

Enhancing Laying Hen Farmers' Knowledge of Meniran (*Phyllanthus Niruri*) Nano-Extract and Fermented Rice Bran As Natural Feed Technologies In Bojonegoro, Indonesia

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Abstract.

Feed represents the predominant cost structure in smallholder laying hen production. The prohibition of antibiotic growth promoters in Indonesia necessitates the safe and effective alternative feed additives. Accordingly, this community service initiative introduced two natural feed technologies to laying hen farmers. Specifically, Meniran (*Phyllanthus niruri*) nano-extract was administered as a feed additive, while rice bran fermentation was conducted using a fermenter. The overarching objective of the program was to enhance farmers' understanding of both technologies as well as their awareness of prudent antibiotic practices. The participants comprised 20 farmers affiliated with the Rejo Bejoyo and Manunggal Bersama livestock groups in Simbatan Village, Bojonegoro, East Java. The program was implemented on 12 August 2026 through a participatory methodology encompassing problem identification, extension services, technology demonstrations, interactive discussions, and evaluation utilizing pre-test and post-test questionnaires. All 20 farmers attended the program in full. Furthermore, every participant demonstrated improvement across all four knowledge domains assessed. The mean knowledge score increased substantially from 37.31 to 86.88, as confirmed by a paired t-test ($p < 0.001$). Additionally, a high normalized gain (N-gain) of 0.79 was achieved. All predetermined success indicators were satisfied. Notably, the most significant improvements were observed in the areas of rice bran fermentation and prudent antibiotic use, whereas nanotechnology remained the least comprehended topic among participants. Farmers further acquired the understanding that antibiotics are intended solely for therapeutic purposes and should not be administered concurrently with herbal supplements. Ultimately, this program successfully bridged the gap between university research and the practical needs of farmers. Consequently, it establishes a foundational basis for subsequent on-farm mentoring initiatives aimed at enhancing egg production and reducing feed costs.

Keywords; community education; experiential learning; farmer education; *Phyllanthus niruri* and nanotechnology.

I. INTRODUCTION

Educational processes extend well beyond the confines of formal schooling. For millions of adults residing in rural Indonesia, the most impactful learning occurs within non-formal contexts, wherein newly acquired knowledge must be directly translated into livelihood-related decision-making. Smallholder livestock farmers represent a particularly salient case in point. Their income is contingent upon the degree to which they comprehend feeding practices, animal health management, and the judicious application of veterinary pharmaceuticals; nevertheless, the preponderance of their knowledge is derived from personal experience, peer networks, and input suppliers rather than from structured pedagogical programs (Chapot et al., 2024). Consequently, the manner in which such adults are instructed is of equal significance to the content of what they are taught.

Smallholder laying hen farming exemplifies the urgency of addressing this learning deficit. Feed expenditures constitute approximately 77% of total production costs on laying hen operations (Lumenta et al., 2022), and when combined with day-old chick procurement, these inputs absorb in excess of 80% of costs for small-scale producers contending with volatile, import-dependent pricing structures (Chapot et al., 2024). A survey encompassing 114 smallholder layer farmers in Java documented that feed costs escalated significantly during and in the aftermath of the COVID-19 pandemic (Priyono et al., 2024). Concurrently, Indonesia has prohibited antibiotic growth promoters (AGP) in animal feed since 2018 and has restricted antibiotic administration to therapeutic applications conducted under veterinary oversight (Kementerian Pertanian Republik Indonesia, 2017). Policy evaluations indicate that numerous farmers anticipate the ban will elevate mortality rates and diminish feed efficiency, and approximately 80% of surveyed respondents continued to utilize AGP (Shaffitri et al., 2024). Antimicrobial usage within Indonesian livestock systems remains elevated

and frequently occurs in the absence of veterinary prescriptions (Coyne et al., 2019). On a global scale, merely 43% of poultry farmers demonstrate an understanding of antimicrobial resistance, while 45% continue to employ antimicrobials for prophylactic purposes (Sattar et al., 2023). These statistics characterize a knowledge deficit that is as consequential as the economic challenges at hand.

