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Barriers to Implementing Organic Waste-Based Fermented Feed Practices Among Livestock Farmers in Kuningan, West Java

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ABSTRACT

Backround: Despite proven technical efficacy and economic benefits, organic waste-based fermented feed adoption remains persistently low among Indonesian livestock farmers, with commercial feed costs consuming 60-70% of production expenses while abundant organic wastes go unutilized, creating sustainability and profitability challenges.

Objective: This study investigates barriers constraining fermented feed adoption among livestock micro-entrepreneurs.

Method: A three-month qualitative study employed semi-structured interviews with 23 livestock farmers representing diverse adoption statuses (non-adopters, discontinued, sustained), complemented by observations and document review.

Findings and Implications: Thematic analysis identified barrier categories and contextual adoption factors. Despite 95.7% awareness and 73.9% training attendance, only 21.7% achieved sustained adoption, with 30.4% having discontinued after attempting. Six interconnected barrier dimensions emerged: technical complexity (65.2% affected), knowledge deficits (60.9%), economic constraints (60.9%), time limitations (73.9%), psychological resistances (56.5%), and quality uncertainty (65.2%). Sustained adopters received intensive multi-session training with ongoing support, accessed reliable organic waste supplies, and benefited from active farmer group networks—factors largely absent for discontinued adopters and non-adopters. Villages with favorable institutional configurations achieved 40-50% adoption versus 0-5% elsewhere despite identical training.

Conclusion: Effective promotion requires comprehensive interventions addressing multiple barriers simultaneously through participatory training, sustained implementation support, farmer organization strengthening, and organic waste supply chain facilitation rather than conventional one-time demonstrations, with institutional development as critical as farmer education for scaling sustainable livestock feeding practices.

INTRODUCTION

West Java's Kuningan district exemplifies challenges facing Indonesia's 2.3 million livestock micro-entrepreneur households (Dewi et al., 2022; Sadeli et al., 2020).

Farmers operate small holdings (0.3-0.8 hectares, 50-300 poultry or 2-6 cattle) while facing escalating commercial feed costs that increased 35-42% during 2020-2023, consuming 60-70% of production expenses.(Dewi et al., 2022; Sadeli et al., 2020). Kuningan district, located in the southeastern highlands of West Java with predominantly agricultural economy, exemplifies the challenges facing livestock micro-entrepreneurs: farmers operate with minimal land holdings (averaging 0.3-0.8 hectares), maintain small livestock populations (50-300 poultry or 2-6 cattle per household), and face persistent profitability pressures from volatile output prices and escalating input costs particularly for commercial feeds whose prices increased 35-42% between 2020-2023 driven by global commodity market disruptions. The district generates substantial organic waste volumes from diverse sources including rice milling operations producing approximately 15,000 tons of rice bran annually, tofu factories generating 8,000 tons of okara (soybean residue) yearly, household food waste, agricultural crop residues from cassava and vegetable production, and livestock manure itself—resources that remain largely underutilized, creating waste management burdens while valuable feed potential goes unharnessed (Damanik et al., 2024; Sari et al., 2020).

Organic waste-based fermented feed production encompasses various technical approaches sharing common principles: controlled microbial fermentation using naturally-occurring or inoculated microorganisms (primarily lactic acid bacteria, yeasts, and beneficial molds) transforms organic substrates through enzymatic degradation, producing feeds with enhanced nutritional profiles and preserved shelf stability through acidification and antimicrobial metabolite generation (Azman et al., 2023; Pazla et al., 2023). Common Indonesian practices include "fermented complete feed" (pakan fermentasi komplit) combining multiple ingredients in balanced rations, "silage" production from green fodder for ruminants, "bokashi" fermentation of agricultural residues with effective microorganism (EM) inoculants, and spontaneous fermentation of single ingredients like cassava peels or tofu waste (Adhianto et al., 2018; Amara & El-Baky, 2023).

Scientific evidence demonstrates multiple benefits: fermentation increases crude protein content by 15-35% through microbial biomass synthesis, reduces fiber fractions improving digestibility by 10-20%, eliminates anti-nutritional factors like tannins and phytic acid that impair nutrient absorption, generates beneficial compounds including short-chain fatty acids that enhance gut health, and extends storage duration from days to weeks through pH reduction preventing spoilage (Fadly et al., 2023; Maula, 2025). Field trials in Indonesian contexts report that poultry fed fermented feeds achieve feed conversion ratios 8-15% better than commercial feeds while reducing mortality rates, cattle supplemented with fermented complete feeds show 12-18% improved daily weight gains, and production costs decrease 25-40% when fermented feeds replace portions of expensive commercial concentrates—outcomes that theoretically position fermentation as transformative technology for resource-constrained livestock micro-entrepreneurs.

The implementation gap manifests in observable patterns: farmers continue purchasing expensive commercial feeds despite escalating costs and compressed profit margins; abundant organic waste resources remain unutilized or disposed of problematically (burned, dumped in rivers, creating odor and vermin issues); and

farmers express fatalistic acceptance of high feed costs as unavoidable business reality rather than actively seeking alternatives (Dewi et al., 2022; Sadeli et al., 2020). Extension officers report frustration that farmers attending fermentation demonstrations express enthusiasm and commitment to implementation, yet follow-through remains minimal, with common explanations including "too complicated," "no time," "tried but failed," or "not confident about quality"—vague attributions that mask underlying barriers requiring deeper investigation.

The consequences of persistent non-adoption prove economically significant: livestock farmers in Kuningan spend an estimated Rp 800,000-1,500,000 monthly on commercial feeds per household depending on scale, representing 55-65% of total production costs; assuming conservative 30% cost reduction potential from fermented feed adoption, non-adopting farmers forego approximately Rp 240,000-450,000 monthly savings (Rp 2.9-5.4 million annually), substantially exceeding household cash liquidity available for investment or consumption smoothing. Moreover, environmental externalities from unutilized organic wastes—greenhouse gas emissions from decomposition, water pollution from tofu waste discharge, public health risks from inadequate disposal—remain unaddressed while circular economy potential sits unharnessed (Bahta, 2021; Duval et al., 2021; Ngoshe et al., 2023).

Understanding barriers to fermented feed adoption carries particular urgency given converging pressures that intensify the feed cost crisis while simultaneously expanding waste management challenges. First, global commodity market disruptions driven by climate change impacts on crop yields, geopolitical conflicts affecting grain trade routes, and pandemic-related supply chain fragilities have generated unprecedented feed price volatility, with Indonesian commercial feed prices increasing 35-42% between 2020-2023 and projections suggesting continued instability rather than return to pre-crisis affordability—creating unsustainable cost burdens for micro-entrepreneurs operating on razor-thin margins (Liu et al., 2022; Lv et al., 2023).

Second, rapid urbanization and economic development in West Java generate exponentially growing organic waste volumes—food processing industries expanding, household consumption rising, agricultural intensification producing more residues—overwhelming existing waste management infrastructure and creating environmental crises that fermented feed adoption could partially mitigate through waste valorization (Hui et al., 2021; Liu et al., 2021). Without empirical identification of specific barriers—technical, knowledge-based, economic, social, psychological—constraining adoption, extension programs and policy interventions risk remaining ineffective, perpetuating the paradox of unused solutions to urgent problems.

