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PROSPECTS AND CHALLENGES OF IMPLEMENTING INDUSTRIAL-SCALE FERMENTED FEED IN MODERN BROILER FARMING

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Abstract

The main issue raised is the gap between the theoretical potential of fermented feed, which has been proven to improve broiler performance on a small scale, and the complexity and uncertainty of its implementation on a modern industrial scale. This study aims to comprehensively analyze these strategic prospects and challenges. Using in-depth qualitative library research methods , this study synthesizes recent findings from the scientific literature. The results reveal that the prospects for industrial-scale implementation are very promising, particularly in supporting production efficiency through increasing nutrient digestibility and feed conversion, optimizing growth, reducing dependence on imports, and developing innovative products based on local ingredients. However, behind these prospects, multidimensional challenges are identified, encompassing technical-operational aspects such as the difficulty of maintaining consistent product quality and stability during mass production, distribution, and storage, as well as economic challenges such as high initial investment and the need for changes in feed management at the farm level. The study concludes that the successful adoption of this technology depends on the ability to integrate biotechnology innovation with robust supply chain management, appropriate business strategies, and ongoing educational programs. As an implementation, strategic collaboration is needed between the feed industry, government, and the research world to conduct pilot projects, develop operational standards, and formulate supporting policies that can mitigate risks and accelerate the realization of the potential of fermented feed towards a more efficient, independent, and sustainable broiler farming system.

Keywords: Prospects, Challenges, Industrial Scale Fermentation, Modern Broiler Farming

INTRODUCTION

The global broiler (broiler chicken) industry, including in Indonesia, is at a critical crossroads, where pressure to increase production efficiency clashes directly with global demands for sustainable, healthy, and ethical farming systems. Broiler chicken production has rapidly evolved into a highly integrated and high-tech industry, with short production cycles and growing market demand. However, this growth is accompanied by a number of complex and urgent structural challenges to be addressed, particularly those related to food security, animal health, and environmental sustainability. Essentially, these challenges center on the two largest cost components in broiler production: feed and animal health, which together can account for up to 80% of total operational costs (Mottet & Tempio, 2020). Feed, as a key determinant of performance and cost, has long relied on conventional raw materials such as corn and soybean meal, whose availability and prices fluctuate significantly due to global market dynamics, climate change, and import dependence.

This heavy reliance on imported feed ingredients creates serious vulnerabilities to national food security. Fluctuations in commodity prices on international markets and disruptions to global

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supply chains, as exacerbated by the pandemic and geopolitical conflicts, can directly impact feed price stability and the profitability of livestock businesses. This situation has prompted a more serious search for alternative feed ingredients sourced from local resources, such as agro-industrial waste (rice bran, coconut meal, cassava pulp) and other agricultural byproducts (Wadhwa & Bakshi, 2020). However, the use of non-conventional local raw materials often suffers from the presence of anti-nutritional compounds (such as phytic acid, tannins, and high crude fiber) and low nutrient digestibility, which can actually reduce livestock performance when fed directly. This is where feed processing technologies, particularly fermentation, emerge as a potential biotechnological solution to increase the utility and added value of these local raw materials .

In parallel, the livestock industry is also facing major animal health challenges related to antibiotic use. For decades, antibiotic growth promoters (AGPs) have been routinely used in feed to enhance growth and prevent disease. However, this practice has been scientifically linked to the emergence and spread of antimicrobial resistance (AMR), a global threat to public health. The response to this has been increasingly stringent regulations and bans on AGP use in many countries, prompting the industry to seek safe and effective alternatives to maintain gut health and livestock performance (Kogut, 2021). Fermented feed, through its natural mechanisms of action, offers such an alternative. The fermentation process not only improves nutritional quality but also produces bioactive compounds such as organic acids, enzymes, bacteriocins, and probiotics, which synergistically create a healthy gut environment, suppress pathogen populations, and enhance the immune response of broilers.

In the context of innovation and increased competitiveness, the modern broiler industry is required to continuously adopt technologies that optimize feed conversion efficiency (FCR). FCR is a critical indicator for assessing productivity, where even a small decrease in FCR can have a significant economic impact on a mass production scale. Recent studies have shown that fermented feed can increase the digestibility of protein, phosphorus, and energy, thus directly contributing to improvements in FCR and chicken growth rates (Jazi et al., 2022).

