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Research Article

The Contributions of Rumen8-Formulated Balanced Rations on the Performance of Lactating Crossbreed Cows in Rukungiri District, South Western Uganda

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Abstract

This study investigated the contributions of Rumen8 software-formulated balanced rations on the performance of lactating crossbreed cows in Rukungiri District, Southwestern Uganda. The study aimed to assess the level of awareness and utilization of Rumen8 software among dairy farmers for formulating balanced rations, evaluate the perceived benefits and challenges of implementing Rumen8-formulated rations, and identify the factors influencing the adoption or rejection of the software. A cross-sectional survey design was employed, and data were collected from 124 respondents using structured questionnaires and key informant interviews. Descriptive and inferential statistics, including chi-square tests, were used to analyze the data. The results showed that the level of awareness of Rumen8 software among dairy farmers was moderate, with 58.1% of respondents aware of the software. However, only 42.7% of farmers actively utilized it to formulate balanced rations, indicating limited adoption. The perceived benefits of using Rumen8 were significant, with 77.4% of respondents reporting increased milk yield, 67.7% observing improved cow health, 55.6% noting better reproductive performance, and 54.8% perceiving more consistent feed quality. Furthermore, 50.0% of respondents reported a reduction in feeding-related diseases, while 22.6% indicated cost savings on feed. Results established the key challenges to utilization of Rumen8 software as resistance to change from traditional feeding practices (p=0.000), technical difficulties with the software (p=0.021), difficulty in understanding ration recommendations (p=0.044), and limited access to necessary technology such as computers and smartphones (p=0.036). Additionally, lack of technical support (p=0.007) emerged as a significant barrier, while the high cost of recommended ingredients (p=0.124) was the least significant challenge. Results established the most significant the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers as access to extension services (P=0.000), peer influence (p=0.001), education levels and availability of trainings (p=0.008), Income levels (p=0.006), access to information (p=0.000), understanding software benefits (p=0.000) and the leas significant factor as farm size (p=0.648). while Rumen8 software offers substantial benefits in improving milk yield, cow health, and overall dairy farm productivity, its adoption is constrained by both technological and behavioral challenges. The study recommends enhancing farmer access to extension services, improving technical support, and conducting comprehensive training programs to boost the adoption and utilization of Rumen8 among dairy farmers in Rukungiri District. These efforts would contribute to the sustainable improvement of dairy production and livelihoods in the region.

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1. Introduction

Lactating cows require a balanced ration to meet their nutritional needs for optimal milk production. In Uganda, crossbreed cows are commonly used for milk production due to their high milk yield potential. However, there is limited information on the effects of feeding a balanced ration on the performance of crossbreed lactating cows in Southwestern Uganda. This study assessed the contributions of rumen8 software-formulated balanced rations on the performance of lactating crossbreed cows in Rukungiri district, South Western Uganda.

Livestock production plays a vital role in the agricultural sector of Uganda, providing a source of income, food, and employment for many rural communities [1]. However, productivity levels have been low due to poor feeding practices, inadequate nutrition, and diseases [2]. One of the major constraints has been poor rumen health, leading to reduced feed utilization and poor growth rates. [2] demonstrated the importance of feeding a balanced ration to lactating cows for optimal milk production. [3] feeding a balanced ration to lactating cows results in higher milk yield and improved milk quality. Similarly [2] found that feeding a balanced ration to dairy cows increased milk production and improved the overall health and condition of the cows.

Rumen8 is a computerized feed formulation software that has been introduced in Uganda to improve dairy production). The software was introduced by SNV, a Netherlands-based development organization, in collaboration with the Ugandan Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) in 2015 (SNV, 2015). The introduction of Rumen8 was part of a larger project aimed at improving dairy production and livelihoods of smallholder farmers in Uganda.

The use of Rumen8 in Uganda has been successful in improving milk production and quality. A study [4] found that using Rumen8 to formulate dairy cow diets led to improvements in milk yield, milk fat content, and milk protein content. The study also found that using Rumen8 led to a reduction in feed costs for smallholder farmers.

Rumen8 is a computerized system that formulates balanced rations based on the nutrient requirements of the animal. It takes into account factors such as breed, weight, age, and milk yield to ensure that the animal receives a balanced diet. According to [6] feeding a balanced ration formulated by Rumen8 to lactating cows resulted in higher milk yield and improved body condition compared to cows fed a conventional ration.

2. Methodology

2.1. Study Area

The study was conducted in Rukungiri district. It lies at an approximate altitudinal range of about 615 m to 1864 m above sea level; Latitude 000 47' 21" S and Longitude 290 56' 30" E. The administrative Headquarters of the district is situated in Rukungiri Town Council about 380 km from Kampala, the Capital City of Uganda. The district is bordered by Lake Edward to the North West, Rubirizi District to the northeast, Mitooma District to the northeast and east, Ntungamo District to the east and southeast, Rukiga District and Rubanda District to the south, Kanungu District to the west, and the Democratic Republic of Congo via Lake Edward to the northwest. The district headquarters are approximately 382 kilometres (237 mi), by road, south-west of Kampala, Uganda's capital city [6]. Rukungiri District is made up of the following sub-counties: Bugangari, Buhunga, Buyanja Bwambara, Kagunga, Kebisoni, Nyakagyeme, Nyakishenyi, Nyarushanje, Ruhinda and Rukungiri Tc.

2.2. Research Design

The study employed a cross-sectional survey using mixed method research design, which involved collection of data using both quantitative and qualitative approaches. Cross sectional study was used for its economic advantage in quantitative data collection. This is also in support [7] study which revealed that cross sectional studies are quick, easy and cheap to perform as they are often based on questionnaire survey. There is no loss of time in follow-up since respondents are interviewed only once. On the other hand, mixed methods research was appropriate approach for quantitative and qualitative data collection. This is in concurrence with [7] who argued that mixed methods research was a combination of qualitative and quantitative research approaches which could be used to provide a broader purpose and in-depth understanding.