Existing research has extensively documented the technical efficacy and nutritional benefits of fermented feeds through controlled feeding trials and laboratory analyses, establishing a robust evidence base for technology effectiveness. Studies from Indonesian and Southeast Asian contexts demonstrate that fermentation of local organic wastes—including cassava peels, rice bran, tofu waste, vegetable residues, and agricultural by-products—using simple fermentation techniques produces feeds with enhanced nutritional quality: crude protein content increases 15-35% through microbial biomass accumulation and enzymatic transformation, crude fiber digestibility improves 10-25% through partial cellulose breakdown, anti-nutritional factors like tannins and phytic acid decline by 30-55%, and beneficial metabolites including lactic acid, enzymes, and vitamins accumulate (Hizbi et al., 2023; Su et al., 2022).

Animal performance trials consistently report positive outcomes: broiler chickens fed fermented feeds show 8-15% improved feed conversion ratios and 5-12% faster growth rates compared to conventional diets, laying hens exhibit 6-10% increased egg production with improved shell quality, beef cattle supplemented with fermented complete feeds gain 12-18% more weight daily, and dairy cattle show 8-14% higher milk yields—benefits attributed to improved nutrient digestibility, probiotic effects enhancing gut health, and immune system stimulation (Hizbi et al., 2023; S. Liu et al., 2022). Economic analyses estimate production cost reductions of 25-40% when fermented feeds replace commercial concentrates, with payback periods for fermentation infrastructure investments (containers, covers, mixing tools) typically under 3-6 months even for small-scale operations, strongly supporting financial viability (Putra et al., 2021; Telupere et al., 2023).

While fermented feed technology research establishes efficacy, a separate literature examines agricultural technology adoption patterns, identifying factors influencing farmer decision-making regarding innovation uptake. Classical diffusion of innovations theory emphasizes innovation characteristics—relative advantage, compatibility with existing systems, complexity, trialability, observability—as primary determinants of adoption rates, suggesting technologies offering clear benefits, fitting farmer practices, appearing simple, allowing low-risk experimentation, and producing visible results diffuse most rapidly (Syamsi & Harwanto, 2023; Yan Tonga et al., 2023).

Studies specifically examining livestock technology adoption in Indonesian contexts identify multiple barriers beyond farmer knowledge deficits: capital constraints limiting investment in equipment or inputs, labor availability competition between livestock and crop activities, technical complexity creating perceived difficulty especially for lower-educated farmers, quality uncertainty regarding product outcomes, market access challenges for output disposal, and institutional gaps in extension support quality and input supply reliability (Apriyana et al., 2021; Fatchiya et al., 2018). Research on composting and organic waste management technologies—conceptually related to fermented feeds through waste valorization—reveals additional psychological and social factors: disgust or stigma associated with waste handling, low perceived urgency when waste problems affect broader community rather than individual households, free-rider dynamics where collective benefits (environmental improvement) compete with individual cost-bearing, and social norm influences where visible community adoption encourages participation while isolation deters it.

This study aims to investigate the barriers to organic waste-based fermented feed adoption among livestock farmers in Kuningan, focusing on technical, economic, social, psychological, and institutional factors. It seeks to identify specific challenges that prevent farmers from starting or continuing fermented feed production, understand farmers' knowledge and perceptions of the practice, explore the experiences of those who have tried it, and analyze the role of contextual factors like waste availability, extension support, and market conditions. The study aims to provide evidence-based insights to improve extension strategies, training programs, and policy interventions, ultimately promoting fermented feed adoption as a sustainable solution to feed cost challenges. The findings offer valuable insights for livestock farmers, agricultural extension personnel, policymakers, and organic waste generators, highlighting the

need for targeted support and policy adjustments to overcome barriers, create waste-to-feed value chains, and foster long-term sustainable transitions in smallholder agricultural practices.

RESEARCH METHOD

This research adhered to ethical research principles and obtained clearance from the institutional research ethics committee prior to data collection. All participants provided informed consent after receiving clear explanations of research purposes, procedures, and their rights including voluntary participation and confidentiality protection. Personal identifying information was anonymized in all data recording and reporting to protect participant privacy. This study employs a rapid qualitative research design utilizing a descriptive exploratory approach to investigate barriers constraining organic waste-based fermented feed adoption among livestock farmers in Kuningan district, West Java, within a compressed three-month research timeframe. The research population comprises small-scale livestock farmers (poultry and cattle) in Kuningan district who: (a) have been engaged in livestock production for at least two years, (b) are aware of fermented feed concepts through extension exposure or peer farmers, and (c) represent diverse implementation experiences including non-adopters (never attempted), discontinued adopters (attempted but stopped), and sustained adopters (currently practicing).

Given time constraints and the exploratory nature of investigating adoption barriers, purposive sampling with maximum variation strategy was employed to select 20-25 participants ensuring representation across key categories: farm type (poultry versus cattle farmers), adoption status (non-adopters, discontinued adopters, sustained adopters), gender (male and female farmers), age groups (under 40, 40-55, above 55 years), and farm scale (micro operations with 50-200 poultry or 2-4 cattle versus small operations with 200-500 poultry or 5-8 cattle). The research instruments consist of: (1) a semi-structured interview guide organized around barrier categories (technical, knowledge, economic, social, institutional) with open-ended questions exploring awareness and understanding of fermented feeds, prior experiences with implementation attempts or decisions not to adopt, perceived challenges and constraints, knowledge gaps, resource availability, social influences, and support needs; (2) a visual elicitation tool using photographs of fermented feed production processes to prompt discussion and assess technical knowledge; (3) an observation protocol documenting farm conditions, feed storage facilities, organic waste availability in surrounding areas, and farmer demonstrations of fermentation knowledge when applicable; and (4) a brief demographic and farm characteristics form.

Data collection employs three complementary techniques: first, in-depth semi-structured interviews lasting 60-90 minutes per participant, conducted in Bahasa Indonesia or Sundanese as preferred at locations convenient to farmers (homes, farms, or village meeting spaces), audio-recorded with informed consent and supported by note-taking; second, farm observation tours where participants show current feeding practices, available resources, and facilities, with researcher documentation through field notes and photographs; and third, supplementary document review of extension materials on fermented feeds, government program reports, and recent studies on

livestock production and organic waste management in West Java to contextualize primary findings and triangulate farmer accounts with institutional perspectives.

The research procedure unfolds across four sequential phases executed within the three-month study period. Phase 1 (Weeks 1-2) encompasses preparatory activities including comprehensive literature review on fermented feed technology and adoption barriers, research instrument development and pre-testing with three farmers outside the study sample, ethical clearance preparation and securing permissions from district agricultural offices, and stakeholder engagement with extension officers and farmer group leaders to facilitate participant recruitment while explaining research purposes and voluntary participation principles. Phase 2 (Weeks 3-9) constitutes the intensive data collection period, during which purposive sampling through agricultural extension networks and farmer cooperatives identifies potential participants representing diverse adoption status categories and demographic profiles, followed by scheduling and conducting in-depth interviews with 20-25 farmers while simultaneously conducting farm observations, collecting organic waste availability information from surrounding agro-industries (rice mills, tofu factories), and reviewing extension program documentation to understand support services provided. Phase 3 (Weeks 10-11) focuses on data processing including audio transcription, translation of Sundanese content to Indonesian and English for key quotes, preliminary coding to identify emerging themes, and member checking with selected participants to validate researcher interpretations and clarify ambiguous information.

