



Beef Cattle Farmers' Perceptions Towards Mineral Block Supplementation in Playen District, Gunung Kidul

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Abstract | Smallholder farmers often struggle to meet the mineral requirements of their cattle, leading to nutritional deficiencies that negatively impact livestock productivity. Mineral block supplementation has been introduced as a practical and cost-effective solution to address this issue. However, its adoption largely depends on farmers' perceptions and acceptance of the technology. This study assesses farmers' perceptions of mineral block supplementation and examines the factors influencing these perceptions. The research was conducted in Playen District, Gunung Kidul, using structured and validated questionnaires administered through direct interviews with 59 farmers from two farmer groups. The findings indicate that farmers generally hold positive perceptions of mineral block supplementation, particularly regarding its relative advantage, compatibility, complexity, trialability, and observability. Multiple linear regression (MLR) analysis revealed that age ($P < 0.05$), formal education ($P < 0.01$), extension services ($P < 0.05$), and institutional support ($P < 0.01$) significantly influenced farmers' perceptions. These findings highlight the importance of targeted extension efforts and institutional support in promoting mineral block adoption among smallholder cattle farmers.

Keywords | Beef cattle farming, Extension services, Farmers' perception, Innovation adoption, Mineral block supplementation, Playen district

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INTRODUCTION

Beef cattle farming is a vital component of Indonesia's livestock sector, contributing significantly to both economic stability and nutritional security. Achieving optimal cattle productivity depends on a well-balanced diet com-

prising carbohydrates, proteins, fats, vitamins, and essential minerals (Lalman and Holder, 2023). Cattle require various macro and micro minerals for optimal health and productivity. Key macro minerals like calcium (2.0–11.0 g/kg DM) and phosphorus (1.0–3.8 g/kg DM) are essential for metabolic processes such as carbohydrate and protein

synthesis, nucleic acid formation, and skeletal development. Magnesium (1.3–2.2 g/kg DM) plays a crucial role in muscle function and rumen metabolism. Micro-minerals such as copper (4–14 mg/kg DM) and zinc (9–20 mg/kg DM) support immune function, while selenium (0.04 mg/kg DM) is vital for reproduction (McDowell, 1996; NRC, 2000; NASEM, 2016). Despite the crucial role of mineral nutrition, deficiencies remain widespread among smallholder farmers, particularly in Indonesia. Farmers typically rely on locally available feed, which is often preferred by the cattle. However, this practice can lead to a mineral imbalance, as essential minerals are not adequately supplemented (Khalil *et al.*, 2015). Consequently, such imbalances can result in impaired growth, reduced reproductive efficiency, and heightened susceptibility to diseases (Wang *et al.*, 2016; Bhalakiya *et al.*, 2019). Mineral deficiencies can lead to several disorders in cattle such as milk fever (hypocalcaemia), grass tetany (hypomagnesaemia), anemia (due to iron or copper deficiency), and reproductive failures linked to selenium and phosphorus deficiency (Wu, 2020). These deficiencies, in the context of Indonesia, have been shown to reduce growth rates of cattle by an average of 0.2 kg/head/day (Khalil *et al.*, 2015). Mineral block supplementation has emerged as a practical and efficient strategy for ensuring consistent mineral intake, particularly in smallholder cattle farming. These blocks provide essential macrominerals and trace elements through a slow-release mechanism, enabling continuous nutrient absorption while minimising the need for frequent supplementation (Mengistu and Hassen, 2017; Palomares, 2022). Compared to mineral concentrates, mineral blocks require less labour, making them a more accessible and convenient solution for small-scale farmers (Windsor *et al.*, 2020). Their application is straightforward, as farmers can simply hang the blocks in cattle pens, allowing livestock to consume minerals as needed. Each 1 kg block, priced at approximately IDR10,000, sustains an adult cow for 3–4 months. High salt content enhances palatability, while a dry matter content exceeding 86% ensures durability, long-term storage, and resistance to breakage (BRIN, 2024). Beyond convenience, mineral block supplementation has been shown to improve nutrient intake, digestibility, weight gain, and overall herd health which are essential factors for sustainable cattle farming (Windsor *et al.*, 2020; SungChinTial *et al.*, 2023). Additionally, research by Windsor and Hill (2022) underscores the adaptability of mineral blocks, as high-quality molasses-based formulations can be tailored to specific needs, incorporating anthelmintics for parasite control or urea to enhance nitrogen availability and rumen fermentation of low-quality forages. By fulfilling essential mineral requirements and improving cattle health, mineral blocks present a cost-effective solution for smallholder farmers (Owen *et al.*, 2012; Patil, 2017; Reshi *et al.*, 2022; Mobashar *et al.*, 2023).