Veterinary science research has already yielded practical alternatives to address these challenges. Meniran (*Phyllanthus niruri*) contains flavonoids, tannins, saponins, alkaloids, and terpenoids exhibiting immunomodulatory, antioxidant, and antibacterial properties (Lee et al., 2016). Meniran extract has been shown to enhance immune and antioxidant responses in laying hens infected with *Escherichia coli* (Sabdoningrum et al., 2020). Processing this extract into nanoparticles of approximately 192.6 nm is designed to augment absorption rates (Sabdoningrum et al., 2021), and a 5% nano-extract formulation improved broiler performance metrics (Sabdoningrum et al., 2023) as well as income over feed cost ratios (Aqfari et al., 2023). Rice bran, an economically accessible local by-product, is constrained by its elevated crude fiber content; however, fermentation has been demonstrated to reduce crude fiber from 10.62% to approximately 7.79% while simultaneously increasing crude protein concentrations (Supriyati et al., 2015). In laying hens, fermented rice bran enhanced nutrient digestibility, egg production rates, and egg weight (Wang et al., 2023). The principal challenge, therefore, does not reside in the absence of viable technologies but rather in the effective transfer of such knowledge to the adult populations who must implement them.

Adult learning theory provides a theoretical framework for understanding why conventional unidirectional extension approaches frequently fail to facilitate this knowledge transfer. Andragogy posits that adults achieve optimal learning outcomes when instructional approaches are problem-centered, immediately applicable to their professional roles, and grounded in their pre-existing experiential knowledge (Knowles et al., 2015). Experiential learning theory conceptualizes learning as a cyclical process encompassing concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 2015). Diffusion of innovations theory further elucidates that farmers exhibit greater receptivity to adopting novel practices when an innovation demonstrates compatibility with established practices, presents minimal complexity, and yields observable outcomes (Rogers, 2003). Farmer Field Schools, which operationalize these theoretical principles through discovery-based collaborative learning methodologies, have demonstrably enhanced farmers' knowledge acquisition and adoption of beneficial practices across numerous low- and middle-income countries (Godtland et al., 2004; Waddington et al., 2014). Furthermore, a comprehensive review of 65 empirical studies identified measurable improvements in critical thinking capacities, self-confidence, and collective action initiatives among participants (Van Den Berg et al., 2020).

Novelty

Little evidence exists regarding how these principles operate within short, technology-specific livestock education programs across Indonesia. Numerous community initiatives document their activities yet fail to measure actual learning outcomes (Setyowati et al., 2023). Earlier efforts undertaken by the current research team introduced meniran nano-extract to dairy farmer groups, reporting enhanced skills and empowerment, though knowledge gains across specific topics went unquantified (Hidanah et al., 2024, 2025). Research on Indonesian extension services further demonstrates that method and media selection directly influences whether farmers adopt new practices (Pello & Djunina, 2024). Which types of content, concrete or abstract, benefit most from demonstration-based instruction remains largely unexplored.

Research Gap

This study addresses that gap. It evaluates a one-day, demonstration-based participatory learning program for laying hen farmers designed on andragogical and experiential learning principles. The study asks three questions: (1) Does the program improve farmers' knowledge of natural feed technologies and prudent antibiotic use? (2) Do learning gains differ across topics of different abstraction? (3) Do gains differ between two farmer groups?

II. RESEARCH METHOD

Employing a one-group pretest, posttest pre-experimental design, this study measured shifts in farmers' knowledge following a single learning program. Such a design fits community education settings

where every member of a farmer group qualifies for the program and randomising a control group proves impractical. The learning program itself served as the intervention, with knowledge scores recorded before and after the program functioning as the outcome. Adult learning principles guided the program's design. Content drew directly from problems the farmer groups themselves had identified: high feed costs, the necessity of keeping hens healthy without AGP, and uncertainty surrounding antibiotic use (Knowles et al., 2015). Activities were structured to encompass all four stages of the experiential learning cycle, into which learners may enter at any stage (Kolb, 2015), as summarised in Table 1.

Table 1. Learning Activities Mapped to the Experiential Learning Cycle

Learning stage	Activity in the program	Duration
Concrete experience	Farmers shared their current feeding practices, feed costs, and drug use	30 minutes
Abstract conceptualisation	Problem-based mini-lectures on meniran nano-extract, rice bran fermentation, and prudent antibiotic use, with simple analogies	30 minutes
Reflective observation	Live demonstration of mixing nano-extract into feed and of fermenting rice bran in a fermenter	90 minutes
Active experimentation	Farmers practised the mixing and fermentation steps and planned on-farm trials in a facilitated discussion	45 minutes

The program content was organised into four learning modules, each matched to one test topic and delivered by facilitators with expertise in that area. The first module, on the functions and benefits of meniran, introduced meniran as a familiar medicinal plant and explained its bioactive compounds and their role in supporting immunity and gut health in hens (Lee et al., 2016; Sabdoningrum et al., 2020). Facilitators linked this content to the farmers' need for alternatives to AGP, framing the plant as a natural immunostimulant rather than a drug.