Phase 4 (Weeks 11-12) comprises intensive data analysis and report synthesis. Data analysis follows thematic analysis procedures adapted to barrier investigation: interview transcripts are systematically coded using both deductive codes derived from technology adoption frameworks (relative advantage perceptions, complexity assessments, trialability constraints, compatibility issues, observability limitations) and inductive codes emerging organically from farmer narratives (disgust responses to waste handling, time allocation conflicts, quality uncertainty, social stigma); codes are organized into coherent barrier categories and sub-themes representing patterns of constraints across technical, knowledge, economic, social, psychological, and institutional dimensions; cross-case comparison examines how barriers vary by adoption status (comparing non-adopters' anticipated barriers with discontinued adopters' experienced challenges versus sustained adopters' strategies for overcoming obstacles) and demographic characteristics (age, gender, education, farm type) to identify factors associated with successful implementation; and triangulation between farmer interviews, observational data from farms, and institutional documents enhances credibility while revealing potential disconnects between extension messaging and farmer realities.

The compressed timeline necessitates pragmatic methodological adaptations consistent with rapid qualitative research principles: limiting sample size to 20-25 participants while ensuring diversity achieves thematic saturation within time constraints, focusing interviews on most critical barrier domains rather than comprehensive exploration of all possible factors, conducting iterative analysis concurrent with data collection allowing real-time identification of saturation and adjustment of inquiry focus, prioritizing actionable insights directly informing

extension program improvement over theoretical contribution, and maintaining analytical rigor through systematic coding procedures, triangulation, and member checking despite accelerated schedule—trade-offs that prioritize policy relevance and timely completion while preserving essential qualitative research standards.

RESULT AND DISCUSSION

Participant Demographics and Fermented Feed Awareness Profile

The study recruited 23 livestock farmers from Kuningan district, focusing on their experiences with organic waste-based fermented feed production. Participants were diverse in age, gender, education, and farm type. The sample included 14 males (60.9%) and 9 females (39.1%), with age distributions skewed toward middle and older farmers: 4 were under 40 years, 11 were aged 40-55, and 8 were over 55 years. Educational attainment varied, with 39.1% having completed primary school, 30.4% with junior high school, and 26.1% with senior high school education. The majority of participants were poultry farmers (56.5%), raising layer hens or broilers, while 43.5% were cattle farmers. Livestock holdings were small, with poultry farmers keeping between 80 and 600 birds (mean 312) and cattle farmers holding 2 to 9 heads (mean 4.7). Household incomes ranged from Rp 1.8 million to Rp 8.5 million monthly, with many supplemented by other agricultural work, off-farm employment, or remittances.

A key aspect of the study was the categorization of participants based on adoption status. Of the 23 participants, 11 (47.8%) were non-adopters who had never attempted fermented feed production, 7 (30.4%) were discontinued adopters who had tried and then abandoned it, and 5 (21.7%) were sustained adopters who had continued regular production. This distribution highlights that barriers to continuing fermented feed adoption are as significant as those to initial adoption. Awareness of fermented feed practices was widespread, with 95.7% of participants reporting prior knowledge, primarily from extension services, peers, and media. However, the depth of understanding varied, with some participants offering vague explanations of the fermentation process, indicating gaps in knowledge and comprehension.

Training exposure played a significant role in adoption outcomes. All sustained adopters had participated in hands-on training sessions, where they received technical guidance and practiced fermentation techniques. Discontinued adopters and non-adopters had less consistent training experiences, with many describing passive demonstrations rather than active participation. This discrepancy suggests that more participatory, hands-on training is crucial for sustaining adoption. The study also identified that exposure alone was insufficient to overcome barriers to continued adoption, emphasizing the need for ongoing support, practical guidance, and follow-up engagement from extension agents.

Table 1. Participant Demographic and Farm Characteristics (N=23)

Characteristic	Category	Frequency	Percentage
Gender	Male	14	60.9%
	Female	9	39.1%
Age Group	Under 40 years	4	17.4%
	40–55 years	11	47.8%
	Above 55 years	8	34.8%
Education Level	Primary School	9	39.1%
	Junior High School	7	30.4%

	Senior High School	6	26.1%
	Vocational Agriculture	1	4.3%
Farm Type	Poultry	13	56.5%
	Cattle	10	43.5%
Livestock Scale	Micro (50–200 birds / 2–4 cattle)	13	56.5%
	Small (201–600 birds / 5–9 cattle)	10	43.5%
Monthly Livestock Income	Rp 1–3 million	12	52.2%
	Rp 3–5 million	7	30.4%
	Rp 5–9 million	4	17.4%
Adoption Status	Non-adopter (never tried)	11	47.8%
	Discontinued adopter (tried, stopped)	7	30.4%
	Sustained adopter (currently using)	5	21.7%
Fermented Feed Awareness	Aware	22	95.7%
	Not aware	1	4.3%
Training Attendance	Attended formal training	17	73.9%
	Never attended training	6	26.1%

Source: Data processed

Perceived benefits of fermented feeds showed interesting patterns. When asked what they believed were advantages of fermented feeds, participants most frequently mentioned feed cost reduction (19 participants, 82.6%), reflecting acute awareness of commercial feed expense burdens. Other commonly cited benefits included: utilizing waste that would otherwise be discarded (15 participants, 65.2%), improved animal health or reduced disease (11 participants, 47.8%), environmental benefits from waste reduction (9 participants, 39.1%), better meat or egg quality (8 participants, 34.8%), and increased farmer self-sufficiency reducing dependence on external suppliers (7 participants, 30.4%). Notably, sustained adopters articulated more diverse and specific benefits based on direct experience—mentioning outcomes like "shinier chicken feathers," "less ammonia smell in the coop," or "cattle gaining weight faster"—while non-adopters and discontinued adopters offered more generic benefits reflecting secondhand information or assumptions rather than observed outcomes.

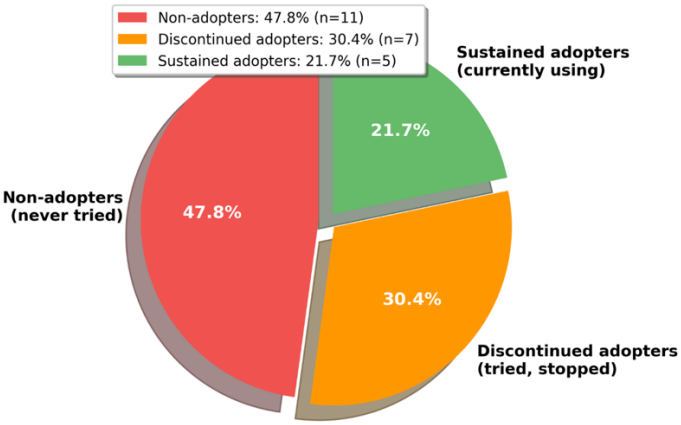

Figure 1. Adoption Status Distribution Among Participants

This awareness profile establishes that information access and basic knowledge about fermented feed existence are not primary adoption barriers—nearly all farmers had heard about the practice and many had attended demonstrations. Instead, the stark contrast between 95.7% awareness and only 21.7% sustained adoption (with an additional 30.4% having tried and discontinued) indicates that barriers operate at implementation stages rather than information availability, pointing toward technical complexity, resource constraints, or psychological factors explored in subsequent findings sections.