The adoption of new agricultural technologies is strongly influenced by farmers' perceptions, which shape their willingness to integrate innovations into their farming systems (Roussy *et al.*, 2017). Perception, in this context, refers to the way individuals interpret information, events, and relationships, influencing decision-making in agricultural practices (Rogers, 2003). Farmers' attitudes towards an innovation can be broadly categorised as either positive—indicating acceptance and readiness to adopt—or negative, reflecting hesitation or opposition (Okello *et al.*, 2021). In the case of mineral block supplementation, farmers' perceptions play a pivotal role in determining its adoption, effectiveness, and long-term implementation. Understanding these perceptions is crucial in efforts to improve cattle health and farm productivity. Previous research has identified multiple factors shaping farmers' perceptions, including internal factors such as socio-demographic characteristics, and external influences such as extension services, and institutional support (Qui *et al.*, 2021; Qui *et al.*, 2025). While considerable research has focused on the nutritional efficacy of mineral blocks in enhancing cattle health and productivity (Khalil *et al.*, 2015; Patil *et al.*, 2017; Palomares, 2022; Mobashar *et al.*, 2023; SungChinTial *et al.*, 2023), there remains a noticeable gap in the literature regarding the socio-behavioural factors influencing their adoption. Studies specifically examining farmers' perceptions of mineral block supplementation within smallholder systems are scarce. This study aims to address this gap by investigating beef cattle farmers' perceptions of mineral block supplementation and analysing the factors influencing these perceptions in Playen District, Gunung Kidul.

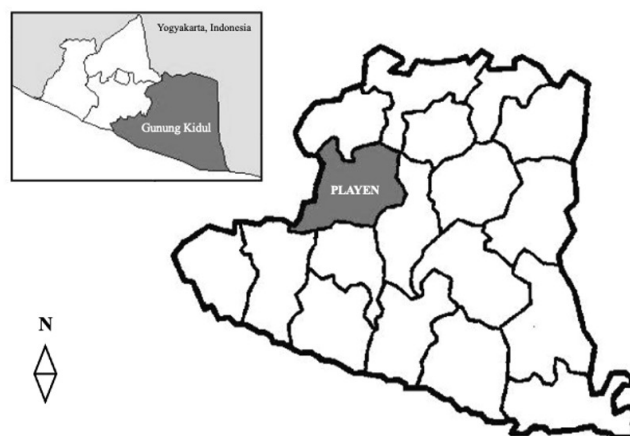


Figure 1: Research location.

MATERIAL AND METHODS

The study site was deliberately selected (purposive sampling) at the Margo Mulyo and Andini Mulyo farmer groups, Playen District, Gunung Kidul (Figure 1). This selection was particularly based on their participation in training on mineral block production provided by National

