Research Article

Drivers of Farmer Adoption for Livestock Feed Inoculants: The Role of Perceived Innovation Attributes

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Abstract | This study aims to analyze the influence of perceived attributes of innovation namely relative advantage, compatibility, complexity, and trialability on the adoption of superior inoculant technology for livestock feed fermentation. A quantitative, cross-sectional research design was employed, and data were collected through a structured questionnaire administered to 200 farmers in Barru Regency, South Sulawesi Province, Indonesia, from September to November 2025, using a purposive sampling technique. The measurement instrument was developed based on the perceived attributes of innovation framework. Data were analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM) with SmartPLS software. Results from the measurement model indicate that all constructs demonstrate satisfactory reliability and convergent validity, with outer loading values above 0.70, Composite Reliability and Cronbach's Alpha values exceeding 0.70, and Average Variance Extracted values above 0.50. Discriminant validity was also confirmed using the Fornell–Larcker criterion. Structural model results show that relative advantage, compatibility, complexity, and trialability significantly influence adoption of superior inoculant technology. Relative advantage has the strongest positive effect on adoption, indicating that farmers are more likely to adopt the technology when they perceive clear benefits such as improved fermentation efficiency, enhanced feed quality, cost reduction, and increased output. Compatibility and trialability also positively influence adoption, suggesting that technologies aligned with existing farming practices and allowing opportunities for experimentation are more readily adopted. In contrast, complexity exhibits a significant negative effect, indicating that perceived difficulty in using the technology hinders adoption. The model explains 20.9% of the variance in adoption behavior ($R^2 = 0.209$) and demonstrates adequate predictive relevance. The relatively modest explanatory power indicates that adoption decisions are also shaped by broader contextual determinants that were not captured in this perception-based model, such as economic capacity, access to inoculant inputs, extension support, and farmers' social networks. These findings highlight that the adoption of superior inoculant technology is shaped by farmers' practical and experiential evaluations rather than by technical characteristics alone. The study contributes to the literature on agricultural innovation adoption by providing a context-specific, perception-based model of adoption behavior and offers practical insights for policymakers, extension agents, and technology developers seeking to promote sustainable livestock feed fermentation practices.

Keywords | Superior inoculant, Feed fermentation, Innovation adoption, Farmer perception, PLS-SEM, Technology diffusion

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INTRODUCTION

The availability and quality of feed are critical challenges in livestock production, particularly for small- and medium-scale farmers. Feed fermentation has been widely adopted as a strategy to improve feed quality, enhance nutrient availability, and utilize locally available feed resources more efficiently. In this context, superior inoculant technology offers a promising innovation by accelerating fermentation processes and improving the physical and nutritional quality of fermented feed (Katu *et al*., 2025).

Despite these technical benefits, the adoption of superior inoculant technology among farmers remains uneven. Empirical evidence suggests that technological superiority alone does not ensure widespread adoption, as farmers' decisions are also influenced by their perceptions, experiences, and practical constraints. For successful adoption in agricultural settings, innovations must not only perform well technically but also align with farmers' routines, resources, and risk tolerance (Mohammed and Abdulai, 2022).

The Perceived Attributes of Innovation framework provides a well-established theoretical basis for explaining adoption behavior. This framework emphasizes key innovation characteristics, including relative advantage, compatibility, complexity, and trialability, as determinants of adoption. Previous applications of this framework have focused on crop technologies, mechanization, or digital agriculture. Empirical research on microbial innovations for livestock feed fermentation remains limited (Yuen *et al*., 2021; Arowosegbe *et al*., 2024). This represents a clear and important gap in the literature. There is a lack of empirical studies that use a perception-based framework and advanced analytical techniques to systematically examine how farmers perceive and adopt superior inoculant technology for feed fermentation. Furthermore, few studies have simultaneously evaluated multiple perceived attributes and quantified their relative influence on adoption within a single structural model (Reproto *et al*., 2024).