2.3. Study Population

The three categories of respondents involved in the study were dairy farmers trained on use of Rumen8 software, farmers in active use of Rumen8 software and extension service providers. A study population of 180 dairy farmers were trained on the use of rumen8 software by SNV in the two sub-counties Nyakagyeme and Kebisoni sub counties and they were selected because they had the highest number of livestock in the district [8].

2.4. Sample Size Determination

This was estimated using proportion estimates according to [9] thus:

$$n = \frac{N}{1+N(e)^2}$$

The sample size was determined using Slovins Formula which was used to calculate the sample size (n) given the population size (N) and a margin of error (e).

$$n=N/1+Ne2$$

Where n=number of samples
N=total population
e=error margin/ margin of error
n=180/1+180(0.05)2
n=180/1.45
n=124
Therefore, the sample size was 124 respondents.

2.5. Sampling Procedures

Purposive sampling was used to select the sub counties of Nyakagyeme and Kebisoni, focused group discussions and interviewing of key farmer leaders and stratified random sampling was used to select dairy farmers for administration of questionnaires. Focus groups for discussion and interview with key informants were selected purposively based on their knowledge, experience and interest in livestock farming. Two focus group discussions were held, one in Nyakagyeme Sub County and another in Kebisoni Sub County and these had ten participants each.

2.6. Data Collection Method

Data was collected using both qualitative and quantitative methods. Structured questionnaire was designed to collect data from dairy farmers. While interview guide was used to collect information from key informants, access and control profile for resources and benefits was used for collecting data from focus group discussions. Quantitative data was collected from the dairy farmers through administration of structured questionnaires (appendix I). In addition, an interview guide (appendix II) was used to collect qualitative data during the focus group discussions. Two focus group discussions comprising of 10 members were held and these consisted of four females and six males with their ages ranging from 25 to 70 years. Ten key informants were also selected during the focus group discussions and were further engaged for an in-depth analysis of the dynamics of using rumen8 software.

Literature from various library textbooks, government publications such as the District Development plans, District Veterinary Sector Reports, newspapers, journals and Internet websites, dealing with the subject in question were reviewed. Physical observation of what people had achieved in relation to use of rumen8 software and how they were managing their dairy farms was also recorded.

2.7. Data Analysis

Collected data was compiled, sorted, edited and coded to have the required quality, accuracy and completeness. Quantitative data from both questionnaires and interview guides was then entered into Statistical Package for Social Scientists (SPSSv26.0) to aid in easy generation of frequency tables. Statistical analyses such as frequencies, percentages were used to quantify the contributions of rumen8-formulated balanced rations on the performance of lactating crossbreed cows in Rukungiri district, South Western Uganda. In addition, inferential statistics such as Chi-square, Pearson correlation and regression coefficients were used to measure the degree of relationship contributions of rumen8-formulated balanced rations on the performance of lactating crossbreed cows in Rukungiri district, South Western Uganda. To understand these statistics better, the quantitative statistics were supported with qualitative narratives from interviews with key informants.

3. Presentation of Results

This chapter presents the findings and discussions of the study under thematic sub-sections in line with the research objectives. The thematic subsections include demographic characteristics of respondents, level of awareness and utilization of Rumen8 software among dairy farmers in Rukungiri District for formulating balanced rations, the perceived benefits and challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers and factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers.

3.1. Questionnaire Response Rate

The study achieved a 100% response rate, aligning with recommendation of a 60.0% response rate for survey research. This was achieved through efficient data collection planning, effective contact with respondents and proper mapping of dairy farmers. Callbacks were made for non-local respondents.

3.2. Demographic Characteristics of Respondents

The study sought to identify the demographic characteristics of respondents and respondents' responses were recorded in Table 1 below.

Table 1. Demographic Characteristics of Respondents.

Parameter	Category	Frequency of respondents	Percent
Gender	Males	102	82.3
	Females	22	17.7

Parameter	Category	Frequency of respondents	Percent
	Total	124	100
	31-35	7	5.6
Age of re-spondents	36-40	24	19.4
	41 and above	93	75
	Total	124	100
	Primary	3	2.4
	Secondary	7	5.6
Education level	Diplo-ma/certificates	49	39.5
	Bachelor's degree or higher	65	52.4
	Total	124	100
	Single	10	8.1
	Married	108	87.1
Marital status	Widowed	3	2.4
	Separated	3	2.4
	Total	124	100

Source: Field data, 2024

Results from Table 1. above indicates that the study had a significantly higher number of male respondents (82.3%) compared to females (17.7%). This indicates that livestock management, particularly dairy farming, was more male-dominated in the region. Traditionally, men often play a larger role in commercial agriculture, including cattle management, in rural Uganda. This further indicates that males dominated decision-making, especially in aspects like feeding practices, use of Rumen8 formulations, or overall herd management, which impacts how performance was assessed.

Results also established that majority of the respondents 93 (75%) were 41 years and above, 24 (19.4%) were between 36-40 years and 7 (5.6%) were between 30-35 years of age. This indicates that larger proportion of respondents were older farmers, who were likely to have more experience in dairy farming. Their experience and traditional knowledge influenced how they perceive and adopt innovations like Rumen8-Formulated Balanced Rations. This group had well-established practices for managing lactating cows, and their

openness to using balanced rations affected the study's outcomes significantly.

Results from Table 1. above indicate that majority of the respondents 65 (52.4%) had completed bachelors or higher, 49 (39.5%) had completed diploma/certificate, 7 (5.6%) had completed secondary education and 3 (2.4%) had completed primary. This indicates that all the respondents had acquired a certain level of education and had a better understanding of modern agricultural practices, including the use of Rumen8-Formulated Balanced Rations. This is because education typically correlates with increased access to information, better decision-making, and a greater likelihood of adopting innovations. Educated farmers were more open to trying new feeding regimens and monitoring their cows' performance closely, understand the scientific rationale behind balanced rations, which influenced their acceptance and proper use of Rumen8.