Research and Innovation Agency (BRIN) and the Faculty of Animal Science Gadjah Mada University. Since 2018, these groups have also been partner beneficiaries of the Australian Centre for International Agricultural Research (ACIAR) under the “Profitable Feeding” program. This region has significant potential for livestock development due to its extensive rainfed agricultural land, making it suitable for beef cattle farming. The selected farmer groups in this study are considered representative of smallholder beef cattle farmers in Gunungkidul Regency and, more broadly, in Indonesia. These farmers typically own 1–5 head of cattle, which aligns with national statistics indicating that the majority of beef cattle ownership in Indonesia is small-scale and subsistence-based (BPS Gunungkidul, 2024; Directorate General of Livestock and Animal Health Services, 2021). National-level data from the 2017 Livestock Business Survey (SOUT) and the 2018 Intercensal Agricultural Survey (SUTAS) conducted by BPS also show that over 95% of beef cattle are raised by smallholder farmers operating on a micro-scale and often as a secondary or subsistence activity. This supports the representativeness of the sample used in our study in reflecting the general characteristics of smallholder cattle farming in similar contexts.

Respondents were selected using a census method, in which all 59 members of the livestock groups were included in the study. All participants were smallholder beef cattle farmers, actively engaged in group activities, and had at least one year of farming experience. In addition, the majority of farmers raised Peranakan Ongole (PO) cattle, which is the predominant breed in the study area.

A structured questionnaire was administered through face-to-face interviews with 59 respondents. To ensure the validity of the instrument, an expert review in social research was conducted, confirming that the items accurately reflected the intended constructs. Internal consistency and item relationships were verified using Pearson correlation analysis. The reliability of the survey instrument was evaluated using Cronbach’s alpha. According to Ursachi *et al.* (2015) and Sugiyono (2017), an instrument is considered reliable if its reliability coefficient is at least 0.6. The results showed that all innovation characteristics met this criterion, with Cronbach’s alpha values ranging from 0.687 to 0.752. The highest reliability was observed in complexity (0.752), while the lowest was in trialability (0.687). These findings confirm that the instrument used in this study is reliable for measuring innovation characteristics. The questionnaire encompassed socio-demographic characteristics, perceptions of mineral block supplementation—assessed through five perception items of innovation characteristics based on Rogers’ diffusion of innovation theory: relative advantage, compatibility, complexity, trialability, and observability—and the roles of extension services and institutional support. The questionnaire was improved in

accordance with validated measurement frameworks and established research guidelines. Moreover, during the questionnaire development stage, we consulted with local experts and field practitioners to ensure the statements were clear and comprehensible, thereby minimising respondent confusion or indecision.

First, the survey collected socio-demographic profiles such as gender, age, formal education, family member, and farming experience. Second, the key construct measured in this study—farmers’ perception towards mineral block supplementation—was conceptualised as unipolar, representing a continuum from low to high perceived benefit. Following Tay and Jebb (2018), this continuum was operationalised using a 4-point Likert scale without a neutral option, thereby encouraging respondents to express a clear stance of agreement or disagreement. The response categories used were: 1-Strongly Disagree, 2-Disagree, 3-Agree, and 4-Strongly Agree. The Likert scale is widely acknowledged as a fundamental and frequently employed psychometric tool in social science research (Joshi *et al.*, 2015). Third, yes/no questions (1=Yes, 0=No) were included as dummy variables followed by open-ended questions to provide deeper insights into farmers’ perspectives on the role of extension services and institutional support in disseminating and assisting with mineral block supplementation.

Data were analysed using SPSS 26.0 and Excel 2019. The analytical method used to answer the research objectives regarding the factors that influence beef cattle farmers’ perception towards mineral block supplementation is multiple linear regression analysis (MLR). The MLR function consists of Y (dependent variable) and X (independent variable) can be illustrated as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + \varepsilon$$

Where Y is the beef cattle farmers’ perception towards mineral block supplementation as dependent variable, β_k refers to constant, X_i is the vector of independent variables such as age (X_1), formal education (X_2), farming experience (X_3), extension services (X_4), and institutional support (X_5). β_k refers to parameter estimate for the i^{th} independent variable and ε represents the error term or residual in the regression model. An explanation of the variable definitions used in this study can be seen in full in Table 1.