Barrier Typology: Technical, Economic, Knowledge, and Psychological Constraints

Interview analysis revealed six interconnected barrier dimensions constraining fermented feed adoption: technical complexity, knowledge deficits, economic constraints, time/labor limitations, psychological resistances, and quality uncertainty. Technical complexity emerged as the most frequently cited constraint, with 15 participants (65.2%) describing fermentation as "too complicated" compared to purchasing commercial feeds. The multi-step process—ingredient sourcing, proportional mixing, moisture adjustment, inoculation, sealing, temperature monitoring, and quality assessment—challenged farmers particularly regarding ingredient proportion calculation, moisture content assessment, starter culture procurement, and contamination prevention. Procedural complexity especially affected older and lower-educated participants who struggled with written recipe cards using technical terminology. Equipment requirements also constituted barriers, with 10 participants (43.5%) citing lack of appropriate containers, mixing tools, and storage space, requiring Rp 300,000-800,000 for basic setups. Knowledge deficits proved distinct from awareness: all 7 discontinued adopters experienced failed batches but lacked diagnostic capacity to identify problems or prevent recurrence. Critical knowledge gaps included ingredient quality assessment, dosing and feeding management, troubleshooting spoilage or contamination, and gradual transition protocols to prevent digestive upsets.

Economic constraints operated through multiple mechanisms affecting 20 participants (87.0%). While fermented feeds theoretically reduce costs, ingredient procurement required cash outlays of Rp 50,000-100,000 per 50kg batch, creating liquidity barriers for farmers operating on tight cash flows. The credit dimension

proved crucial: 13 participants (56.5%) purchased commercial feeds on informal credit from suppliers, enabling continuous feeding while deferring payment until livestock sales generated income. Fermented feed production disrupted this system by requiring upfront cash for ingredients from suppliers who didn't offer credit, creating timing mismatches that made adoption financially impractical despite lower unit costs. Labor opportunity costs represented significant barriers, with 9 participants (39.1%) describing conflicts between fermentation time and other income-generating activities, particularly affecting women balancing livestock work with household responsibilities. Risk of batch failure constituted another economic barrier: 4 discontinued adopters (57.1%) had lost Rp 50,000-150,000 investments on failed batches, creating strong loss aversion that drove reversion to commercial feeds despite higher costs.

Time and labor limitations emerged as distinct physical capacity constraints, with 17 participants (73.9%) describing already densely-packed daily routines incompatible with fermentation's 2-4 hour preparation blocks. Fermentation's 3-7 day advance planning requirement proved incompatible with opportunistic management styles, with 11 participants (47.8%) expressing difficulty maintaining continuous production cycles. Labor intensity particularly constrained larger-scale producers requiring 100kg+ batches beyond individual capacity. Psychological resistances encompassed emotional factors including disgust reactions to handling organic wastes (39.1%), fear of harming animals through unsafe feeds (56.5%), and cognitive biases. Status quo bias appeared in 16 participants (69.6%) preferring familiar commercial feeds despite recognizing cost savings potential. Loss aversion manifested in disproportionate weighting of potential negative outcomes over gains. Social identity considerations influenced younger farmers who perceived fermented feeds as "backward" practices inconsistent with modern farming identities, suggesting extension messaging requires reframing as innovative circular economy approaches.

Quality uncertainty concerns reflected rational information asymmetries affecting 15 participants (65.2%). Unlike commercial feeds with standardized quality, labeled nutrients, and regulatory oversight, fermented feeds lacked objective verification mechanisms, creating profound uncertainty about safety and nutritional adequacy. Farmers articulated inability to assess fermentation success beyond crude sensory indicators, fears of invisible problems like mycotoxin contamination, and absence of troubleshooting support when uncertain situations arose. This uncertainty particularly affected discontinued adopters: 6 of 7 (85.7%) doubted quality of batches they produced, leading to heavy dilution with commercial feeds (eliminating cost benefits) or proactive discard of batches with minor quality concerns. Animal consumption willingness served as primary quality indicator, but introducing unfamiliar fermented feeds often caused temporary palatability issues that farmers misinterpreted as quality problems rather than normal adjustment periods. Four discontinued adopters abandoned fermentation after observing reluctant animal consumption, without recognizing that gradual transition would resolve palatability issues, indicating extension training failures in preparing farmers for predictable adaptation phases.

Table 2. Barrier Categories and Prevalence Among Participants

Barrier Category	Specific Constraint	Participants Mentioning	Percentage
Technical Complexity	Too many procedural steps	15/23	65.2%
	Difficulty calculating proportions	11/23	47.8%
	Moisture content adjustment is challenging	9/23	39.1%
	Lack of appropriate equipment	10/23	43.5%
	Contamination/spoilage risks	12/23	52.2%
Knowledge Deficits	Cannot diagnose failed batches	14/23	60.9%
	Unclear ingredient quality standards	12/23	52.2%
	No understanding of feeding management	10/23	43.5%
	Cannot adapt recipes to real conditions	13/23	56.5%
Economic Constraints	No upfront budget for ingredients	14/23	60.9%
	Loss of access to commercial feed credit	13/23	56.5%
	Fear of financial loss due to batch failure	11/23	47.8%
	Time opportunity costs	9/23	39.1%
Time/Labor Limitations	No time in the daily schedule	17/23	73.9%
	Physical labor intensity is too high	8/23	34.8%
	Cannot plan production cycles in advance	11/23	47.8%
Psychological Resistances	Disgust handling organic waste	9/23	39.1%
	Fear of harming animals	13/23	56.5%
	Status quo bias (“Why change?” mentality)	16/23	69.6%
	Viewed as backward/poverty-associated	5/23	21.7%
Quality Uncertainty	Cannot verify safety and nutritional value	15/23	65.2%
	No access to testing facilities	18/23	78.3%
	Animal palatability concerns	12/23	52.2%

Source: Data processed

This barrier typology demonstrates that adoption constraints operate simultaneously across multiple dimensions—technical, knowledge, economic, temporal, psychological, and quality-related—creating compounding obstacles where addressing any single factor proves insufficient. The finding that sustained adopters mentioned substantially fewer barriers or described having overcome initial concerns through experience and support suggests that barriers are not insurmountable but

require comprehensive intervention addressing multiple constraint categories simultaneously rather than narrow technical training alone.