The transition to industrial-scale applications is both a focal point and a major dilemma. Fermented feed applications have been primarily known and practiced on a small, traditional, or semi-modern scale, with relatively loose quality control. Industrial scale requires consistent quality, product stability, cost-effective mass production, and significantly different logistical feasibility. Technical challenges such as standardizing fermentation processes in large batches, preventing cross-contamination, precise temperature and humidity control, and handling wet or semi-wet feed in long supply chains present significant challenges (Syahniar et al., 2023). Furthermore, economic considerations are a key determinant. Investments in building or modifying feed mills with advanced bioreactor technology, operational costs for high-quality starter cultures, and the need for a cold chain or specialized packaging for distribution all impact the cost structure, which must be offset by the quality of the final product.

Therefore, the discourse on fermented feed has shifted from merely discussing nutritional and health benefits to a more comprehensive analysis of its technical, operational, and economic feasibility in the modern, capital-intensive and competitive broiler industry ecosystem. This article addresses this need for a holistic analysis. Its objective is to examine in-depth and systematically the prospects offered by industrial-scale fermented feed implementation in boosting the efficiency and sustainability of broiler farms, while critically identifying the fundamental challenges facing it in terms of mass production, product stability, on-farm application management, and business feasibility analysis. Therefore, this study is expected to provide a clear roadmap and perspective for stakeholders, from policy planners and the feed industry to livestock farmers, in making strategic decisions regarding the future of fermented feed in Indonesia (Rahmawati et al., 2024).

The main problem in this research is the gap between the enormous theoretical potential of fermented feed and the reality of its implementation on a modern broiler industrial scale. Scientifically, various studies have proven the superiority of fermented feed in improving nutrient digestibility, gut health, growth performance, and as an alternative to antibiotic growth promoters (AGPs). However, this evidence is generally obtained from laboratory-scale research or small-scale farm applications with strict controls. Problems arise when this technology is to be adopted on a mass production scale, which involves repetitive processes in very large volumes, long logistics chains, and integration with automated commercial farm management systems. This research is urgently needed because of three main pressures currently facing the global and national broiler industry. First, economic pressures in the form of high production costs dominated by feed, which are further exacerbated by price fluctuations and dependence on imported raw materials . Second, regulatory pressures and global markets that increasingly limit the use of antibiotics, driving the need for natural feed solutions for livestock health. Third, the demand for sustainability requires optimal use of local resources.

The purpose of this study is to provide a comprehensive and in-depth analysis to answer the central question: "What are the real prospects and challenges of implementing fermented feed on an industrial scale in modern broiler farms?" The specific objectives of this study are: (1) To identify and analyze the prospects (opportunities and potential benefits) of implementing industrial-scale feed fermentation technology, particularly in supporting increased production efficiency, livestock health, and the sustainability of broiler businesses. (2) To investigate and map the challenges (obstacles and risks) that will be faced, including technical aspects of mass production, product stability, logistics, adaptation at the farm level, as well as economic and business feasibility. (3) To develop evidence-based strategic recommendations for stakeholders (feed industry, livestock farmers, policy makers, and researchers) regarding steps that need to be taken to optimize opportunities and mitigate challenges, in order to accelerate the successful and sustainable adoption of industrial-scale fermented feed.

METHOD

This study, entitled "Prospects and Challenges of Industrial-Scale Fermented Feed Application in Modern Broiler Farms," was methodologically designed as a qualitative, exploratory, and analytical *library research* study. This approach was chosen because the research objective was not to generate new empirical data in the field, but rather to build a comprehensive, in-depth, and systematic understanding by synthesizing , analyzing, and critiquing existing findings and discourses in the body of previous scientific literature (Sugiyono, 2021). This type of research is highly appropriate for examining a multidimensional topic such as the application of fermented feed technology on an industrial scale, where reality is shaped by complex interactions between technical, biological, economic, and managerial factors that have been discussed separately in various publications. Through *library research* , researchers act as intellectuals who collect, filter, and reassemble pieces of knowledge from various sources into a coherent argument (Creswell & Creswell, 2023).