RESULT AND DISCUSSION

THE DESCRIPTION OF SOCIO-DEMOGRAPHIC CHARACTERISTICS OF BEEF CATTLE FARMERS

The socio-demographic characteristics of beef cattle farmers in Playen District, Gunung Kidul, reveal several key insights into the farming community (Table 2). Gender distribution shows that the majority of farmers are female

(64.41%), while males constitute 35.59% of the total respondents. This suggests a significant role of women in cattle farming, possibly in household-based livestock management, decision-making, or labour distribution.

Table 1: Variable definition.

Variables	Definition
1. Beef cattle farmers' perception	Beef cattle perception of mineral block technology reflects their response to this innovation, evaluated based on Rogers' diffusion of innovation theory. This includes relative advantage, compatibility, complexity, Trialability, and observability as key characteristics influencing their acceptance. This variable is measured using the likert scale: 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree
2. Demographic Characteristics	
Age	The age of beef cattle farmers from the date of their born to the last birthday (years).
Gender	The biological classification of beef cattle farmers as male or female (1=male, 0=female).
Formal Education	The education of beef cattle farmers in the school (1=primary school, 2=secondary school, 3=high school, 4=diploma).
Family Member	The total number of individuals living in the beef cattle farmers's household.
Farming Experience	Experience of the beef cattle farmers in livestock business in years.
3. Extension Services	The access to guidance or training on mineral block supplementation from agricultural extension agents or advisory services (1=yes, 0=no)
4. Institutional Support	The assistance from institutions such as BRIN and UGM in the form of information, or facilitation related to mineral block supplementation (1=yes, 0=no)

The average age of respondents is 56.92 ± 11.66 years, with 74.58% classified as productive and 25.42% as unproductive. This indicates that most farmers are still in their productive years, though the relatively high average age suggests a potential challenge in the long-term sustainability of cattle farming due to aging farmers and limited regeneration of younger livestock producers. Education levels vary, with most farmers having completed primary school (33.90%) or secondary school (33.90%), while 30.51% attained a high school education, and only 1.69% pursued higher education (diploma level). The average length of formal education is 9.00 ± 2.55 years, suggesting that while basic literacy is present, advanced education in livestock management may be limited. This could influence farmers' ability to access and apply more advanced livestock technologies, including mineral block supplementation. The average household size is 2.02 ± 1.24 members, indicating relatively small family units, which may affect labour avail-

ability for cattle farming. Meanwhile, farming experience averages 25.85 ± 17.27 years, showing that most farmers have extensive hands-on knowledge in livestock management.

Table 2: Beef cattle farmers' socio-demographic characteristics.

No Socio-demographic characteristics		Results	
		N	Percentage
1. Gender	Male	21	35,59
	Female	38	64,41
2. Age		56,92	11,66
	Productive	44	74,58
	Unproductive	15	25,42
3. Formal Education		9,00	2,55
	Primary School	20	33,90
	Secondary School	20	33,90
	High School	18	30,51
	Diploma	1	1,69
4. Family Member		2,02	1,24
5. Farming Experience		25,85	17,27

BEEF CATTLE FARMERS' PERCEPTION TOWARDS MINERAL BLOCK SUPPLEMENTATION

Based on Table 3 and 4, the results indicate that most beef cattle farmers in Playen District, Gunung Kidul, hold a positive perception of mineral block supplementation, as assessed using Rogers' diffusion of innovation theory. The highest mean score was recorded for observability (3.559 ± 0.497), suggesting that farmers found the benefits of mineral block supplementation, such as improved cattle weight gain and ease of replication, to be highly visible and verifiable. Compatibility (3.354 ± 0.483) also received strong agreement, indicating that farmers perceived mineral blocks as aligning well with existing livestock management practices, particularly in terms of ease of use, ingredient safety, and low risk to cattle. Similarly, relative advantage (3.213 ± 0.658) was positively rated, with farmers recognising the economic and nutritional benefits of mineral block supplementation, including improved cattle health, increased weight gain, and affordability. The affordability of the mineral blocks, priced at IDR 10,000 per block, was a key factor in the positive perception, with 86.44% of farmers considering the price reasonable and within their financial means. This low cost enhances the perceived economic benefit, as farmers do not see the price as a barrier to adoption. Additionally, the ability to produce and sell mineral blocks to other farmers creates further economic value, reinforcing the relative advantage of this practice. Similar findings have been reported in other contexts, where mineral block supplementation provided an accessible source of nutrients during the dry season, improved body condition

Table 3: Beef cattle farmers' perceptions towards mineral block supplementation in Playen District, Gunung Kidul.