Experiences of Implementation Attempts: Success and Failure Pathways

Problem encounters and critical junctures determined whether attempts continued or ceased. All 12 participants experienced fermentation problems—no implementation proceeded smoothly. The differentiating factor was access to troubleshooting support. Sustained adopters accessed multiple support pathways: extension agents who made follow-up farm visits to examine failed batches and identify issues (insufficient moisture, contaminated ingredients, premature harvest); consulting experienced farmers in their networks (one farmer described a neighbor who "came over, smelled my batch, tasted a little bit, and immediately told me I had added too much water and needed to add more bran to absorb it"); and engaging in systematic experimentation guided by record-keeping (maintaining notebooks documenting each batch's ingredients, conditions, and outcomes to identify patterns). Discontinued adopters lacked such support pathways. When problems arose, they had no one to consult and no frameworks for diagnosing issues. Six discontinued adopters (85.7%) described experiencing "mysterious failures"—batches that smelled wrong, looked abnormal, or were rejected by animals—without understanding what went wrong or how to prevent recurrence, leading to abandonment after one or two failed attempts.

Time investment and production integration patterns revealed critical differentiators. Sustained adopters developed efficient routines embedding fermentation into weekly schedules: dedicating specific days for batch preparation, cycling multiple batches at different fermentation stages, standardizing procedures reducing decision-making burden, and developing rhythms coordinating fermentation timing with feeding schedules. Discontinued adopters failed to achieve such integration—fermentation remained episodic rather than routine, creating unsustainable labor demands. Economic outcomes varied dramatically despite technically similar practices. Sustained adopters reported 20-35% feed cost reductions translating to Rp 800,000-1,200,000 monthly savings, while discontinued adopters achieved minimal or negative returns through batch losses and time investments without offsetting savings. Social validation influenced persistence: sustained adopters received positive recognition from peers, extension agents, and community members, with some becoming local resource persons earning social capital and modest income from mentoring. Discontinued adopters reported neutral-to-negative social experiences—their brief attempts went largely unnoticed, some faced skeptical comments from neighbors ("why waste time on that?"), and none achieved visible success warranting recognition. This social dimension suggests adoption sustainability depends partly on whether farmers receive external validation reinforcing continued effort beyond individual cost-benefit calculations.

Table 3. Differentiating Factors Between Sustained and Discontinued Adopters

Factor Dimension	Sustained Adopters (N = 5)	Discontinued Adopters (N = 7)
Initial Batch Size	Small (10–20 kg), gradual scaling	Large (40–50 kg), immediate full-scale
Training Depth	Repeated training, hands-on practice	Single demonstration, passive observation
Equipment Readiness	Proper containers purchased in advance, good sealing	Improvised equipment, poor sealing control
Support Access	Continuous access to extension agent via phone and follow-up visits	No structured troubleshooting support
Problem Response Behavior	Continued with guidance, used trial-and-error learning	Stopped when facing obstacles, returned to commercial feed
Batch Success Rate	85–95% batch success after stabilization	30–40% success at early stage, inconsistent continuation
Time Investment	3–4 hours weekly (systematized & routine-based)	6–8 hours per batch (episodic & irregular schedule)
Feed Cost Reduction Outcome	25–35% monthly savings, consistently positive	10–15% savings or even negative due to batch failure
Production Integration	Scheduled routine, family labor division, shared responsibility	Production is individual-driven and unplanned
Timing of Production	Consistent scheduling (weekly routine)	Individual, unplanned, sporadic
Social Experience	Positive reinforcement, community respect, social support	Embarrassment or isolation, lower community support

Source: Data processed

This experiential analysis reveals that adoption outcomes hinge not primarily on farmer characteristics (sustained adopters were not notably younger, more educated, or wealthier than discontinued adopters) but on implementation contexts: quality and intensity of training, support availability when problems arise, initial approach (gradualist versus rushed), and whether systems are developed for sustainable integration. This suggests intervention opportunities: improving training depth, establishing ongoing support mechanisms, encouraging careful pilot approaches, and facilitating peer learning communities could convert potential discontinued adopters into sustained users.

Social and Institutional Factors Shaping Adoption Dynamics

Beyond individual-level barriers and experiences, adoption patterns reflected broader social and institutional contexts creating enabling or constraining environments for fermented feed implementation. Social network influences and peer effects proved substantial. Farmers did not make adoption decisions in isolation but were influenced by observable behaviors and reported experiences of peers within their reference groups. The distribution of sustained adopters in the sample revealed spatial clustering: 4 of 5 sustained adopters (80%) resided in two adjacent villages (Desa Cibeureum and Desa Cibunar) that had active farmer groups with at least one early adopter who successfully demonstrated fermentation and shared knowledge. In

contrast, no sustained adopters emerged from four other villages represented in the sample despite farmers from those areas having attended identical extension training—a pattern suggesting peer influence and localized knowledge spillovers significantly impacted adoption. When asked about influence factors, 9 participants (39.1%) explicitly mentioned observing peer farmers as affecting their considerations: "I saw Pak Tarno's chickens and they looked very healthy. He told me he uses fermentation.

That made me think maybe I should try too." However, peer effects operated through complex mechanisms beyond simple imitation: presence of successful adopters in communities created several pathways including direct knowledge transfer through visits and observation (7 participants had visited peer farmers' operations), informal troubleshooting support when problems arose (3 sustained adopters described helping neighbors attempting fermentation), normalization of practices reducing perceived novelty or difficulty (seeing peers succeed made fermentation seem achievable rather than impossibly complex), and competitive dynamics where some farmers felt pressure to adopt innovations their peers had implemented to avoid appearing backward. Yet peer influence also constrained adoption in communities lacking examples: in villages without visible sustained adopters, 6 participants expressed skepticism about fermentation viability—"if it really worked, someone here would be doing it"—suggesting that absence of local examples was interpreted as evidence against technology suitability rather than neutral information.

Farmer group dynamics influenced adoption through organizational channels. Kuningan's agriculture is organized into kelompok tani (farmer groups) serving as primary extension contact points, input procurement cooperatives, and social networks. Groups with strong leadership, regular meetings, and active knowledge exchange appeared to facilitate adoption: the two villages with concentrated sustained adopters both had farmer groups meeting monthly, organizing joint training attendance, and establishing collective ingredient sourcing arrangements (negotiating bulk purchases from tofu factories, coordinating rice bran purchases). In contrast, villages with nominal farmer groups that rarely met or functioned primarily as administrative requirements for accessing subsidies showed minimal adoption. This suggests that farmer groups function as crucial intermediary institutions—providing information dissemination channels, creating social pressure for participation (when groups actively promote practices, members face reputational costs for non-adoption), enabling collective problem-solving norms supporting troubleshooting, facilitating economies of scale in input procurement, and establishing quality standards through peer monitoring. However, farmer group effectiveness varied dramatically: 8 participants (34.8%) described their groups as "active" with monthly meetings, collective activities, and leadership engagement, while 13 participants (56.5%) characterized their groups as "inactive" or "nominal" with infrequent meetings, minimal collective action, and leadership serving primarily bureaucratic functions. This variation in organizational functionality created systematic differences in adoption opportunities across communities.