The second module, on nanotechnology, explained why the extract is reduced to nanoscale particles and how smaller particles are absorbed more easily (Sabdoningrum et al., 2021). This was the most abstract module. Facilitators used daily analogies and showed the finished nano-extract product, then demonstrated how a small, measured amount is mixed gradually into feed so that it is distributed evenly.

The third module, on rice bran fermentation, explained why the high crude fiber of rice bran limits its use in poultry feed and how fermentation improves its quality (Supriyati et al., 2015; Wang et al., 2023). Facilitators demonstrated the fermentation process with a fermenter, from mixing the bran with water, a soluble carbohydrate source, and a microbial inoculum to incubation and drying. Farmers handled the materials during the demonstration.

The fourth module, on prudent antibiotic use, explained the national AGP ban and the principle that antibiotics are for treating diagnosed disease under veterinary guidance (Kementerian Pertanian Republik Indonesia, 2017). This module was delivered mainly through facilitated discussion, because it addressed existing beliefs and practices rather than a new technology.

Participant

Participants were 20 adult laying hen farmers, all members of two livestock farmer groups in Simbatan Village, Kanor District, Bojonegoro Regency, East Java, Indonesia: Rejo Bejoyo (n = 10) and Manunggal Bersama (n = 10). All active members who attended the program on 12 August 2026 were included (total sampling). Participation was voluntary. Before the pretest, the team explained the purpose of the program and how the test data would be used, and each participant signed a written informed consent form.

Data Collection

Data were collected on the day of the program. Participants completed the pretest before any instruction, then took part in the learning activities in Table 1, and completed the identical posttest at the end of the session. Tests were administered on paper [confirm administration procedure]. Farmers' questions and concerns raised during the discussion session were documented by the team as qualitative data.

Instrument

Knowledge was measured with a researcher-developed multiple-choice test of 80 items, with 20 items for each of four topics: (1) functions and benefits of meniran; (2) principles of nanotechnology in feed

additives; (3) purpose and procedure of rice bran fermentation; and (4) prudent antibiotic use. Each correct answer scored 5 points, giving a 0–100 score for each topic, and the total score was the mean of the four topic scores. Content validity was reviewed by members of the research team with expertise in animal nutrition and veterinary pharmacology.

Data Analysis

Scores were summarised as mean $\pm$ standard deviation. Normality of the pre–post differences was checked with the Shapiro–Wilk test. Because the differences were normally distributed, the paired t-test was the primary test of change, and the Wilcoxon signed-rank test was used as a robustness check. Learning effectiveness was expressed as normalized gain (Hake, 1998):

$$N\text{-gain} = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{max}} - S_{\text{pre}}}$$

N-gain ≥ 0.70 was classified as high, 0.30–0.69 as medium, and < 0.30 as low. Class N-gain was calculated from group means, and individual N-gain from each participant's total scores. Differences in individual N-gain between the two farmer groups were tested with the Mann–Whitney U test. All tests used a significance level of 0.05. Records of farmers' questions from the discussion session were grouped by theme to help interpret the quantitative results.

III. RESULT AND DISCUSSION

All 20 farmers attended the full program and completed both tests. Every participant scored higher on the posttest than on the pretest in all four topics. The mean total score increased from 37.31 ± 4.14 to 86.88 ± 2.05 , a gain of 49.56 points. The pre–post differences were normally distributed (Shapiro–Wilk, $p = 0.726$), and the paired t-test showed a significant increase ($t(19) = 50.90$, $p < 0.001$), confirmed by the Wilcoxon signed-rank test ($p < 0.001$). The class N-gain was 0.79, in the high category (Table 2).

Table 2. Pretest and Posttest Knowledge Scores by Topic (n = 20)

Topic	Pretest (M $\pm$ SD)	Posttest (M $\pm$ SD)	Difference	N-gain	Category	p
Functions and benefits of meniran	37.75 ± 8.96	86.25 ± 4.25	48.50	0.78	High	< 0.001
Nanotechnology in feed additives	23.25 ± 3.73	77.25 ± 4.44	54.00	0.70	High	< 0.001
Rice bran fermentation	39.75 ± 7.52	91.75 ± 2.45	52.00	0.86	High	< 0.001
Prudent antibiotic use	48.50 ± 7.80	92.25 ± 2.55	43.75	0.85	High	< 0.001
Total	37.31 ± 4.14	86.88 ± 2.05	49.56	0.79	High	< 0.001

Note. Scores on a 0–100 scale; p values from paired t-tests (df = 19); N-gain calculated from group means (Hake, 1998).