No	Statements	Degree of perception towards mineral block			
		1	2	3	4
1.	Relative advantage				
	Mineral blocks help fulfil the mineral requirements of cattle.	0	11,86	57,63	30,51
	Cattle exhibit better growth compared to those not supplemented with mineral blocks.	1,70	13,56	59,32	25,42
	Cattle have greater resistance to diseases.	1,70	6,78	69,50	22,03
	The raw materials for producing mineral blocks are easily accessible.	0	11,86	66,11	22,03
	The mortality rate of cattle is relatively lower with the utilization of mineral blocks.	1,70	8,48	64,40	25,42
	The cost of purchasing equipment for mineral block maintenance remains affordable.	1,70	11,86	42,37	44,07
	Mineral blocks are easy to produce.	1,70	6,78	55,93	35,59
	The price of mineral blocks is relatively low.	0	13,56	44,07	42,37
	Mineral blocks can be produced and sold to other farmers, creating economic value.	1,70	8,48	59,32	30,50
	Mineral blocks help increase cattle appetite and weight gain.	0	10,17	42,37	47,46
	Mineral blocks are economically beneficial for farmers.	0	11,86	44,07	44,07
	Average:	3,213	0,658		
2.	Compatibility				
	Mineral blocks are highly palatable to cattle.	0	0	74,58	25,42
	The ingredients used in mineral block production are safe and meet quality standards.	0	0	71,19	28,81
	The production of mineral blocks for cattle is simple, following similar methods for goats and dairy cattle.	0	0	77,97	22,03
	Mineral blocks are easily provided by hanging them in the barn.	0	1,70	45,76	52,54
	Mineral blocks are made from materials that are widely available in the surrounding environment.	0	0	71,19	28,81
	Mineral blocks align with farmers' needs and expectations.	0	0	81,36	18,64
	The use of mineral blocks poses no risks to cattle.	0	0	33,90	66,10
	The use of mineral blocks in cattle farming can be widely promoted in communities.	0	0	57,63	42,37
	Average:	3,354	0,483		
3.	Complexity				
	Mineral block production is easy to apply.	1,70	30,51	37,28	30,51
	The process is simple and uncomplicated.	1,70	32,20	38,98	27,12
	Production time is relatively short.	0	27,12	54,24	18,64
	Ingredient composition is easily measurable.	5,09	28,81	49,15	16,95
	It does not require much time to produce.	8,48	25,42	44,07	22,03
	Average:	2,875	0,8		
4.	Trialability				
	Each farmer has the opportunity to try making mineral blocks independently.	1,70	32,20	38,98	27,12
	Extension officers and partner institutions facilitate training sessions on mineral block production.	1,70	30,51	42,37	25,42
	Extension officers and partner institutions also provide sample mineral blocks as references.	0	28,81	54,24	16,95
	Farmers can easily conduct trials by administering mineral blocks to their cattle.	5,09	28,81	49,15	16,95
	Partners and extension officers offer direct assistance and supervision during the trial process.	8,48	25,42	45,76	20,34

Average:	2,854	0,788		
5. Observability				
Extension officers and partners provide support by offering expert speakers for mineral block training.	0	0	38,98	61,02
The mineral block production training process is easy to observe.	0	0	40,68	59,32
The effectiveness of mineral block use can be evaluated through cattle weight gain.	0	0	49,15	50,85
Partners assist farmers in analysing the benefits of mineral blocks.	0	0	32,20	67,80
Other farmers can easily replicate the practice of administering mineral blocks.	0	0	59,32	40,68
Average:	3,559	0,497		

Note: scale ranging from 1 (strongly disagree) to 4 (strongly agree), Source: Primary Data (2023).

and weight, enhanced livestock health, and supported food security and sustainable meat production (Windsor and Hill, 2022).