Extension service quality and institutional support represented critical institutional factors with substantial variance across villages. Villages served by

dedicated extension agents emphasizing fermentation as priority activities showed markedly higher adoption rates. In Desa Cibeureum, the extension agent had conducted monthly fermentation training sessions over two years, maintained demonstration plots at the farmer group facility, organized peer farmer exchange visits, and provided ongoing technical support through farm visits responding to farmer requests—4 of 5 sustained adopters came from this village. The agent described fermentation promotion as his "main program" with personal conviction about environmental and economic benefits, translating to sustained effort and relationship-building with farmers. In contrast, extension agents serving other villages described fermentation as one minor activity among many competing responsibilities (rice intensification, vegetable GAP, livestock vaccination campaigns), with training consisting of one-time lecture-based events without follow-up.

Extension content and pedagogy also shaped outcomes. Sustained adopters described training that was hands-on participatory (participants actually prepared batches during training rather than only observing demonstrations), provided written materials with visual diagrams rather than text-heavy instructions, included follow-up sessions addressing common problems encountered during early implementation, and connected participants with successful peer farmers for ongoing mentoring. Discontinued and non-adopters more commonly experienced lecture-based training emphasizing technical information without practical skill development, creating knowledge-practice gaps where farmers understood concepts but couldn't execute procedures confidently. These patterns suggest that extension effectiveness depends not merely on message content but on pedagogical approaches, agent commitment levels, organizational continuity, and post-training support systems.

Table 4. Institutional Factor Comparisons Across Villages

Village	Sustained Adopters	Extension Quality	Farmer Group Activity	Waste Access	Notes
Cibeureum	2	High (dedicated & committed agent, frequent contact)	Very active (monthly meetings, collective purchases)	Excellent (2 tofu factories within 2 km radius)	Favorable institutional environment
Cibunar	2	High (supported by the same agent as Cibeureum)	Active (bi-monthly meetings)	Good (rice mill 1.5 km, tofu factory 4 km)	Favorable institutional environment
Jalaksana	1	Moderate (occasional demonstrations only)	Moderate (quarterly meetings)	Moderate (rice mill 5 km away)	Mixed institutional environment
Pasawahan	0	Low (minimal assistance and limited engagement)	Low (annual meetings only, non-productive group structure)	Poor (12 km to nearest production waste source)	Unfavorable institutional environment

Village	Sustained Adopters	Extension Quality	Farmer Group Activity	Waste Access	Notes
Ciwaru	0	Low (separate agent, inconsistent guidance, competing priorities)	Low (inactive group, nominal coordination only)	Poor (10 km distance to waste sources)	Unfavorable institutional environment
Kramatmulya	0	Moderate (training delivered, but no follow-up support)	Low (no functional or active partnerships within farmer groups)	Moderate (rice mill 6 km away)	Mixed institutional environment

Source: Data processed

This institutional analysis demonstrates that individual farmer adoption decisions occur within opportunity structures created by social networks, organizational capacities, waste supply chains, market conditions, and policy environments—factors largely beyond individual control yet profoundly shaping feasibility. Villages with favorable institutional configurations (committed extension agents + active farmer groups + good waste access) achieved substantially higher adoption rates (40-50% of trained farmers sustaining practice) compared to villages with unfavorable configurations (0-5% adoption) despite farmers in both contexts attending identical district-level training. This suggests effective promotion requires institutional development beyond farmer education: strengthening extension systems, building functional farmer organizations, facilitating waste supply chains, and creating policy incentives are prerequisites for adoption at scale.

Organic Waste Availability and Access Challenges

The analysis specifically examined organic waste resource availability and accessibility—the raw material foundation for fermented feed production—revealing that assumptions about abundant unused waste often did not match ground-level realities and that access barriers extended physical proximity. Types and volumes of organic wastes available in Kuningan varied by waste stream. Agricultural residues from crop production constituted the largest category by volume: rice straw from paddy harvests (generating approximately 3-5 tons per hectare twice annually), cassava peels from tuber processing (households processing cassava for chips or gaplek producing 10-20kg peels weekly), and vegetable residues from production (cabbage leaves, carrot tops, damaged produce). However, these materials presented challenges for livestock feed use: rice straw requires extensive processing (chopping, fermentation, urea treatment) to achieve digestibility adequate for ruminants and is entirely unsuitable for poultry; cassava peels contain cyanogenic glycosides requiring fermentation or cooking to detoxify but farmers expressed uncertainty about safety even after fermentation; and vegetable residues, while suitable, were generated

diffusely across individual households in small quantities rather than concentrated sources.

Agro-industrial by-products represented more promising feedstocks: rice bran from milling operations, tofu waste (okara/ampas tahu) from soy processing, and brewery waste from traditional tape (fermented cassava) production. Rice bran was commercially available at mills throughout the district (26 mills operating in Kuningan per Agriculture Office data), but already commanded market prices (Rp 2,500-4,000 per kg) due to existing demand from livestock farmers and fish farmers, meaning it represented purchased input rather than free waste. Tofu waste emerged as the most desired fermentation feedstock among participants: highly palatable, protein-rich (15-20% crude protein), generated in substantial daily volumes (factories producing 100-300kg okara per day), and truly waste from processors' perspectives (disposal cost rather than revenue source). However, tofu factories were spatially concentrated in specific sub-districts with soybean cultivation traditions (Cibeureum, Cimahi, Cidamas), leaving farmers in other areas without access.

Food waste from households and markets presented theoretical potential but proved difficult to mobilize systematically. Household food scraps generated 1-3kg per household daily but were: (1) highly heterogeneous (vegetable peels, spoiled rice, meat scraps, bones) requiring sorting and quality assessment, (2) diffused across individual households creating collection logistics challenges, and (3) culturally viewed as "garbage" rather than resource, creating social stigma around collection. Two participants who attempted using household food waste described neighbors' reactions as embarrassing: "People thought I was so poor I had to collect garbage. They gossiped about my family's hardship." Market vegetable waste accumulated in larger volumes at wholesale markets but was: (1) located in urban centers distant from most farmers, (2) already contested by existing users (some pig farmers collected market waste), and (3) required early morning collection (markets generating waste 4-6 AM) conflicting with farmers' livestock care schedules.

Access barriers beyond distance operated even when organic wastes existed nearby. Ownership and control issues affected agro-industrial wastes: tofu factories and rice mills commonly sold by-products to established buyers (animal feed manufacturers, livestock traders, or regular individual customers) through informal long-term relationships, with transactions occurring daily or weekly at factory gates. New farmers seeking access faced entry barriers: factories preferred dealing with familiar reliable buyers rather than unknown individuals; existing buyers sometimes held informal exclusive arrangements discouraging factories from selling to others; and factories prioritized buyers purchasing larger consistent volumes rather than small irregular amounts individual farmers needed.

Transportation and storage logistics created access barriers independent of waste proximity. Organic wastes are highly perishable materials degrading rapidly without proper handling: tofu waste spoils within 24-48 hours in tropical heat; rice bran becomes rancid within weeks if not stored properly; food waste ferments and attracts pests within hours. This perishability required: (1) daily or frequent collection from sources, demanding time and transportation capacity many farmers lacked (15 participants did not own motorcycles or vehicles, relying on walking or occasional transport); (2) immediate processing or storage capacity to preserve materials until fermentation, requiring containers and space many households lacked; and (3)

coordination between waste availability timing and farmer schedules, creating logistical complexity.