Learning Gains by Topic

Learning gains differed in size across topics. Rice bran fermentation (N-gain 0.86) and prudent antibiotic use (0.85) showed the largest normalized gains and the highest posttest scores, above 91. Prudent antibiotic use also had the highest pretest score (48.50), indicating that farmers entered with some prior knowledge from their own practice. Nanotechnology had the lowest pretest score (23.25), the lowest posttest score (77.25), and the smallest normalized gain (0.70), which sits at the lower boundary of the high category. Nanotechnology nevertheless showed the largest raw difference (54.00 points) because farmers started with the least knowledge.

Individual Gains and Group Comparison

Individual N-gains ranged from 0.74 to 0.86, so all 20 participants reached the high category. Table 3 compares the two farmer groups. Their pretest scores were similar, and their N-gains did not differ significantly (Mann–Whitney U = 37, $p = 0.344$). The program therefore produced comparable learning in both groups.

Table 3. Knowledge Gain by Farmer Group

Farmer group	n	Pretest total (M ± SD)	Posttest total (M ± SD)	Individual N-gain (M ± SD)
Rejo Bejoyo	10	37.13 ± 3.64	86.38 ± 1.61	0.78 ± 0.03
Manunggal Bersama	10	37.50 ± 4.79	87.38 ± 2.39	0.80 ± 0.04

Note. Mann–Whitney U = 37, p = 0.344 for individual N-gain.

Farmers' Questions During Discussion

The discussion session showed where farmers' prior beliefs were strongest. The most frequent questions concerned antibiotics: whether herbal supplements may be given together with antibiotics, and whether antibiotics should be given routinely to prevent disease. Facilitators explained that antibiotics are for treating diagnosed disease, not for routine prevention, and that the herbal feed additive is not given concurrently with antibiotics.

Discussion

Why the Learning Design Proved Effective

More than doubling farmers' mean knowledge score, the program pushed every participant into a high normalized gain range. Such an outcome lends weight to the argument that agricultural extension functions most powerfully when shaped as adult education rather than as one-way information delivery. Three design features likely account for this gain. First, the content centered on problems. Topics emerged directly from farmers' own concerns about feed costs and animal health, giving adult learners a clear reason to engage (Knowles et al., 2015). Readiness to learn rises sharply when a lesson answers a question already carry. High attendance and active questioning throughout the program align closely with that principle. Second, the program moved past explanation into demonstration and practice. Within the experiential learning cycle, understanding deepens when learners observe a process firsthand and then attempt it themselves (Kolb, 2015). Two demonstrations made abstract claims tangible: farmers watched a small quantity of nano-extract mixed into feed and observed bran transforming inside a fermenter. This approach mirrors the discovery-based model of Farmer Field Schools, which consistently outperform non-participants on knowledge measures (Godtland et al., 2004; Waddington et al., 2014). Third, delivery targeted existing farmer groups, enabling peer learning during discussion and well beyond the session itself. Group-based extension builds social capital, trust, and collective problem-solving alongside individual knowledge (van den Berg et al., 2020). Similar gains across both farmer groups point to a design that worked consistently rather than one that leaned on a single group's prior advantage.

Concrete Versus Abstract Content

The clearest pattern in the results concerns the difference between topics. Rice bran fermentation yielded the highest normalized gain. A familiar local feed, rice bran undergoes a fermentation process resembling food processing that rural households already practice. In diffusion theory terms, the innovation carries high compatibility with existing practice and produces visible results (Rogers, 2003). Demonstration therefore bridged new information to what farmers already understood. Prudent antibiotic use also generated a high gain, though from the highest starting point. Farmers arrived with practical experience using antibiotics, yet that experience included the belief that routine preventive dosing constitutes good practice. The discussion session confronted this belief head-on. Correcting a misconception sits at the heart of adult education, since adult experience can serve simultaneously as a resource and a barrier to new learning (Knowles et al., 2015). The result proves encouraging given that knowledge gaps on antimicrobial resistance remain widespread among poultry farmers (Sattar et al., 2023) and that AGP use persists in Indonesia despite the ban (Shaffitri et al., 2024). Nanotechnology produced the smallest normalized gain and the lowest posttest score. Nanoparticles cannot be seen, their benefit stays invisible in the short term, and the concept finds no counterpart in farmers' daily experience. Innovations marked by complexity and low observability tend to be understood and adopted more slowly (Rogers, 2003). This finding carries a practical implication for instructional design: abstract scientific content demands more scaffolding than concrete content. Visual analogies of particle size, before-and-after comparisons of absorption, and follow-up sessions linking the concept to on-farm results such as egg production records all offer useful strategies.