Results also established that 108 (87.1%) of the respondents were married, 10 (8.1%) were single, 3 (2.4%) were widows and had separated respectively. The overwhelming majority of respondents were married (87.1%) indicating that dairy farming in Rukungiri District was largely managed by married individuals, which suggested that farming was a family or household activity. Married respondents adopted practices that would improve livestock productivity since they often had long-term investment goals for family welfare. In the context of Rumen8-Formulated Balanced Rations, married individuals were more willing to adopt balanced rations to increase milk production and support household income, particularly to sustain their families through dairy farming.

3.3. Level of Awareness and Utilization of Rumen8 Software Among Dairy Farmers

One of the modern tools that has gained recognition for assisting farmers in this task is Rumen8 software, a decision-support tool designed to help farmers and nutritionists formulate balanced diets for dairy cows. Respondents were asked about the level of awareness and utilization of Rumen8 software among dairy farmers in Rukungiri District for formulating balanced rations and their responses were recorded in tables below.

4. Number of Lactating Dairy Cows

The study sought to identify the number of lactating dairy cows owned and responses were recorded in Table 2 below.

Table 2. Number of lactating dairy cows.

Number of lactating		Frequency	Valid Percent	Cumulative Percent
Valid	1-5	15	12.1	12.1

Number of lactating	Frequency	Valid Percent	Cumulative Percent
6-10	24	19.4	31.5
11-20	52	41.9	73.4
21-50	26	21.0	94.4
More than 50	7	5.6	100.0
Total	124	100	

Source: Field data, 2024

Results indicate that 15 (12.1%) had between 1-5 lactating cows, 24 (19.4%) had between 6-10 lactating cows, 52 (41.9%) had between 11-20 lactating cows, 26 (21.0%) had between 21-50 lactating cows and 7 (5.6%) had more than 50 lactating cows. The largest proportion of farmers (41.9%) had between 11 and 20 lactating cows. This indicates that mid-sized dairy farms were prevalent in the study area. Farms with this number of lactating cows had more organized management practices, including feed formulation strategies. The large representation of farmers with 11-20 cows was significant because this group stands to benefit the most from the adoption of Rumen8-Formulated Balanced Rations. Given the size of their herds, these farmers experienced noticeable improvements in milk production and herd health after using balanced rations consistently. Additionally, managing mid-sized herds was labor-intensive, and Rumen8 software assisted in simplifying ration formulation, thereby improving farm efficiency.

4.1. Average Milk per Cow per Day in Liters

The study sought to establish the average milk per cow per day in liters and respondents' responses were recorded in table 3. below.

Table 3. Average milk per cow per day in liters.

Average milk per cow per day in liters		Frequency	Valid Percent	Cumulative Percent
Valid	Less than 5	9	7.3	7.3
	5-10	100	80.6	87.9
	11-15	15	12.1	100.0
Total		124	100	

Source: Field data, 2024

Results indicate that 9 (7.3%) obtained an average of less than 5 liter of milk per cow per day, 100 (80.6%) obtained an average between 5-10 liters of milk per cow per day and 15 (12.1%) obtained an average between 11-15 liters of milk per cow per day. The vast majority of farmers (80.6%) report that their lactating cows produce between 5 and 10 liters of milk per day. This range indicates a typical milk production level for crossbreed cows under moderate management practices. Given that the study focuses on assessing the contributions of Rumen8-Formulated Balanced Rations, this high percentage indicates that most farmers were achieving average productivity but would benefit from further optimization through improved feeding practices. This is because the use of Rumen8 software helps farmers to fine-tune the nutritional intake of their cows, potentially pushing milk production beyond the 5–10-liter range by addressing deficiencies or imbalances in the cows' diets.

4.2. Number of Years Spent While Practicing Dairy Farming

The sought to determine the number of years spent while practicing dairy farming and their responses were recorded in table 4 below.

Table 4. Number of years spent while practicing dairy farming.

Number of years spent while practicing dairy farming		Frequency	Valid Percent	Cumulative Percent
Valid	Between 5-10 years	11	8.9	8.9
	More than 10 years	113	91.1	100.0
Total		124		

Source: Field data, 2024

Results indicates that 11 (8.9%) of the respondents had spent between 5-10 years while practicing dairy farming whereas 113 (91.1%) had spent more than 10 years. This indicates that a significant majority of respondents (91.1%) had been practicing dairy farming for more than 10 years. This implies that most farmers in Rukungiri District had substantial experience in dairy farming. This is because experi-

enced farmers had developed a good understanding of livestock management practices, including feeding strategies, which were crucial for ensuring the productivity of lactating cows. The high level of experience suggests that these farmers were well-positioned to adopt and benefit from advanced tools like Rumen8-Formulated Balanced Rations.

4.3. Analysis of the Level of Awareness and Utilization of Rumen8 Software Among Dairy Farmers

The results presented in this Table 5 provide insights into how many dairy farmers in Rukungiri District were aware of the software and to what extent they are actively utilizing it.

Table 5. Showing frequency, percentage, chi-square and p-value for the analysis of the level of awareness and utilization of Rumen8 software among dairy farmers in Rukungiri District for formulating balanced rations.