To address this gap, this study applies the perceived attributes of innovation framework specifically to superior inoculant technology for livestock feed fermentation. By employing Partial Least Squares–Structural Equation Modeling (PLS-SEM), this study aims to analyze the effects of relative advantage, compatibility, complexity, and trialability on the adoption of superior inoculant technology by farmers. The findings are expected to contribute to the literature on agricultural innovation adoption and provide practical insights for promoting sustainable feed fermentation technologies.

CONCEPTUAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

This study is grounded in the Perceived Attributes of Innovation framework, which explains technology adoption as a process shaped by individuals' evaluations of key innovation characteristics, namely relative advantage, compatibility, complexity, and trialability (Montes de Oca Munguia *et al*., 2021). In the context of livestock feed fermentation, superior inoculant technology is conceptualized as an agricultural innovation whose adoption depends on how farmers perceive these attributes in relation to their farming practices and production needs. The conceptual framework can be seen in Figure 1.

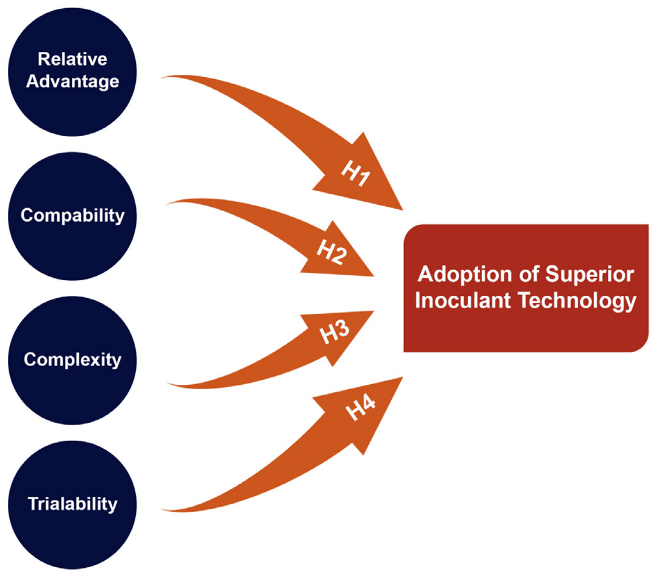

Figure 1: Conceptual Framework

Relative advantage refers to the extent to which superior inoculant technology is perceived to provide better outcomes than conventional fermentation methods. In livestock feed fermentation, perceived advantages may include faster fermentation processes, improved feed quality, reduced production costs, and increased output quantity. Innovations that are perceived to offer greater benefits are generally more attractive to farmers and are therefore more likely to be adopted (Mombeuil and Uhde, 2021; Shamout *et al*., 2022). Based on this reasoning, the following hypothesis is proposed:

H1: Relative advantage positively influences the adoption of superior inoculant technology:

Compatibility reflects the degree to which the technology is perceived to align with existing practices, available feed materials, community norms, and sustainability values. Innovations that fit well with current practices typically require fewer adjustments and are easier to integrate into daily farming routines. When farmers perceive a high level of compatibility, they are more inclined to adopt the technology (Okoye *et al*., 2023; Chen *et al*., 2025).

Accordingly, the following hypothesis is formulated:

H2: Compatibility positively influences the adoption of superior inoculant technology:

Complexity refers to farmers' perceptions of how easy it is to understand, apply, store, and manage the inoculant technology. Technologies perceived as easier to use are adopted more readily as they reduce the cognitive and operational burden on farmers. Therefore, lower perceived complexity is expected to encourage adoption (Denton *et al*., 2017; Kaine and Wright, 2022). Based on this perspective, the following hypothesis is proposed:

H3: Complexity negatively influences the adoption of superior inoculant technology:

Trialability represents the extent to which farmers can experiment with the inoculant technology on a limited basis before committing to full-scale adoption. Opportunities to test, compare outcomes, and observe peer results reduce uncertainty and build confidence. Consequently, more trialable innovations are more likely to be adopted (Emerick and Dar, 2021; Farris *et al*., 2024). Thus, the following hypothesis is proposed:

H4: Trialability positively influences the adoption of superior inoculant technology:

Overall, this study proposes a conceptual framework in which farmers' perceptions of relative advantage, compatibility, complexity, and trialability. This study proposes a framework in which perceptions of relative advantage, compatibility, and trialability positively influence adoption, while complexity negatively influences it. The results will be interpreted within the specific socioeconomic and agricultural context of the study area. (Farquharson *et al*., 2013; Shang *et al*., 2021).