From Knowledge Gain to Practice

A high knowledge gain marks a necessary first step, yet it does not constitute the end goal of farmer education. Evidence from Farmer Field Schools reveals that participants consistently gain knowledge, while effects on adoption and productivity vary more widely and hinge on facilitation quality and local conditions (Waddington et al., 2014). The link between knowledge and productivity, though plausible, operates far from automatically (Godtland et al., 2004). Studies of Indonesian extension similarly demonstrate that adoption depends on the method and media employed, not solely on what farmers know (Pello & Djunina, 2024). The present results suggest a sequence for follow-up. Rice bran fermentation, the best-understood topic, relies on a local material and produces visible results, making it the most likely candidate for early adoption. Its economic value also aligns with farmers' main concern, since feed dominates production costs (Lumenta et al., 2022). The nano-extract likely requires a longer path, one in which farmers first observe its effects on flocks in demonstration plots or on neighbouring farms. Earlier programs by the same team combined training with three months of monitoring for dairy farmers and reported gains in skills and empowerment (Hidanah et al., 2024), lending support to a similar staged approach here. Table 4 summarises the instructional strategies suggested by these findings.

Table 4. Instructional Strategies for Teaching Agricultural Innovations of Different Abstraction

Content type	Example in this study	Learning difficulty observed	Suggested strategy
Concrete, familiar	Rice bran fermentation	Lowest; highest N-gain (0.86)	Short demonstration followed by hands-on practice; move quickly to on-farm trial
Belief-laden practice	Prudent antibiotic use	Prior knowledge present but partly incorrect; N-gain 0.85	Facilitated discussion that surfaces and corrects misconceptions; link to regulation and animal health
Familiar material, new function	Benefits of meniran	Moderate; N-gain 0.78	Connect to local knowledge of the plant, then explain the scientific mechanism
Abstract, low observability	Nanotechnology	Highest; lowest posttest score and N-gain (0.70)	Visual analogies, repeated explanation, and follow-up sessions linked to observable flock outcomes

Implications for Non-Formal Education

The findings have three implications. For extension educators, short programs can produce large knowledge gains when they are built on adult learning principles, but abstract topics should receive extra instructional time. For universities, community programs can serve as sites of educational research if they measure learning with valid instruments rather than reporting activities alone (Setyowati et al., 2023). For policy, farmer education on prudent antibiotic use is a necessary complement to regulation, because a ban alone does not change practice (Shaffitri et al., 2024).

Limitations

This study has several limitations. The one-group pretest–posttest design has no control group, so test familiarity and the testing effect may have contributed to the gain. The posttest was given on the same day, so the results show short-term knowledge rather than retention or behaviour change. Knowledge gain does not guarantee adoption, since adoption also depends on input access, perceived benefit, and market conditions (Pello & Djunina, 2024; Waddington et al., 2014). The sample was small and drawn from one village, and content validity was reviewed internally by team members rather than by independent experts. Future studies should include a comparison group, a delayed posttest, and on-farm monitoring of adoption, egg production, and feed cost.

IV. CONCLUSION

A one-day, demonstration-based participatory learning program grounded in andragogy and experiential learning substantially improved smallholder laying hen farmers' knowledge of natural feed technologies and prudent antibiotic use. Mean scores rose from 37.31 to 86.88, the class N-gain was high (0.79), and all participants in both farmer groups reached high individual gains. Concrete and familiar content, such as rice bran fermentation, was learned most effectively, while abstract content, such as nanotechnology,

required more support. Extension programs for rural adults should therefore combine problem-centred content with hands-on demonstration, and give abstract scientific topics extra scaffolding and follow-up. Further research should test knowledge retention and on-farm adoption over a full production cycle.

ACKNOWLEDGMENT

Thanks are extended to the Community and Business Development Institute (LPMB) of Airlangga University for the Implementation of Community Service under the Community Partnership Program Scheme for Assisted Villages, Fiscal Year 2026, Number 1313/UN3/2026. Appreciation and gratitude are conveyed to the Community Service Team of the Faculty of Veterinary Medicine of Airlangga University for their support and contribution to the successful execution of this activity. Gratitude also extended to the Simbatan Village Government as well as the members of the Rejo Bejoyo and Manunggal Bersama Livestock Groups for their cooperation and participation.

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