Table 4: Innovation characteristics categorization.

Innovation characteristics	Category	Score	Frequency	Percentage
Relative Advantage	Good	11 - 27,5	52	88,14
	Not Good	27,6 - 44	7	11,86
Compatibility	Good	8 - 20	100	100
	Not Good	20,1 - 32	0	0
Complexity	Good	5 - 12,5	40	67,80
	Not Good	12,6 - 20	19	32,20
Triability	Good	5 - 12,5	39	66,10
	Not Good	12,6 - 20	20	33,90
Observability	Good	5 - 12,5	100	100
	Not Good	12,6 - 20	0	0

However, complexity (2.875 ± 0.800) and trialability (2.854 ± 0.788) received lower scores, reflecting more varied responses. Although many farmers agreed that mineral block production was relatively simple, some farmers reported challenges in accurately measuring the ingredients needed for mineral block production, as well as concerns about the time required for the process, particularly the drying phase, which can take approximately 5–7 days. These practical difficulties were mentioned during the open-ended responses. Trialability also exhibited moderate agreement, with some farmers unsure about their ability to independently test mineral blocks, possibly due to a lack of prior experience in experimenting with new feeding technologies. In addition, although technically the administration of mineral blocks to cattle only requires hanging the blocks, there were concerns regarding their durability. Some farmers experienced cases where the mineral blocks crumbled easily during or shortly after the hanging process. This issue was partly attributed to the fact that many farmers were not yet fully skilled in the production process, which affected the structural quality and consistency of the final product.

FACTORS INFLUENCING BEEF CATTLE FARMERS' PERCEPTION TOWARDS MINERAL BLOCK SUPPLEMENTATION

The data used has met the classical assumptions, including the tests for normality, multicollinearity, and heteroscedasticity. After meeting the classical assumption tests, multiple regression analysis was conducted. This involved performing the simultaneous test (F-test), the partial test (t-test), constructing the regression model, and testing the coefficient of determination. The F-test assesses the joint effect of independent variables on the dependent variable. If the significance value (Sig.) is less than 0.05, it indicates a significant simultaneous impact of the independent variables on the dependent variable. The t-test assesses each independent variable's effect on the dependent variable. If the significance value (Sig.) is less than 0.05, the variable has a significant partial effect. If the significance value (Sig.) is more than 0.05, the effect is not significant. Coefficient of Determination (R²) Test, this test measures how well the regression model explains the impact of independent variables on the dependent variable. The R² value ranges from 0 to 1; a value closer to 1 indicates a better fit, meaning the model more effectively explains the variation in the dependent variable. Adjusted R² is preferred because it adjusts for the number of predictors in the model. Unlike R², which can artificially increase with the addition of more variables, adjusted R² provides a more accurate measure of model performance by correcting for the inclusion of irrelevant predictors. This adjustment ensures that the model's explanatory power is evaluated more accurately, reflecting only the predictors that truly contribute to explaining the dependent variable. The result of the analysis can be shown in Table 5 and Table 6.

Table 5: Multiple Linier Regression Analysis (F-test).

Parameter	Sum of Squares	df	Mean Square	F	Sig.
Regression	6253,449	5	1250,690	45,508	0.000
Residual	1456,585	53	27,483		
Total	7710,034	58			

Table 6: Multiple Linier Regression Analysis (t-test).