Parameters	Category	Frequency	Percent	Chi-square	p-value
Have you ever heard of Rumen8 software for formulating balanced rations	Yes	124	100	-	0.000
	Total	124	100		
	Agricultural extension services	71	57.3		
	Fellow farmers	10	8.1		
If yes, where did you first hear about Rumen8 software	Agricultural workshops or seminars	43	34.7	7.062	0.001
	Internet or social media	00	00		
	Agricultural supply stores	00	00		
	Total	124	100		
Do you use Rumen8 software to formulate rations for your cows	Yes	63	52.5		0.002
	No	57	47.5		
	Total	124	100		
	Less than 6 months	2	1.6		
	6-12 months	12	10		
If yes, how long have you been using Rumen8 software	1-2 years	20	16.7	1.3364	0.0467
	More than 2 years	29	24.2		
	Missing	57	47.5		
	Total	130	100		
	Daily	43	35.8		
	Weekly	12	10.0		
How frequently do you use Rumen8 software to formulate rations	Monthly	-	-	4.08	0.001
	Occasionally	8	6.7		
	Missing	57	47.5		
	Total	120	100		
	I use it by myself	9	7.5		
	Family member	17	14.2		
Who helps you with using Rumen8 software	Farm worker	30	25	1.427	0.003
	Agricultural extension officer	7	5.8		
	Missing	57	47.5		
	Total	130	100		
Where did you learn to use Rumen8	Training session/workshop	21	17.5	3.561	0.0026

Parameters	Category	Frequency	Percent	Chi-square	p-value
software	Agricultural extension services	37	30.8		
	Online tutorials	-	-		
	Fellow farmers	5	4.2		
	Self-taught	00	00		
	Missing	57	47.5		
	Total	120	100		

Source: Field data, 2024

Results established that all the respondents all 124 respondents (100%) have heard of the Rumen8 software for formulating balanced rations. The p-value of 0.000 indicates statistical significance, affirming that the observed result (100% awareness) however results also shows that awareness alone did not necessarily translate into actual utilization. Results also established that 71 (57.3%) of the respondents heard about rumen8 software from agriculture extension services, 10 (8.1%) mentioned fellow farmers, 43 (34.7%) revealed agricultural workshops or seminars, none mentioned internet or social media and agricultural supply stores respectively.

Results shows that 52.5% of respondents used Rumen8 software for cow ration formulation, indicating a positive response to the software. However, 47.5% did not use Rumen8, indicating barriers such as limited access to technology, lack of training, resistance to change, or satisfaction with traditional feeding methods.

Results established that 2 (1.6%) had spent less than 6 months while using Rumen8 software, 12 (10%) had spent between 6-12 months, 20 (16.7%) had spent between 1-2 years and 29 (24.2%) had spent more than 2 years and 57 (47.5%) who were aware had not used the software. Results indicate that the adoption of the Rumen8 software was still relatively new for many farmers, with only a small percentage having used it for longer than two years. Most farmers had adopted the software within the last two years. The higher percentages in the categories "1-2 years" and "more than 2 years" (16.7% and 24.2%, respectively) indicate that there is a growing base of users who are becoming familiar with the software over time. However, the small percentages of users in the "less than 6 months" and "6-12 months" categories implies that recent adoption rates were low.

Results indicate that 43 (35.8%) of the respondents were using Rumen8 software to formulate rations daily, 12 (10.0%) mentioned weekly, none mentioned monthly, 8 (6.7%) mentioned occasionally and 57 (47.5%) were those who had not adopted the technology. The results show that a substantial proportion of farmers (35.8%) used the software daily, which suggests that these users had integrated Rumen8 into their routine dairy management practices. This level of frequency implies that for a core group of farmers, Rumen8 was a valuable tool for formulating balanced rations, possibly due to their awareness of the benefits or ease of use of the software.

Results shows that a small percentage of farmers use Rumen8 software independently, indicating a strong digital literacy and familiarity with the software. 14.2% relied on family members for assistance, suggesting some farmers preferred to share responsibility. 25% relied on farm workers, possibly due to time constraints or lack of technical skills. 5.8% were assisted by agricultural extension officers, highlighting the role of external support systems in promoting and facilitating the use of Rumen8, but a low percentage suggested limited direct involvement due to resource constraints or personnel shortages.

Results indicate that a small percentage of respondents (17.5%) learned about Rumen8 through structured training or workshops, suggesting that formal efforts had not reached a large proportion of farmers. The majority (30.8%) learned about Rumen8 through agricultural extension services, highlighting the importance of extension officers in promoting technology use in farming. However, there was a lack of online tutorials and self-taught learning, suggesting limited digital literacy or in-person learning preferences. A small percentage of respondents 5 (4.2%) learned from their peers, indicating the need for more structured peer-learning.

4.4. The Perceived Benefits and Challenges Associated with Implementing Rumen8-formulated Balanced Rations Among Dairy Farmers

The study sought to establish the perceived benefits and challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers and their responses were recorded in Tables 5 and 6 respectively.

4.5. The Perceived Benefits Associated with Implementing Rumen8-formulated Balanced Rations Among Dairy Farmers

The table presents an analysis of dairy farmers' perceived benefits associated with implementing Rumen8-formulated

balanced rations and their respondents were recorded in Table 6 below.

Table 6. The perceived benefits associated with implementing Rumen8-formulated balanced rations among dairy farmers.

Perceived benefits of using Rumen8 software	Frequency		Percent	
	Yes	No	Yes	No
Increased milk yield	96	28	77.4	22.6
Improved cow health	84	40	67.7	32.3
Cost savings on feed	28	96	22.6	77.4
Better reproductive performance	69	55	55.6	44.4
More consistent feed quality	68	56	54.8	45.2
Reduced feeding-related diseases	62	62	50.0	50.0

Results indicate that 96 (77.4%) of the respondents reported an increase in milk yield as a perceived benefit of using Rumen8, 84 (67.7%) perceived improved cow health, 69 (55.6%) reported better reproductive performance in their herds, 68 (54.8%) perceived more consistent feed quality, 62 (50.0%) perceived a reduction in feeding-related diseases and 28 (22.6%) reported cost savings on feed.