MATERIALS AND METHODS

Research design and data collection

This study employed a quantitative, cross-sectional research design to examine the influence of perceived attributes of innovation on the adoption of superior inoculant technology for livestock feed fermentation. The research was conducted in Barru Regency, South Sulawesi Province, Indonesia, from September to November 2025. This region was selected due to its prevalent livestock farming and feed fermentation practices. The target respondents were farmers engaged in feed fermentation who had some experience with or knowledge of superior inoculant technology. Data were collected through a structured questionnaire administered via a field survey. The questionnaire items were adapted from prior studies on perceived innovation attributes and were reviewed prior to administration to ensure clarity, relevance, and consistency with the local context. Participation was voluntary, and respondents were informed about the purpose of the study. Before completing the survey, all respondents received an explanation of the study objectives and provided verbal informed consent. No personal identifiers were collected, and responses were recorded anonymously to ensure confidentiality. The study involved a non-invasive, minimal-risk survey and did not collect sensitive personal data. Ethical considerations, including informed consent, anonymity, and confidentiality, were strictly observed in accordance with applicable institutional and local guidelines at the time of data collection. Anonymity and confidentiality were ensured to meet ethical research standards (Mazhar *et al*., 2021).

Measurement and instrument development

The measurement instrument was developed based on the Perceived Attributes of Innovation framework, which emphasizes relative advantage, compatibility, complexity, and trialability as key determinants of innovation adoption. All constructs were specified as reflective constructs and adapted to the context of livestock feed fermentation using superior inoculants, following established innovation diffusion literature (Yin *et al*., 2022).

All indicators were measured on a five-point Likert scale (1= strongly disagree to 5= strongly agree). The questionnaire items were reviewed to ensure clarity, relevance, and contextual suitability prior to data collection. The operational design of the variables can be seen in Table 1.

Sample and sampling procedure

The population of this study consisted of farmers engaged in livestock feed fermentation activities in Barru Regency, South Sulawesi Province, Indonesia. A purposive sampling technique was applied to select respondents who met the criteria of having experience with, or exposure to, superior inoculant technology. A total of 200 valid responses were collected and included in the analysis.

The sample size was considered adequate for Partial Least Squares–Structural Equation Modeling (PLS-SEM), which prioritizes predictive accuracy and is suitable for complex models with multiple constructs and indicators (Hair and Alamer, 2022).

The purposive sampling strategy was intentionally employed to target farmers who had prior experience with or exposure to superior inoculant technology, as the primary objective of this study was to examine perception-based determinants of adoption among informed users rather than to estimate population-level adoption rates. Consequently, the findings should be interpreted as reflecting adoption behavior among farmers who are already aware of the technology, and

Table 1: Operational design of research variables.