Variable	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	82,212	4,806	17,150	0.000
Age (X_1)	-0.163	0,076	-2.143	0.037**
Formal Education (X_2)	2.827	0.350	8.077	0.000***
Farming Experience (X_3)	0.016	0.053	0.298	0.767
Extension Services (X_4)	5.591	2.350	2.379	0.021**
Institutional Support (X_5)	6.147	2.270	2.708	0.009***

Dependent Variable: beef cattle farmers' perception (Y);

Description: **: 5% significance; ***: 1% significance;

Noted: adjusted R^2 : 0.793; sig.: 0.000.

The F-test results indicated a significance value (Sig.) of 0.000, which is less than 0.05. This demonstrates that age (X_1), formal education (X_2), farming experience (X_3), extension services (X_4), and institutional support (X_5), collectively have a significant influence on farmers' perception with the mineral block supplementation (Y). The t-test results revealed that age ($P < 0.05$), formal education ($P < 0.01$), extension services ($P < 0.05$) and institutional support ($P < 0.01$) were significant determinants of perception. Regression model based on the result can be shown as follows:

$$Y = 82.212 - 0.163X_1 + 2.827X_2 + 5.591X_4 + 6.147X_5 + 4.806$$

The coefficient of determination (adjusted R^2) is found to be 0.793 indicates that 79.3% of farmers' perception (Y) is explained by age ($P < 0.05$), formal education ($P < 0.01$), extension services ($P < 0.05$) and institutional support ($P < 0.01$) then 20.7% was influenced by other variables not included in the research model. The positive constant of 82.212 indicates that, when X_1 , X_2 , X_4 and X_5 are constant, the average farmers' perception (Y) is 82.212. In our analysis, the regression output includes an error value of +4.806. This figure represents the average deviation of the observed values from the predictions generated by the model, after accounting for the effects of the independent variables. Age (X_1) has a negative effect ($P < 0.05$) with a coefficient of -0.163, indicating that as farmers age, their perception of mineral block supplementation tends to decline. This may suggest that older farmers are more resistant to adopting new innovations or have more ingrained traditional practices (John *et al.*, 2023). Furthermore, our study revealed that older farmers faced physical challenges that limited their ability to fully participate in mineral block production training sessions. These difficulties were mainly associated with the precision required in measuring ingredients, controlling the water content in the mixture, and manually pressing the mineral block mixture into the moulds. Formal education (X_2) shows a highly significant positive effect ($P < 0.01$) with a coefficient of 2.827, mean-

ing that farmers with higher education levels tend to have a more favourable perception. This aligns with the idea that education enhances farmers' ability to process information and understand the benefits of supplementation. Farmers with higher education levels, particularly high school graduates, managed more productive farms than those with only primary education, highlighting the role of education in improving farm efficiency (Vu *et al.*, 2019). Educated farmers were more inclined to seek information, adopt innovations, and embrace sustainable practices, ultimately enhancing productivity. Previous studies also emphasize that formal education equips farmers with the knowledge to understand complex agricultural advancements and effectively apply modern farm management techniques (Biru and Korgitet, 2019; Qui *et al.*, 2025). This may be due to their high literacy levels and available resources, enabling them to access and interpret information effectively (Okello *et al.*, 2021). Since education level significantly influence farmers' perceptions, several adjustments are recommended to better support less-educated farmers. Programmes should place greater emphasis on visual aids, such as step-by-step posters, pictorial guides, and short instructional videos, which could be highly effective in improving understanding, particularly for farmers with limited formal education.