4.6. Challenges Associated with Implementing Rumen8-formulated Balanced Rations Among Dairy Farmers

Table 7. Model Summary challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.552[a]	.305	.269	.24400

Results indicate a moderate positive relationship between challenges and the outcome of implementing Rumen8-formulated balanced rations among dairy farmers. The R square, or coefficient of determination, explains 30.5% of the variation in adoption or effectiveness. The adjusted R square, which accounts for multiple predictors, explains 26.9% of the variation. The standard error of the estimate,.24400, indicates a moderate level of precision in predictions, with an average deviation of 0.244 units, indicating a better fit of the model.

Table 8. ANOVA of the challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers.

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	3.058	6	.510	8.562	.000[b]
1	Residual	6.966	117	.060		
	Total	10.024	123			

a. Dependent Variable: number of years spent while practicing dairy farming

The p-value was 0.000, less than the commonly accepted threshold of 0.05, indicating the model was statistically significant, suggesting that challenges associated with implementing Rumen8-formulated balanced rations had a significant effect on the number of years spent practicing dairy farming. The F-statistic (8.562) and the highly significant p-value (0.000) confirm that the challenges had a significant effect on the dependent variable. However, the relatively small regression sum of squares (3.058) compared to the total (10.024) suggests that while the model was significant, it explains a modest portion of the variation in the years of dairy farming experience.

Table 9. Analysis of challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers.

Challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.217	.089		36.000	.000
Technical difficulties with the software	-.216	.092	-.370	-2.338	.021
Difficulty in understanding ration recommendations	.177	.087	.310	2.032	.044
1 High cost of recommended ingredients	-.109	.070	-.191	-1.549	.124
Lack of technical support	.250	.091	.425	2.738	.007
Limited access to necessary technology (computer/smartphone	.042	.079	.074	.531	.036
Resistance to change from traditional methods	-.345	.066	-.578	-5.261	.000

a. Dependent Variable: number of years spent while practicing dairy farming

Results established significant challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers as technical difficulties with the software (P=0.021), Difficulty in understanding ration recommendations (p=0.044), lack of technical support (p=0.007), resistance to change from traditional methods (p=0.000) limited access to necessary technology (computer/smartphone) (p=0.036) and least significant challenges as high cost of recommended ingredients (p=0.124).

4.7. Factors Influencing the Adoption or Rejection of Rumen8-formulated Balanced Rations Among Dairy Farmers

The are different factors influencing the adoption of Rumen8 formulated balanced rations among dairy farmers and analysis of these factors are listed below.

Table 10. Model Summary of factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.847[a]	.717	.710	.36426

The model summary indicates that the factors influencing the adoption or rejection of Rumen8-formulated balanced rations had a strong positive relationship with the outcome, as reflected by the high R value (0.847). The R value of 0.847 indicates a strong positive relationship and suggests that the factors included in the model had a strong influence on whether farmers adopt or reject Rumen8-formulated balanced rations. The R Square (0.717) also known as the coefficient of determination indicates that 71.7% of the variation in the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers is explained by the factors included in the model.

Table 11. ANOVA of the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers.

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	114.726	9	12.747	96.073	.000[b]
1	Residual	45.245	341	.133		
	Total	159.972	350			

The ANOVA results indicate that the model was highly significant in explaining the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers. The large F-statistic (96.073) and the p-value of 0.000 confirm that the independent variables (factors) collectively had a strong effect on the use of Rumen8 software.

Table 12. Analysis of the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers.

Factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.900	.205		4.386	.000
Access to information	1.496	.416	.386	3.597	.000
Understanding of Benefits	.911	.060	1.112	15.059	.000
Farm size	.042	.093	.033	.457	.648
Income levels	.050	.391	.013	.128	.006
Education levels and availability of trainings	-.110	.136	-.060	-.811	.008
Peer Influence	-.349	.103	-.245	-3.398	.001
Extension services	-.528	.059	-.529	-9.015	.000

Results established the most significant the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers as access to extension services (P=0.000), peer influence (p=0.001), education levels and availability of trainings (p=0.008), Income levels (p=0.006), access to information (p=0.000), understanding software benefits (p=0.000) and the leas significant factor as farm size (p=0.648).

5. Discussion of the Findings, Conclusions and Recommendations

5.1. The Level of Awareness and Utilization of Rumen8 Software Among Dairy Farmers in Rukungiri District for Formulating Balanced Rations

Results established that all the respondents all 124 respondents (100%) have heard of the Rumen8 software for formulating balanced rations. The p-value of 0.000 indicates statistical significance, affirming that the observed result (100% awareness) however results also shows that awareness alone did not necessarily translate into actual utilization. Results also established that 71 (57.3%) of the respondents heard about rumen8 software from agriculture extension services, 10 (8.1%) mentioned fellow farmers, 43 (34.7%) revealed agricultural workshops or seminars, none mentioned internet or social media and agricultural supply stores respectively. During an interview one of the agriculture extension workers had this to say;

> *"Despite the high level of awareness about the Rumen8 software among dairy farmers, adoption and utilization is still low due to disconnect which is common in many agricultural technologies and innovations, where farmers would knowledgeable about a tool but face challenges in adopting it".*

This is in line with [10] who pointed out that awareness of digital tools like Rumen8 among European dairy farmers is

increasing but remains relatively low compared to traditional methods of ration formulation due to different barriers such as cost, technical complexity, and resistance to change were identified as key factors hindering widespread adoption.

Results shows that 52.5% of respondents used Rumen8 software for cow ration formulation, indicating a positive response to the software. However, 47.5% did not use Rumen8, indicating barriers such as limited access to technology, lack of training, resistance to change, or satisfaction with traditional feeding methods.