Variable	Indicator (Code = Description)	Scale
Relative advantage (X1)	RA1 = Faster fermentation process	Likert 1-5
	RA2 = Improved quality of fermented products	
	RA3 = Reduction in feed and fertilizer costs	
	RA4 = Additional benefits compared to other methods	
	RA5 = Fermented product quality standards	
	RA6 = Increased fermentation output quantity	
Compatibility (X2)	COM1 = Compatibility with current farming practices	
	COM2 = Suitability of available feed materials	
	COM3 = Alignment with community farming practices	
	COM4 = Ease of integration into daily activities	
	COM5 = Consistency with sustainable farming principles	
Complexity (X3)	CPLX1 = Ease of understanding usage instructions	
	CPLX2 = Ease of mixing with fermentation materials	
	CPLX3 = Ease of dosage and measurement	
	CPLX4 = Ease of storage and quality maintenance	
	CPLX5 = Practical and user-friendly packaging	
	CPLX6 = Ease of selling fermented products	
Trialability (X4)	TRI1 = Small-scale trial before regular use	
	TRI2 = Comparison of fermentation results	
	TRI3 = Observation of results from other farmers	
	TRI4 = Confidence after trial use	
Adoption of Innovation (Y)	ADOP1 = Regular use of superior inoculant	
	ADOP2 = Intention to continue use	
	ADOP3 = Inoculant as standard farming practice	
	ADOP4 = Willingness to recommend to others	

may not be fully generalizable to non-adopters who have rejected or have never been exposed to the inoculant. This sampling approach may over-represent farmers with relatively favorable perceptions; however, it allows for a more focused examination of how perceived innovation attributes shape adoption decisions once exposure has occurred. Future research should employ probability-based sampling or comparative designs that explicitly include non-adopters to strengthen external validity and capture rejection dynamics.

Data analysis technique

Data were analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM) with the assistance of SmartPLS 4.0 software. PLS-SEM was selected due to its suitability for predictive research, its ability to handle complex models, and its robustness with non-normal data distributions (Ghafourian *et al*., 2021).

The analysis followed a two-stage procedure. First, the measurement model was evaluated by assessing indicator reliability (outer loadings), internal consistency (Cronbach's Alpha and Composite Reliability), convergent validity (average variance extracted), and discriminant validity using the Fornell–Larcker criterion. Second, the structural model was evaluated by examining multicollinearity (variance inflation factor), path coefficients and their significance using bootstrapping, coefficient of determination (R^2), and predictive relevance (Q^2). These procedures ensured the rigor and validity of the proposed research model (Haji-Othman *et al*., 2024).

RESULTS

Measurement model results

Reliability and convergent validity

Table 2 shows that all indicators have outer loading values above 0.70, indicating that each indicator adequately reflects its corresponding construct. The Cronbach's Alpha and Composite Reliability values exceed 0.70 for all constructs, confirming internal consistency reliability. Furthermore, all AVE values are above 0.50, indicating that each construct explains more than half of the variance of its indicators. These results confirm that the measurement model meets the criteria for reliability and convergent validity.

Table 2: Reliability and convergent validity results.

Construct	Indicator	Loading	CR	Cronbach's Alpha	AVE
Relative Advantage	RA1	0.742	0.899	0.866	0.597
	RA2	0.761			
	RA3	0.788			
	RA4	0.832			
	RA5	0.845			
	RA6	0.804			
Compatibility	COM1	0.768	0.883	0.826	0.603
	COM2	0.714			
	COM3	0.721			
	COM4	0.792			
	COM5	0.809			
Complexity	CPLX1	0.773	0.889	0.843	0.574
	CPLX2	0.801			
	CPLX3	0.786			
	CPLX4	0.758			
	CPLX5	0.718			
	CPLX6	0.770			
Trialability	TRI1	0.781	0.896	0.844	0.670
	TRI2	0.832			
	TRI3	0.848			
	TRI4	0.806			
Adoption of Innovation	ADOP1	0.795	0.899	0.850	0.690
	ADOP2	0.846			
	ADOP3	0.858			
	ADOP4	0.821			

