to be more accurate in quality categorization.

Acknowledgments: Thanks to the team at D3 Study Program in Informatics Management, STMIK Bina Patria, Magelang City, Central Java, Indonesia, and Bachelor of Information Systems Study Program, STMIK Bina Patria, Magelang City, Central Java, Indonesia, hopefully this research will be a good reference and can be developed in similar and linear research, especially in the field of Artificial Intelligence (AI) development in the future.

Author contributions: All authors are responsible for building Conceptualization, Methodology, analysis, investigation, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision of project administration, funding acquisition, and have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. F.Fitrawaty, et.al, (2023). “Improving the Quality of Animal Feed by Fermentation Technique in Goat Livestock Business Group in Patumbak I Deli Serdang Village”, Jurnal Pengabdian Masyarakat, STIE Asia, Vol.4.No.1, doi: 10.32815/jpm.v4i1.1336 [Crossref]
2. B.P.Widiarso, N.N.Afifah, A.Perdinan (2023), "Pengaruh Penambahan Lactobacillus plantarum dengan Level yang Berbeda Terhadap Kualitas Organoleptik, pH dan Kandungan Nutrien Silase Limbah Sayur Kol (Brassica oleracea L. var. capitata L.), Jurnal Penelitian Peternakan Terpadu, Vol.5 No.2, e-ISSN:2714-5964, [Crossref]
3. S.B.L.Dewi, et.al, 2024, "Inovasi Fermentasi Jerami Padi Sebagai Pakan Ternak guna Menciptakan Kesejahteraan Peternak di Desa Musir Lor", Jurnal Pengabdian Masyarakat Inovasi Indonesia, JPMII, Vol.2.No.3, DOI: 10.54082/jpmii.469 [Crossref]
4. Yuliana, Paradise, dan Kusrini, 2018, "Sistem Pakar Diagnosa Penyakit Ispa Menggunakan Metode Naive Bayes Classifier Berbasis Web", CSRID Journal, Vol. 10 No. 3 Juni 2018, Hal. 127-138 ISSN: 2085-1367, https://www.doi.org/10.22303/csrid.10.3.2018.127-138 eISSN :2460-870X or https://garuda.kemdikbud.go.id/documents/detail/998837
5. D.A.I.Sari, et.al, 2022, "Penerapan Metode Forward Chaining pada Sistem Pakar Pendeteksi Awal Omicron", Edumatic, Jurnal Pendidikan Informatika, Vol.6, No.2, doi:10.29408/edumatic.v6i2.6316 [Crossref]
6. A.M.Yusuf, A.Priatna, C.Cristiani, 2022, "Rancang Bangun Sistem Pakar Pola Hidup Sehat Berbasis Web Dengan Metode Forward Chainning", Jurnal Teknologi Sistem Informasi dan Sistem Komputer TGD, Vol.5 No.2, doi: 10.53513/jsk.v5i2.5639 [Crossref]

7. Ns, N, Khulaimi, M, & Taqiudin, M (2023). Computer Service Expert System Design Using Forward Chaining Method. Jurnal Tampiasih, Jurnal.aspirasi.ac.id,https://jurnal.aspirasi.ac.id/index.php/thanks/article/view/9
8. D. R. Mardian, S. Risnanto, E. Garnia, K. M. Adhinugraha, H. Rahayu and R. S. Rachman, "Forward Chaining and Certainly Factor Method Optimization for Lung Disease Expert System," 2023 17th International Conference on Telecommunication Systems, Services, and Applications (TSSA), Lombok, Indonesia, 2023, pp. 1-4, doi: 10.1109/TSSA59948.2023.10366958.
9. I. Taufik, M. Irfan, D. Wahyudi, Y. A. Gerhana and A. R. Atmadja, "Implementation of the Forward Chaining and Dempster Shafer Methods in Diagnosing Tonsillitis," 2023 IEEE 9th International Conference on Computing, Engineering and Design (ICCED), Kuala Lumpur, Malaysia, 2023, pp. 1-5, doi: 10.1109/ICCED60214.2023.10425389.
10. H. Mustafidah, B. R. Alfiansyah, Suwarsito, Purnomo and N. Hidayat, "Expert System Using Forward Chaining to Determine Freshwater Fish Types Based on Water Quality and Area Conditions," 2023 Eighth International Conference on Informatics and Computing (ICIC), Manado, Indonesia, 2023, pp. 1-5, doi: 10.1109/ICIC60109.2023.10382066.
11. M. Iqbal and R. Omar, "Automatic Guided Vehicle (AGV) Using Forward Chaining Method," 2023 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE), Bandar Lampung, Indonesia, 2023, pp. 56-60, doi: 10.1109/ICCTEIE60099.2023.10366680.
12. M.T.Hafizal, et.al, 2023, "Implementation of expert systems in potassium deficiency in cocoa plants using forward chaining method", Procedia Computer Science, Volume 216, Pages 136-143, doi:10.1016/j.procs.2022.12.120
13. M. Iqbal and R. Omar, "Automatic Guided Vehicle (AGV) Using Forward Chaining Method," 2023 International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE), Bandar Lampung, Indonesia, 2023, pp. 56-60, doi: 10.1109/ICCTEIE60099.2023.10366680.
14. J. H. J. C. Ortega et al., "Designing Student's Study Plan: Decision-Based Recommendation System Towards Program Completion Using Forward Chaining Algorithm," 2023 IEEE 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), Coron, Palawan, Philippines, 2023, pp. 1-6, doi: 10.1109/HNICEM60674.2023.10589118.
15. B. O. R. Pratama, A. C. Nugroho and T. B. Chandrawati, "Expert System for Initial Diagnosis of Covid-19 Using the Forward Chaining Method and Ripple Down Rules," 2023 7th International Conference on Information Technology (InCIT), Chiang Rai, Thailand, 2023, pp. 141-146, doi: 10.1109/InCIT60207.2023.10412944.
16. Herly Nurrahmi and Liza Amalia Putri, 2024, "The Development of TOEFL ITP Learning Determination Application Using Forward Chaining Method", Devotion Journal of Community Service 5(8), August, DOI: 10.59188/devotion.v5i8.776
17. Fajar Rahardika Bahari Putra, Abdul Fadlil, and Rusydi Umar, 2024, "Application of Forward Chaining Method, Certainty Factor, and Bayes Theorem for Cattle Disease", International Journal on Advanced Science Engineering and Information Technology 14(1):365-374,February, DOI: 10.18517/ijaseit.14.1.18912
18. T.Andriani, et.al, 2024, "Expert System for Diagnosing Gastric Disease Using the Forward Chaining Method", Instal Jurnal Komputer 16(02):110-119, June, DOI: 10.54209/jurnalinstall.v16i02.226
19. K. D.Goda and Jenny Ronawati Bay, 2024, "Forward Chaining Method in Expert System for Diagnosing Pests and Plant Diseases: A Systematic Literature Review", Journal of Artificial Intelligence and Engineering Applications (JAIEA) 3(3):870-875, June, DOI: 10.59934/jaiea.v3i3.535
20. B.Bligania, et.al, 2024, "Diagnosis of Cucumber Plant Diseases Using Certainty Factor and Forward Chaining Methods", February, Jurnal Techno Nusa Mandiri 21(1):1-8, DOI: 10.33480/techno.v21i1.5355
21. F. Fajriani, et.al, 2023, "A comparison between forward chaining-certainty factor and forward chaining-Dempster Shafer methods for ear, nose, and throat (ENT) expert system", March, AIP Conference Proceedings 2609(1):040002, DOI: 10.1063/5.0124207