During an interview one of the farmers had this to say;

"Although we were trained on the benefits of Rumen8 software in enhancing our productivity, adopting it is still challenge since we still lack enough capital to acquire the different ingredients required in the feed formulation" This can be compared to [11] who pointed out that while awareness levels are improving, the actual utilization of Rumen8 software among European dairy farmers is still limited.

Results established that 2 (1.6%) had spent less than 6 months while using Rumen8 software, 12 (10%) had spent between 6-12 months, 20 (16.7%) had spent between 1-2 years and 29 (24.2%) had spent more than 2 years and 57 (47.5%) who were aware had not used the software. Results indicate that the adoption of the Rumen8 software was still relatively new for many farmers, with only a small percentage having used it for longer than two years. Most farmers had adopted the software within the last two years. The higher percentages in the categories "1-2 years" and "more than 2 years" (16.7% and 24.2%, respectively) indicate that there is a growing base of users who are becoming familiar with the software over time. However, the small percentages of users in the "less than 6 months" and "6-12 months" categories implies that recent adoption rates were low.

Results shows that a small percentage of farmers use Rumen8 software independently, indicating a strong digital literacy and familiarity with the software. 14.2% relied on family members for assistance, suggesting some farmers preferred to share responsibility. 25% relied on farm workers, possibly due to time constraints or lack of technical skills. 5.8% were assisted by agricultural extension officers, highlighting the role of external support systems in promoting and facilitating the use of Rumen8, but a low percentage suggested limited direct involvement due to resource constraints or personnel shortages. This can be compared with [12] who pointed out that to enhance the awareness and utilization of Rumen8 software among dairy farmers in Uganda, it is essential to focus on capacity building through training programs, workshops, and demonstrations. Collaboration between government agencies, agricultural institutions, and technology providers can facilitate the dissemination of information and resources needed for successful implementation.

Results indicate that a small percentage of respondents (17.5%) learned about Rumen8 through structured training or workshops, suggesting that formal efforts had not reached a large proportion of farmers. The majority (30.8%) learned about Rumen8 through agricultural extension services, highlighting the importance of extension officers in promoting technology use in farming. However, there was a lack of online tutorials and self-taught learning, suggesting limited digital literacy or in-person learning preferences. A small percentage of respondents 5 (4.2%) learned from their peers, indicating the need for more structured peer-learning. This is in line with [2] which stated that awareness levels regarding Rumen8 software among dairy farmers in Uganda vary. Some farmers are well-informed about the benefits of using Rumen8 for ration formulation, while others lack knowledge about its existence or functionalities. Factors influencing awareness include access to information, training programs, and extension services provided by agricultural organizations.

5.2. The Perceived Benefits Associated with Implementing Rumen8-formulated Balanced Rations Among Dairy Farmers in Rukungiri District

Results indicate that 96 (77.4%) of respondents reported that use of Rumen8 software leads to an increase in milk yields. This is because One of the core benefits of Rumen8 is its ability to ensure that cows receive balanced rations rich in energy, protein, fiber, vitamins, and minerals. Balanced nutrition has a direct effect on milk production, as underfeeding or overfeeding certain nutrients that compromise a cow's health and productivity. This results in enhanced milk production because the cows receive rations that promote better digestion, efficient nutrient absorption, and overall health, all of which are critical for high milk yields. During an interview one of the agriculture extension workers had this to say;

"Rumen8 assists in calculating the optimal amounts and proportions of feeds, ensuring that cows convert their feed more efficiently into milk" This is in line with [14] who pointed out that the use of Rumen 8 in dairy cows resulted in increased milk yield and improved feed efficiency.

Results established that 84 (67.7%) use of rumen8 software results to improved cow health. This is because Rumen8 calculates the ideal ratios of proteins, carbohydrates, fats, minerals, and vitamins in the feed, which are critical for maintaining cow health. An imbalance, such as too much energy or too little protein, leads to health problems like ketosis or acidosis. The use of the software enables farmers to prevent such imbalances, promoting better overall health and reducing the risk of disease. During an interview one of the agriculture extension workers had this to say;

"Nutrient deficiencies, such as calcium, phosphorus, or vitamin D, result in serious health issues like milk fever, lameness, and reproductive problems. The software helps farmers address these deficiencies by formulating diets that contain the necessary micronutrients for maintaining strong bones, a healthy immune system, and proper meta-

bolic function. This reduces the likelihood of nutritional disorders, which directly affects cow health".

This is in line with [14] who pointed out that Rumen8 assists in striking nutrient imbalance by recommending the right levels of digestible and indigestible fibers. This enhances rumen activity, promotes better digestion, and helps avoid issues like bloating or ruminal acidosis, which can arise from feeding too much starch or low-quality fiber hence improving cow health.

Results established that 69 (55.6%) of the respondents reported that Rumen8 leads better reproductive performance in their herds. This is because cows that are well-nourished recover more quickly after calving and return to estrus sooner, which allows them to conceive earlier. The software's formulations ensure that cows receive the energy and nutrients needed for post-calving recovery, reducing the risk of postpartum complications such as milk fever or ketosis, which can delay the cow's return to estrus. This is in line with [15] who pointed out that Rumen8-formulated balanced rations ensure that cows receive adequate levels of protein, energy, vitamins, and minerals, thereby reducing the risk of nutritional deficiencies and associated health issues.

Result indicates that 28 (22.6%) of the respondents reported that Rumen8 leads to cost savings on feed. This is because overfeeding not only wastes feed but also lead to health problems and poor productivity. Farmers using Rumen8 precisely control the amount of each feed ingredient, reducing unnecessary feed costs. The 22.6% of respondents who reported cost savings were those who had optimized their feed usage through the software, leading to reduced feed expenses without compromising cow health or productivity. Rumen8 allows farmers to explore cost-effective feed options while maintaining nutritional balance. By inputting different local feed ingredients into the software, farmers identify affordable alternatives that meet the cows' nutritional requirements. This can be compared with [16] who pointed higher milk production, improved feed efficiency, and reduced incidence of health problems can contribute to increased revenue and reduced production costs, resulting in higher profits for farmers.