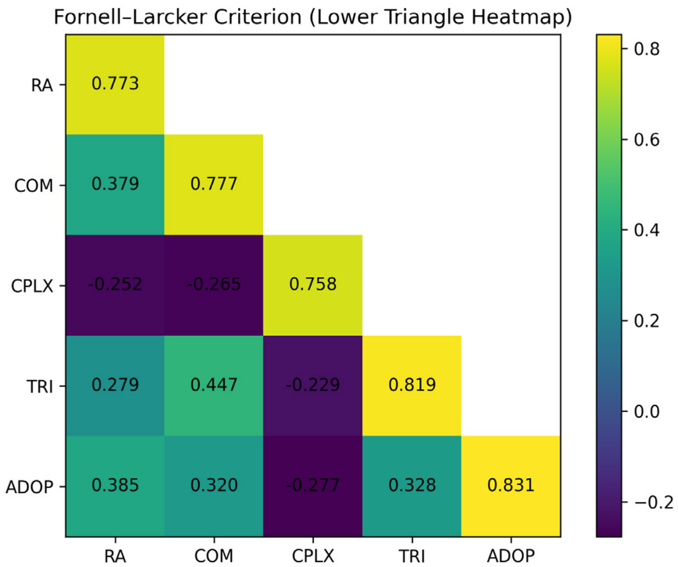

Figure 2: Discriminant Validity (Fornell–Larcker Criterion)

Discriminant validity

Figure 2 illustrates discriminant validity using a lower-triangular heat map illustrates the Fornell Larcker criterion with the square roots of the AVE on the diagonal and the inter-construct correlations in the lower off-diagonal cells. The diagonal values for all constructs relative advantage (0.773), compatibility (0.777), complexity (0.758), trialability (0.819), and adoption of innovation (0.831) are consistently higher than their corresponding correlations with other constructs, which range from −0.277 to 0.447. The highest correlation is observed between Compatibility and trialability (0.447), while correlations involving Complexity are generally weaker and negative, such as with adoption of innovation (−0.277). As none of the inter-construct correlations exceed the square roots of the AVE (the diagonal values), the results visually and numerically confirm that the measurement model satisfies the discriminant validity criterion and that all constructs are empirically distinct.

Structural model results

Multicollinearity assessment

Table 3 shows that all Variance Inflation Factor (VIF) values are below 5, indicating no significant multicollinearity among the predictor constructs. This suggests that the estimates of the structural paths are not affected by collinearity issues.

Table 3: Variance inflation factor (VIF).

Exogenous construct	VIF
Relative advantage	1.12
Compatibility	1.25
Complexity	1.08
Trialability	1.03

Model explanatory power and predictive relevance

Table 4 shows that the model explains 20.9% of the variance in adoption (R^2= 0.209). The positive Q^2 value indicates that the model has adequate predictive relevance, demonstrating that the exogenous constructs provide meaningful explanatory power.

Table 4: Coefficient of determination and predictive relevance.

Endogenous construct	R^2	Q^2
Adoption of innovation	0.209	0.181

The modest explanatory power of the model (R^2= 0.209) suggests that adoption decisions are influenced by factors beyond perceptual evaluations. In smallholder livestock systems in Indonesia, likely contributors to the unexplained variance include economic affordability, access to inoculant supply chains, peer influence, and the availability and quality of extension services. Among these, extension service quality and peer influence appear particularly important, as farmers rely heavily on demonstrations, interpersonal learning, and trusted intermediaries when assessing unfamiliar microbial technologies. Accordingly, perceived benefits alone may be insufficient to drive adoption unless supported by effective extension mechanisms and social validation at the community level.

Hypothesis testing

Table 5 indicates that all hypothesized relationships are statistically significant at the 5% significance level. Relative advantage, compatibility, and trialability have positive effects on adoption of innovation, whereas complexity has a negative effect.

Table 5: Structural paths and hypothesis testing.

Hypothesis	Path	β	t value	p value	Decision
H1	RA→ADOP	0.277	4.010	0.000	Supported
H2	COM→ADOP	0.179	2.552	0.011	Supported
H3	CPLX→ADOP	-0.146	2.234	0.027	Supported
H4	TRI → ADOP	0.170	2.386	0.018	Supported

Effect size

Table 6 shows that relative advantage has a small-to-moderate effect on adoption, while compatibility, complexity, and trialability have small effect sizes. This indicates that although all constructs significantly influence adoption, their individual contributions differ in magnitude.

Table 6: Effect size (f^2).