Extension services (X_4) also have a significant positive effect ($P < 0.05$), with a coefficient of 5.591. This suggests that farmers who have greater access to extension services develop a better perception of mineral block supplementation. Agricultural extension services provide farmers with essential knowledge and hands-on guidance, helping them understand and implement technological advancements. Informal learning opportunities within extension programs serve as a key source of information, enabling farmers to overcome challenges and make more informed decisions (Qui *et al.*, 2021; Kassem *et al.*, 2021). The role of regular extension services is particularly important in minimizing economic losses by equipping farmers with better livestock management skills (Putra *et al.*, 2024). Additionally, frequent engagement with extension workers fosters a problem-solving mindset among farmers, encouraging them to take a more proactive approach in addressing livestock-related issues. Moreover, consistent extension support helps address the challenges associated with aging, which can make it harder for farmers to adopt new techniques and adapt to evolving agricultural practices (Yu *et al.*, 2023). Older farmers, who may face cognitive and physical barriers to learning, would benefit from simplified technical procedures and training sessions conducted at a pace suited to their needs. Regular follow-up visits by extension officers would also reinforce knowledge and offer opportunities for personalized assistance. Additionally, peer learning approaches, where experienced farmers help others, should be encouraged to create a more supportive

learning environment. Previous studies on mixed crop and livestock (MCL) farming technology have shown that engaging with extension agents, attending training sessions, duration of group membership, and experience in livestock farming expand farmers' access to information. These factors significantly contribute to improving their understanding and knowledge of MCL technology, which has been proven to increase adoption levels (Putra *et al.*, 2019; Widarni *et al.*, 2020).

Institutional support (X_5) has the strongest positive influence ($P < 0.01$) with a coefficient of 6.147. The support provided by institutional partners encompassed several key aspects. First, mineral block formulations and production procedures were supplied, developed, and validated through both in vitro and in vivo testing, ensuring safety and effectiveness. Second, essential equipment and materials were provided during training sessions to facilitate practical adoption. Third, extension officers and institutional partners served as facilitators and trainers during group-based workshops, strengthening farmers' technical competencies. Finally, selected farmers received assistance in conducting mineral block trials directly on their cattle, offering hands-on experience and reinforcing practical confidence. Institutional partnerships, particularly with UGM and BRIN, proved pivotal in shaping beef cattle farmers' perceptions of innovation, especially in the adoption of mineral block supplementation. According to Syihabuddin *et al.* (2025), strong institutional relationships, supported through consistent engagement and monitoring, enable smoother transitions to new technologies. This collaboration not only facilitates effective knowledge transfer but also builds farmers' confidence in adopting practices that enhance livestock health and resilience. Without continuous extension and adequate support, farmers may struggle to keep pace with advancements, potentially limiting their capacity to sustain and improve farming operations. Thus, maintaining regular extension initiatives and strengthening institutional partnerships are essential for fostering long-term agricultural resilience and ensuring farmers remain well-equipped to adapt to technological changes.

CONCLUSIONS AND RECOMMENDATIONS

This study found that beef cattle farmers generally had a positive perception of mineral block supplementation, particularly in terms of its relative advantage, compatibility, complexity, trialability, and observability. Factors such as age, education level, extension services, and institutional support significantly shaped these perceptions. Strengthening institutional collaboration and maintaining continuous extension efforts are essential for fostering long-term agricultural resilience, ensuring that farmers of all ages

have the knowledge and resources to adapt to technological advancements, thereby enhancing cattle nutrition and farm productivity. We recommend further research on the economic impact of mineral block use on farm profitability, as well as qualitative studies to explore behavioural drivers and potential barriers to the adoption of mineral block supplementation practices.

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NOVELTY STATEMENT

Previous studies have largely focused on the nutritional efficacy of mineral block supplementation, while research on farmers' perceptions of this innovation and the factors influencing them remains limited. This study fills that gap by examining beef cattle farmers' perceptions of mineral block supplementation and identifying key socio-demographic and external factors—such as extension services and institutional support—that shape these perceptions. Consequently, this research provides a more comprehensive understanding of the role of perception in the successful implementation of mineral block supplementation strategies in smallholder farming systems.

AUTHOR'S CONTRIBUTIONS

All authors collaboratively worked on the manuscript, contributing equally to its development. Each author was actively involved in various stages of the research, including conceptualization, data collection, analysis, and manuscript writing. Their contributions were evenly distributed, ensuring a balanced effort in shaping the final paper.

CONFLICT OF INTEREST

We declare that there is no Conflict of Interest with financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

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