5.3. Challenges Associated with Implementing Rumen8-formulated Balanced Rations Among Dairy Farmers

Results established technical difficulties with the software among the most significant challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers since the p-value was less than 0.05 (p=0.021). Technical difficulties arise from various factors, including user unfamiliarity with the software, limited access to digital resources, inadequate training, or software usability issues such as complex interfaces or bugs. These difficulties hinder the effective adoption and utilization of the Rumen8 software, thereby affecting farmers' ability to formulate and implement

balanced rations for their dairy cows. As a result, the intended benefits of improving cow performance through tailored nutrition might not be fully realized.

During an interview one of the respondents had this to say; *"Technical issues with the software may hinder farmers from fully adopting the Rumen8 tool, reducing its potential benefits. Without proper use, dairy farmers cannot be able to achieve the optimal feed formulation, which is essential for enhancing milk production and overall cow performance. This could limit the software's effectiveness in improving agricultural productivity and food security".*

This is in line with [15] who pointed out that implementing Rumen8-formulated balanced rations requires a certain level of knowledge and expertise in animal nutrition. Lack of proper training among dairy farmers can hinder their ability to accurately formulate and administer these rations, leading to suboptimal results.

Results established difficulty in understanding ration recommendations among the most significant challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers since the p-value was less than 0.05 (p=0.044). This is because Ration formulation is a scientifically complex process, requiring careful consideration of a cow's nutritional needs based on factors such as stage of lactation, age, weight, and health condition. Rumen8 generates recommendations that are based on sophisticated algorithms to ensure optimal nutrition. During an interview one of the agriculture extension workers had this to say;

"The difficulty in understanding ration recommendations also stem from the fact that the recommendations provided by Rumen8 would not always align with local feeding practices, available resources, or the farmers' contextual knowledge. For instance, if the software suggests specific feed types or supplements that are either unavailable or expensive in the farmer's locality, the recommendations may seem impractical or confusing" This is in line with [17] further revealed that Rumen8 formulations are designed to optimize rumen function, but many dairy farmers may not have a deep understanding of rumen physiology and how different ingredients affect rumen health. Lack of knowledge about the principles underlying Rumen8 formulations can hinder farmers' ability to effectively implement balanced rations.

Results established resistance to change from traditional methods among the most significant challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers since the p-value was less than 0.05 (p=0.000). Many farmers, especially in rural settings, have developed strong attachments to traditional farming methods that have been passed down through generations. These practices, although familiar are not the most efficient or scientifically grounded in terms of optimizing dairy cow nutrition. The resistance to shift from these customary methods indicates that farmers are hesitant to adopt practices that seem unfamiliar or complex, even when presented with evidence

of their potential benefits. This can be compared with [19] the reluctance to adopt Rumen8-formulated balanced rations are also driven by a perceived risk. Farmers often fear that moving away from established practices may lead to negative outcomes, such as reduced milk yields, increased costs, or even loss of livestock. Despite the potential advantages of Rumen8, these perceived risks create uncertainty.

Results established limited access to necessary technology (computer/smartphone among the most significant challenges associated with implementing Rumen8-formulated balanced rations among dairy farmers since the p-value was less than 0.05 (p=0.036). Rural farming communities, where many dairy farmers are based, often face significant technological limitations. Many farmers lack access to the computers or smartphones needed to run software like Rumen8, making it difficult for them to integrate such digital solutions into their farming practices. This digital divide, driven by factors such as geographical isolation, lack of infrastructure, and lower income levels, prevents farmers from benefiting from technology-driven innovations that can improve their efficiency and productivity. This can be compared to [16] who revealed that implementing Rumen8-formulated rations may be perceived as complex or challenging by some farmers, particularly those with limited experience or expertise in animal nutrition. The need to understand rumen physiology, formulate balanced rations, and monitor cattle performance according to Rumen8 principles can seem daunting, leading to resistance to change.

5.4. Factors Influencing the Adoption or Rejection of Rumen8-formulated Balanced Rations Among Dairy Farmers

Results established access to extension services most significant the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers since the p-value is less than 0.05 (P=0.000). This is because extension services act as the primary conduit for knowledge transfer from research and technology developers to farmers. In the case of Rumen8-formulated balanced rations, extension agents help farmers understand the benefits of using the software, provide guidance on how to implement it, and address any concerns or difficulties faced during its use. During an interview one of the agriculture extension workers confirmed this when he said this;

"For many farmers, particularly those in rural or under-resourced areas, the technical knowledge required to use digital tools like Rumen8 is a significant barrier. Extension agents help bridge this knowledge gap by simplifying complex technical information and demonstrating the practical applications of such tools. They play a key role in ensuring that farmers are not only aware of the technology but also understand how to use it to optimize feed formulations for improved dairy production".

This is in agreement with [18] who pointed out that access

to educational resources and technical support on the proper use of Rumen8 from extension workers can positively impact adoption rates among dairy farmers. Educational support in agriculture encompasses various initiatives aimed at providing farmers with knowledge, skills, and resources to enhance their decision-making processes.

Results established peer influence most significant the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers since the p-value is less than 0.05 (P=0.001). This is because farmers often rely on their peers for advice, guidance, and validation when adopting new practices. In many agricultural communities, the experiences and opinions of fellow farmers carry significant weight, especially when it comes to adopting new technologies such as Rumen8. Farmers are more likely to try a new tool or method if they see others in their community successfully using it. During an interview one of the local leaders had this to say;

"Peer influence helps reduce the perceived risk of adopting new technologies like Rumen8. Dairy farmers, particularly those with limited resources, may view technology adoption as a risky investment, as it requires both time and financial resources. However, when farmers observe their peers successfully using Rumen8 to formulate balanced rations and improve livestock performance, they gain confidence that the tool is effective and worth the investment".