Exogenous construct	f^2	Effect category
Relative advantage	0.077	Small–Medium
Compatibility	0.035	Small
Complexity	0.026	Small
Trialability	0.032	Small

Structural model diagram

Figure 3 visually summarizes the structural relationships among the constructs along with their standardized path coefficients and explanatory power. The diagram indicates that relative advantage has the strongest positive effect on adoption of innovation (β = 0.277), followed by compatibility (β= 0.179) and trialability (β= 0.170). In contrast, complexity shows a significant negative relationship with adoption (β= -0.146). The diagram also displays the coefficient of determination for adoption of innovation (R^2= 0.209), indicating that 20.9% of the variance in adoption is explained jointly by relative advantage, compatibility, complexity, and trialability. Overall, the diagram provides a concise visual representation of the direction, strength, and explanatory capacity of the structural relationships identified in the model. This finding suggests that while demonstrating clear benefits is necessary, it is not sufficient to drive widespread adoption in the absence of supportive economic, social, and institutional conditions.

DISCUSSION

This study investigates how farmers' perceived attributes of innovation influence the adoption of superior inoculant technology in livestock feed fermentation. By applying the perceived attributes of innovation framework, this discussion interprets the empirical results to explain how farmers' perceptions translate into adoption behavior in a practical agricultural setting.

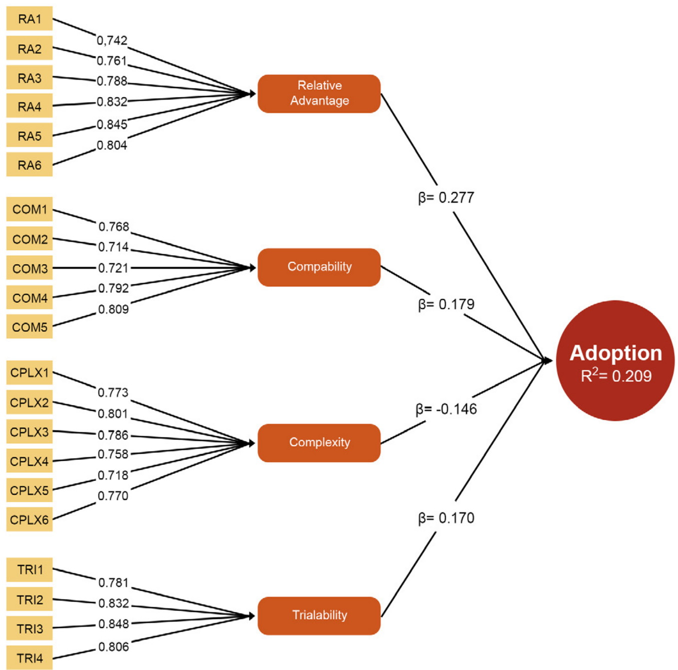

Figure 3: Structural Model Diagram.

The measurement model results indicate that the constructs employed in this study are both reliable and valid. As presented in Table 2, all indicators exhibit outer loading values exceeding the recommended threshold of 0.70, confirming that each indicator adequately reflects its respective construct. Furthermore, the Cronbach's Alpha and Composite Reliability values for all constructs are above 0.70, while Average Variance Extracted (AVE) values exceed 0.50. These findings demonstrate that farmers are able to consistently evaluate the superior inoculant technology in terms of perceived benefits, compatibility, complexity, trialability, and adoption. This suggests that the attributes of innovation are cognitively meaningful to farmers and can be reliably captured through the measurement instrument (Zahara, 2021).

Discriminant validity was also confirmed. As illustrated in Figure 2, the square roots of AVE for all constructs Relative

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Advantage (0.773), Compatibility (0.777), Complexity (0.758), Trialability (0.819), and Adoption of Innovation (0.831) are higher than the inter-construct correlations, which range from −0.277 to 0.447. The highest correlation occurs between Compatibility and Trialability (0.447), while correlations involving Complexity are weaker and negative, particularly with Adoption of Innovation (−0.277). These results indicate that although some constructs are related, each represents a distinct perceptual dimension. This distinction is important, as it confirms that farmers assess different attributes of the inoculant technology separately when forming adoption decisions (Burli *et al*., 2021; Gandasari, 2021).