Quality and safety concerns related to organic wastes created hesitation even when access was feasible. Participants expressed fears about: contaminated materials (vegetable waste from markets potentially containing pesticide residues; rice bran from mills possibly mixed with dust, stones, or chemical treatments); spoiled or rotten waste causing animal illness rather than fermentation fixing quality problems; unknown chemical residues from agricultural production (cassava peels from tubers grown with pesticides); and inability to assess material safety without laboratory testing unavailable locally. Seasonal availability fluctuations affected certain waste streams: tofu production occurred year-round with relatively stable waste generation, but agricultural residues (rice straw, cassava peels) and some food processing wastes varied seasonally, with irregular supply discouraging adoption requiring consistent waste access for continuous fermentation. Collective action opportunities and coordination failures emerged as relevant to waste access: several participants independently suggested farmer group coordination could facilitate bulk waste procurement from processors, shared transportation reducing individual costs, collective quality monitoring, and negotiated access agreements. However, 13 participants (56.5%) described farmer groups as inactive or dysfunctional with meetings rarely occurring and collective activities minimal, preventing waste access coordination that might otherwise address individual farmer constraints.

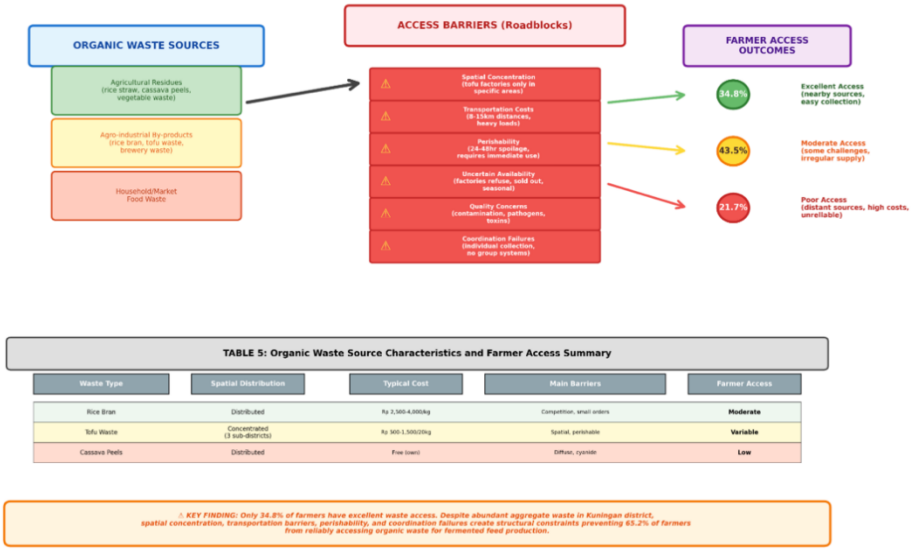

Figure 2. Organic Waste Availability and Access Challenges Map

This organic waste analysis demonstrates that fermentation adoption is constrained not just by farmer knowledge or motivation but by material input supply systems that remain underdeveloped. While the district generates substantial organic waste volumes in aggregate, effective farmer access requires: spatial proximity to concentrated sources (disadvantaging farmers in certain villages), transportation capacity and logistics for collection (excluding those with vehicle or mobility constraints), storage and processing facilities handling perishability (requiring

infrastructure investments), and organizational systems coordinating supply chains (absent where farmer groups are weak). Policy and programmatic interventions to facilitate waste access—through cooperative collection systems, transportation support, quality standards, and market mechanisms—appear necessary complements to farmer training for adoption to scale beyond currently-favorable locales.

Discussion

The findings from this rapid qualitative study investigating barriers to organic waste-based fermented feed adoption among livestock farmers in Kuningan, West Java, reveal a multidimensional barrier landscape far more complex than simplistic explanations centered on farmer awareness deficits or lack of technical information. The research documented that while 95.7% of participants were aware of fermented feed practices and 73.9% had attended formal training, sustained adoption remained limited to just 21.7% of the sample, with an additional 30.4% having attempted implementation but subsequently discontinued—a pattern indicating that barriers operate predominantly at implementation stages rather than information access phases.

The barrier typology identified six interconnected constraint categories—technical complexity, knowledge and skill deficits, economic factors, time and labor limitations, psychological resistances, and quality uncertainty concerns—that operated simultaneously to create compounding obstacles where addressing any single factor proved insufficient for enabling sustained adoption. Furthermore, experiential analysis of farmers who attempted fermentation revealed that outcomes hinged less on inherent farmer characteristics than on implementation contexts: the quality and intensity of training received, availability of ongoing support when problems arose, initial approach strategies (gradualist versus rushed), and development of systematic production routines integrating fermentation into regular farm operations (Apriyana et al., 2021; Syamsi & Harwanto, 2023; Telupere et al., 2023).

These findings both confirm and extend prior research on agricultural technology adoption while highlighting sector-specific and practice-specific factors that generic adoption frameworks miss. The documented paradox of high awareness (95.7%) yet low sustained adoption (21.7%) aligns with van Deursen and Helsper (2017) influential work on digital divides, which distinguished between first-level divides (access to technology/information) and second-level divides (capacity for effective usage)—a framework applicable beyond digital contexts to any knowledge-intensive technology. Just as smartphone ownership creates an illusion of digital inclusion while masking persistent capability gaps, fermented feed awareness creates a false impression of readiness that obscures profound implementation barriers. The present study demonstrates that this awareness-capability gulf operates powerfully in livestock feeding practices, where farmers possess conceptual knowledge that fermentation exists yet lack the procedural knowledge, troubleshooting skills, and systems integration capacity necessary for sustained implementation. This extends theoretical understanding by showing that information diffusion, while necessary, represents merely an initial step in adoption processes for complex practices requiring ongoing behavioral change rather than one-time input purchases.

The finding that technical complexity and knowledge deficits constituted primary barriers—cited by 60-90% of participants across various specific dimensions—

resonates with Rogers' classic diffusion of innovations theory, which identified perceived complexity as among the strongest negative predictors of adoption rates. However, the present findings nuance this relationship: complexity is not intrinsic to fermentation technology objectively, but rather emerges from mismatches between practice requirements and farmer capabilities shaped by educational background, numeracy, literacy, and prior experience.

The observation that sustained adopters (who successfully navigated fermentation) were not notably more educated than discontinued adopters suggests that complexity is surmountable given appropriate support and pedagogical approaches, rather than representing absolute barriers requiring educational prerequisites. This challenges deficit-model assumptions that low adoption reflects farmer limitations, instead highlighting how training content, delivery methods, and support systems either bridge or perpetuate capability gaps. (Feyisa, 2020) recent agricultural technology adoption research emphasized that innovation characteristics are not fixed attributes but are socially constructed through interactions between technologies, users, and institutional contexts—an argument this study empirically validates by showing how identical fermentation technology was experienced as impossibly complex by some farmers yet straightforward by others depending on training quality and support availability.