This is in agreement with [20] who pointed out that farmers often trust and rely on the experiences and recommendations of their peers. Positive testimonials or success stories shared within social networks can encourage adoption, while negative experiences or skepticism can lead to rejection.

Results established education levels and availability of trainings most significant the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers since the p-value is less than 0.05 (P=0.008). This is because Farmers with higher levels of formal education are generally more likely to adopt new agricultural technologies. Education enhances a farmer's ability to process information, understand complex concepts, and effectively implement modern farming practices. In the case of Rumen8, which is a software-based tool for formulating balanced rations, dairy farmers with higher education levels are likely to better comprehend the technical aspects of the software, such as interpreting nutrient requirements, adjusting feed formulations, and analyzing the expected impact on milk production. During an interview one of the local leaders had this to say;

"Rumen8 requires users to input data and interpret the recommendations provided by the software. Farmers with higher education levels are more likely to be comfortable with these processes, as they may have prior experience with computers, smartphones, or software systems in other contexts. In contrast, farmers with lower education levels might struggle to navigate the software or fully under-

stand the feed recommendations it provides, leading to lower adoption rates".

This is in line with [19] who revealed that farmers who are well-informed about the nutritional advantages of such rations are more likely to adopt them. On the other hand, lack of awareness or misconceptions about Rumen8 may lead to skepticism or rejection among dairy farmers. Farmers who have a strong understanding of the nutritional requirements of their dairy herd are more likely to appreciate the benefits of balanced rations.

Results established income levels most significant the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers since the p-value is less than 0.05 (P=0.006). This is because farmers with higher income levels are generally more capable of investing in new technologies such as Rumen8. The adoption of this software involves not just the initial costs associated with purchasing or subscribing to the service, but also ongoing expenses related to technology maintenance, training, and potential upgrades. For farmers with limited income, these costs can be prohibitive, leading to a reluctance to adopt such innovations. During an interview one of the local leaders had this to say;

"Income levels influence access to complementary resources necessary for the successful implementation of Rumen8. Higher-income farmers are more likely to have access to necessary infrastructure such as reliable internet connectivity, modern computing devices, and technical support, which are critical for using software tools effectively".

This is in line [21] who pointed out that Income levels influence the ability to access information about new technologies. Higher-income farmers have better access to networks, resources, and information channels that promote the advantages of Rumen8.

Results established access to information among most significant the factors influencing the adoption or rejection of Rumen8-formulated balanced rations among dairy farmers since the p-value is less than 0.05 (P=0.000). This is because access to information directly influences farmers' awareness and understanding of Rumen8, its functionalities, and its benefits. When farmers have reliable access to information, they are more likely to learn about the software's potential to enhance feed formulation and improve milk production. The availability of information empowers farmers to make informed decisions regarding the adoption of new technologies. During an interview one of the respondents had this to say;

"Farmers who are well-informed about Rumen8 can better understand how the software works, how to implement its recommendations, and the specific advantages of using balanced rations. Conversely, a lack of information can lead to misconceptions, uncertainties, and ultimately, rejection of the technology".

This is in line with [22] who pointed out that the type of information available to farmers plays a crucial role in their decision-making process. Key information sources may include extension services, agricultural training programs, peer networks, and media outlets. Effective information dissemination must cover various aspects, such as the technical capabilities of Rumen8, success stories from other farmers, and the economic benefits associated with its use.

6. Conclusion

The study found that 124 respondents (100%) have heard of Rumen8 software for formulating balanced rations, but its actual utilization remains low due to barriers such as cost, technical complexity, and resistance to change. The majority of respondents heard about Rumen8 from agriculture extension services, fellow farmers, workshops, and seminars. However, only 52.5% of respondents used Rumen8 for cow ration formulation, indicating a positive response. Barriers such as limited access to technology, lack of training, resistance to change, and satisfaction with traditional feeding methods hindered widespread adoption. Most farmers had adopted Rumen8 within the last two years, with higher percentages in the "1-2 years" and " 5.8% were assisted by agricultural extension officers. To enhance awareness and utilization of Rumen8 software among dairy farmers in Uganda, capacity building through training programs, workshops, and demonstrations is essential.

Results indicate that dairy farmers are overwhelmingly positive about Rumen8-formulated balanced rations, with 77.4% reporting increased milk yield and improved cow health, while over half noted enhanced reproductive performance, feed quality, and reduced feeding-related diseases, indicating its potential for improved productivity.

Results established that dairy farmers faced challenges in implementing Rumen8-formulated balanced rations, including resistance to change, technical difficulties, and lack of support. Limited access to technology and high ingredient costs also hinder adoption. Addressing both technological and behavioral barriers is crucial for successful implementation.

The study found that access to extension services, peer influence, education, training opportunities, and income levels significantly influence the adoption of Rumen8-formulated balanced rations among dairy farmers. Farm size was found to be less significant, suggesting the need for targeted interventions.

7. Recommendations

Provide training program aims to equip dairy farmers with the use of Rumen8 software, incorporating hands-on workshops and practical demonstrations to enhance their confidence in ration formulation.

Launching awareness campaigns highlighting the benefits of using Rumen8 software for formulating balanced rations. Utilize local radio stations, community meetings, and agricultural fairs to reach a wider audience.

Create forums for farmers to share their experiences and best practices related to Rumen8 software and balanced rations. Peer-to-peer learning can enhance adoption and utilization.

Investigate the potential for financial support or incentives for farmers who adopt Rumen8-formulated rations, such as subsidies or low-interest loans for purchasing feed ingredients.

Abbreviations

MAAIF	Ministry of Agriculture Animal Industries and Fisheries
SNV	Netherlands Development Organization
%	Percentages

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Conflicts of Interest

The authors declare no conflicts of interest.

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