The structural model results further clarify how these perceptions influence adoption behavior. The multicollinearity assessment (Table 3) shows that all Variance Inflation Factor (VIF) values are well below the threshold of 5, indicating that each perceived attribute contributes independently to explaining adoption. The very low VIF values further suggest that respondents were able to clearly distinguish between different innovation attributes when evaluating the technology. This pattern is theoretically plausible within the perceived attributes of innovation framework, which conceptualizes relative advantage, compatibility, complexity, and trialability as distinct evaluative dimensions rather than overlapping constructs. Therefore, the low intercorrelations support discriminant validity and conceptual clarity rather than indicating misinterpretation by farmers. The model explains 20.9% of the variance in adoption of innovation (R^2= 0.209; Table 4) and demonstrates adequate predictive relevance (Q^2= 0.181). While the adoption of feed fermentation technologies is influenced by many external factors, such as resource availability and market conditions, these results suggest that farmers' perceptions of innovation attributes constitute a meaningful explanatory foundation for adoption decisions (Izzulhaq *et al*., 2023). However, the modest R^2 value also indicates that adoption behavior is shaped by additional determinants beyond perceived innovation attributes, which were not captured in this study. In social and agricultural contexts, adoption decisions are often constrained by farmers' economic capacity (e.g., affordability and access to credit), access to inoculant inputs and distribution channels, extension and institutional support, and social networks or peer influence. Therefore, the current model should be interpreted as a context-specific, perception-based explanation of adoption among surveyed farmers rather than a comprehensive account of all adoption drivers. Future studies should incorporate these broader socioeconomic and institutional factors to build more comprehensive and powerful models of adoption.

Although the model explains a modest proportion of adoption variance (R^2= 0.209), this reflects the inherently complex and multidimensional nature of technology adoption in smallholder farming systems rather than an insufficiency of the perceived attributes framework. The framework captures the cognitive and evaluative dimensions of adoption, while structural and institutional factors such as capital availability, input supply chains, credit access, and extension support operate alongside perceptions to shape adoption decisions and should therefore be viewed as complementary rather than comprehensive. In this context, the negative effect of perceived complexity should be interpreted cautiously, as it may stem from both informational constraints (e.g., limited training or unclear guidance) and objective design-related challenges inherent in the technology. Consequently, reducing complexity-related barriers may require both improved farmer training and simplification or adaptation of technology design, underscoring the need for future research that integrates perception-based models with objective technological and institutional assessments. Within this perception-based framework, relative advantage emerges as the strongest determinant of adoption; however, its effect size remains modest (β= 0.277; Table 5). This indicates that farmers are more likely to adopt superior inoculant technology when they perceive clear advantages in fermentation outcomes, such as faster processing, improved feed quality, reduced costs, and increased output. In livestock farming systems, where feed efficiency and quality directly affect productivity and profitability, innovations offering observable and tangible benefits are particularly compelling. Nevertheless, the modest magnitude of this effect suggests that while demonstrating clear benefits is necessary for adoption, it is not sufficient to drive widespread uptake in the absence of enabling economic, social, and institutional conditions (Yin *et al*., 2024; Ngeno, 2024).Compatibility also has a positive and significant effect on adoption (β= 0.179; Table 5), indicating that farmers are more inclined to adopt the inoculant when it aligns with their existing fermentation practices, available feed materials, community norms, and sustainability principles. This result underscores that adoption is not solely a matter of technical superiority but also of practical fit. Technologies that can be integrated into daily farming routines without requiring major changes reduce the perceived costs of adoption and facilitate gradual incorporation into existing livestock production systems (Anang *et al*., 2023).