The documentation of substantial discontinued adoption (30.4% of sample had tried and stopped) represents a critical empirical contribution often overlooked in adoption research, which typically employs cross-sectional binary classifications (adopter versus non-adopter) that miss discontinuation dynamics. The finding that discontinued adopters' experiences were characterized by problem encounters without accessible troubleshooting support, episodic rather than systematic production patterns, minimal economic returns due to high failure rates, and social embarrassment from perceived personal inadequacy illuminates adoption as a process involving multiple decision points rather than a single binary choice.

This process perspective aligns with Foster and Rosenzweig's longitudinal work on agricultural learning, which documented that technology adoption among smallholders involves trial, error, and gradual capability accumulation over repeated production cycles—a learning process that requires sustained engagement but faces high attrition when farmers encounter problems they cannot resolve. The present finding that sustained adopters received average 3-4 training sessions with follow-up support compared to discontinued adopters' average 1-2 sessions without follow-up validates the importance of ongoing institutional support emphasized in recent innovation systems scholarship. Technology transfer cannot be reduced to information provision; it requires sustained accompaniment through implementation challenges.

The experiential narratives revealed psychological dimensions—fear of harming animals, disgust responses to waste handling, status concerns about fermentation appearing backward—that quantitative adoption studies typically neglect but qualitative inquiry illuminates as profoundly consequential. These findings extend behavioral economics perspectives on farmer decision-making, which have increasingly recognized that smallholders' choices reflect not just profit maximization but also risk aversion, loss aversion, present bias, and social identity considerations. (Oyetunde-Usman, 2022) experimental work on technology adoption in East Africa

demonstrated that psychological barriers including fear of failure and social stigma operated as powerfully as economic constraints in preventing uptake of beneficial innovations—a pattern this study confirms in Indonesian livestock contexts. The documentation that 56.5% of participants expressed fear of harming animals through feeding uncertain-quality fermented feeds, even when intellectually recognizing potential cost savings, illustrates how emotional factors override economic rationality in domains where farmers bear responsibility for sentient beings' welfare. This suggests that extension messaging emphasizing financial benefits may prove insufficient without addressing affective concerns through confidence-building approaches, success demonstrations reducing perceived risks, and quality assurance mechanisms alleviating uncertainty.

The social and institutional analysis revealed that individual adoption decisions occur within opportunity structures created by peer networks, farmer group capacities, extension service quality, organic waste supply chains, and policy environments—factors largely beyond individual control yet profoundly shaping feasibility (Magfiroh, 2025). The finding that the two villages with concentrated sustained adopters (4 of 5 total sustained adopters) both had active farmer groups, committed extension agents providing follow-up support, and excellent waste access illustrates how favorable institutional configurations enable adoption rates 8-10 times higher than villages with unfavorable configurations despite farmers in both contexts receiving identical formal training.

This pattern validates innovation systems perspectives emphasizing that technology diffusion requires not just innovation supply (training, information) but also demand-side enabling environments including functional organizations, supportive institutions, and resource availability. Lamptey, (2022)agricultural innovation research argued that persistent low adoption of sustainable intensification practices often reflects not farmer irrationality or ignorance but rather absence of innovation support infrastructure—networks providing knowledge, services, inputs, and collective action capacity—without which individuals cannot successfully implement practices that are technically feasible. The present study demonstrates this dynamic empirically: fermentation is technologically viable and economically beneficial, yet remains largely unadopted because institutional scaffolding required for widespread implementation does not exist in most locales.

The organic waste access analysis uncovered a particularly important yet underappreciated constraint: assumptions about abundant freely-available waste often do not match ground realities where spatial concentration, transportation barriers, perishability, uncertain availability, quality concerns, and coordination failures create genuine access obstacles even in a district that appears waste-rich in aggregate. The finding that only 34.8% of participants enjoyed excellent waste access while 21.7% faced poor access illuminates how material input supply systems for fermented feeds remain underdeveloped compared to commercial feed supply chains.

This extends circular economy literature, which often celebrates waste valorization opportunities theoretically without grappling with practical implementation barriers. Geislar's work on organic waste management in Southeast Asia noted that "closing nutrient loops" requires not just technical knowledge but also logistics systems, quality assurance, and economic incentives currently absent for waste-to-feed pathways—challenges this study empirically documents. The implication is that fermentation promotion cannot succeed solely through farmer

capacity building; it requires parallel development of waste supply chains including cooperative collection systems, quality standards, and potentially policy interventions incentivizing waste generators to facilitate farmer access.

The research provides actionable implications for agricultural extension services, policymakers, farmer organizations, and waste-generating industries to support sustainable livestock feed systems. For extension services, the findings emphasize the need for ongoing, hands-on training with follow-up support to help farmers overcome technical, psychological, and institutional barriers. Extension programs should focus on confidence-building, troubleshooting skills, and using local resources. For policymakers, the research suggests facilitating organic waste supply chains, developing quality assurance frameworks for fermented feeds, and strengthening the extension system to provide more intensive support. The study also highlights the potential for farmer organizations to coordinate collective actions, like shared infrastructure and resource procurement, to overcome individual challenges and enhance adoption rates. For waste-generating industries, the research points to the value of establishing partnerships with farmers to facilitate waste distribution, creating a mutually beneficial arrangement.

The study's limitations include a small sample size and a focus on Kuningan district, which may limit the generalizability of the findings to other regions with different agricultural or institutional characteristics. The three-month research timeframe constrained the ability to observe long-term adoption trends or assess the effectiveness of specific interventions over time. Additionally, the study did not include perspectives from other value chain actors, such as organic waste generators or livestock output buyers, which could reveal additional coordination challenges. Future research could address these limitations by expanding the sample, incorporating longitudinal data, and including multi-stakeholder perspectives to gain a more comprehensive understanding of the barriers and drivers for fermented feed adoption across diverse regions.

CONCLUSION

This study reveals that low fermented feed adoption (21.7% sustained) despite high awareness (95.7%) stems from six interconnected barriers: technical complexity (65.2%), knowledge deficits (60.9%), economic constraints (60.9%), time limitations (73.9%), psychological resistance (56.5%), and quality uncertainty (65.2%). Critically, adoption success depends more on implementation context than farmer characteristics. Sustained adopters received intensive training (3-4 participatory sessions) with ongoing support and reliable waste access, while discontinued adopters (30.4%) faced isolation after passive demonstrations. Institutional configurations proved decisive: villages with active farmer groups, committed extension agents, and accessible waste supplies achieved 40-50% adoption versus 0-5% elsewhere despite identical training. These findings challenge binary adopter/non-adopter frameworks, revealing adoption as a multi-stage process requiring sustained capability development and accompaniment through early implementation challenges. Effective interventions must address multiple barriers simultaneously through participatory training, continuous support systems, farmer organization strengthening, and organic waste supply chain development. Future research should employ longitudinal designs

tracking adoption trajectories, experimental evaluations comparing training modalities, multi-site studies across varied contexts, and cost-effectiveness analyses to advance evidence-based programming that transforms fermented feeds into widespread sustainable practice.

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