Trialability further contributes positively to adoption (β= 0.170; Table 5), emphasizing the importance of experiential learning in the adoption of feed fermentation technologies. Farmers who are able to test the superior inoculant on a small scale, compare fermentation results, and observe outcomes from other farmers gain greater confidence in continuing its use. In livestock feed fermentation, where unsuccessful outcomes can directly affect animal health

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and performance, the opportunity to experiment before full adoption plays a crucial role in reducing uncertainty and perceived risk (Mohammed and Abdulai, 2022).

In contrast, complexity exhibits a negative and significant relationship with adoption (β = −0.146; Table 5), indicating that perceived difficulties related to understanding instructions, mixing materials, dosage management, storage, or handling fermented products discourage adoption. This finding highlight that even innovations with clear benefits may face resistance if they are perceived as technically demanding. For farmers managing multiple daily tasks, simplicity and ease of use are essential considerations. Thus, reducing perceived complexity is critical for supporting wider adoption of superior inoculant technology (Mohammed and Abdulai, 2023).

The effect size analysis (Table 6) provides additional insight into the relative contributions of each perceived attribute. Relative advantage exhibits a small-to-moderate effect (f^2 = 0.077), while compatibility (f^2 = 0.035), trialability (f^2 = 0.032), and complexity (f^2 = 0.026) show small effect sizes. Although these effect sizes are modest, they should not be interpreted as trivial. In complex agricultural decision-making contexts, adoption behavior is rarely driven by a single dominant factor. Instead, small but statistically significant effects across multiple perceptual attributes can accumulate and jointly influence adoption decisions. From a policy perspective, this suggests that interventions targeting compatibility or trialability alone may yield incremental gains, but are likely to be more effective when combined with broader structural measures such as extension support, improved input accessibility, and financial facilitation (Qi *et al*., 2021).

Finally, the structural model diagram (Figure 3) synthesizes these findings by visually illustrating relative advantage as the primary driver of adoption, supported by compatibility and trialability, and constrained by perceived complexity. Together, the results suggest that successful diffusion of superior inoculant technology for livestock feed fermentation requires not only demonstrating technical and economic benefits but also ensuring that the technology is compatible with existing practices, easy to use, and accessible for trial. This farmer-centered perspective reinforces the importance of aligning technological innovation with farmers' perceptual and practical realities to achieve sustained adoption (Hajar, 2025).

CONCLUSION

This study shows that farmers' perceptions of innovation attributes significantly influence the adoption of superior inoculant technology in livestock feed fermentation. Relative advantage is the main driver of adoption, while compatibility and trialability further support farmers' willingness to adopt technologies that fit existing practices and can be tested before full use. Conversely, perceived complexity hinders adoption, indicating the importance of simple and user-friendly technologies. Overall, the findings highlight that adoption of feed fermentation innovations is shaped by farmers practical and experiential evaluations rather than by technical characteristics alone.

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NOVELTY STATEMENT

This study offers a novel contribution by providing one of the first perception-based empirical analyses of farmer adoption of superior inoculant technology specifically in the context of livestock feed fermentation. Unlike prior adoption studies that predominantly focus on crop technologies, mechanization, or digital agriculture, this research applies the Perceived Attributes of Innovation framework to a microbial-based feed technology and simultaneously evaluates the relative effects of relative advantage, compatibility, complexity, and trialability within a single PLS-SEM model. By empirically demonstrating how farmers' practical and experiential perceptions shape adoption decisions in a developing-country livestock system, the study extends the application of innovation adoption theory to an underexplored domain and offers context-specific evidence to inform extension strategies and technology diffusion in livestock feed fermentation.

AUTHOR'S CONTRIBUTION

JM, MIS, and AMD Conceptualization, methodology, study design. JM, II: Investigation, data collection. II: Formal analysis, data curation. JM and AMD: Writing original draft. MIS, AMD, II: Writing review and editing. MIS: Supervision, project administration. All authors critically reviewed and approved the final version of the manuscript.

Generative AI and AI-assisted technology statement

The authors declare that no Generative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

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