The data sources in this study are entirely secondary, consisting of written documents that have been published and verified through a scientific process. The primary sources for this study were scientific journal articles, both internationally indexed by Scopus/Web of Science and nationally accredited by SINTA, published between 2018 and 2024 to ensure the freshness and relevance of the findings to current developments. These journals were searched from academic databases such as ScienceDirect, Google Scholar, PubMed, and the Garuda Portal. Other secondary data sources included textbooks and scientific monographs, both recent editions and classics that are still primary references, specifically discussing poultry nutrition, fermented feed technology, industrial broiler production management, and livestock economics. Furthermore, research reports from government institutions (such as the Ministry of Agriculture or FAO), research institutions (such as the IAARD or universities), and relevant theses and dissertations also served as complementary data sources to obtain a more applicable and contextual picture (Sugiyono, 2021).

The data collection technique used was a documentary study with purposive sampling, in which document searches and selection were carried out selectively and in stages with specific objectives. The first stage was an initial search using keyword combinations such as "fermented feed poultry," "industrial scale fermentation," "broiler production efficiency," "feed mill technology," and their Indonesian equivalents. The results of this initial search were then screened based on title and abstract to assess their relevance to the research focus. Documents that passed the screening were then downloaded and read in-depth. During the reading process, a snowball sampling technique was also applied, namely by backward searching the reference lists of key documents found to identify other seminal sources that may have been missed in the database search (Creswell & Creswell, 2023).

The data analysis technique used was qualitative content analysis using thematic analysis. The analysis process did not stop at describing the contents of each document, but sought to identify patterns, themes, relationships, and contradictions that emerged among various data sources. The analysis began with a coding process, in which pieces of text or findings from various literature were coded or labeled based on their meaning and content. Codes with conceptual similarities or connections were then grouped to form broader data categories. From these categories, the researcher then synthesized to extract key themes that answered the research questions, namely themes related to "Implementation Prospects" and "Implementation Challenges" (Miles et al., 2020).

To ensure the validity of the data and findings in this qualitative literature study, several testing techniques were applied. First, credibility was maintained through triangulation of data sources, namely by comparing and checking the consistency of information obtained from various sources (journals, books, reports) and from different researchers or institutions. Second, dependability or reliability of the research process was maintained by conducting an audit trail, namely documenting in detail and systematically the entire research process, from search keywords, databases used, inclusion and exclusion criteria, to coding and analytical decision-making (Miles et al., 2020). Third, confirmability or objectivity was enhanced through the practice of reflexivity, in which researchers critically reflect on their subjective positions and assumptions regarding the research topic and strive to present evidence from both supporting and contradictory literature in a balanced manner in the final report. Fourth, transferability was not the primary goal in analytical research such as this, but research findings could be transferred contextually through rich description (Creswell & Creswell, 2023).

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RESULTS AND DISCUSSION

a. Prospects for the Application of Industrial-Scale Fermented Feed to Support the Efficiency of Modern Broiler Production

The prospect of implementing fermented feed on an industrial scale in modern broiler farming systems is very promising, especially when viewed from the perspective of improving overall production efficiency. The fermentation process, which involves the activity of microorganisms such as lactic acid bacteria, yeast, or mold, naturally changes the chemical structure of feed ingredients, resulting in systemic positive impacts. Literature reviews indicate that this transformation not only enhances the nutritional value of locally sourced ingredients , which are often difficult to digest, but also creates new bioactive compounds beneficial for poultry health (Ricke et al., 2020). Therefore, the integration of standardized fermentation technology into commercial feed production is seen as a strategic innovation leap to address efficiency and sustainability challenges.

One of the key prospects identified is improving nutrient digestibility and feed conversion. The fermentation process plays a role in breaking down complex and anti-nutritional compounds commonly found in plant-based feed ingredients, such as phytic acid in corn and soybean meal, and crude fiber in bran. The enzymatic activity of microbes during fermentation hydrolyzes these bonds, thereby increasing the availability of amino acids, phosphorus, and energy for broilers. A direct impact of this improved digestibility is an improved feed conversion ratio (FCR), meaning each kilogram of body weight is produced using less feed. This efficiency is a key parameter in modern broiler farming, as feed accounts for up to 70% of total production costs (Jinno, 2022). With a lower FCR, farmers can significantly increase profit margins.

Furthermore, increased nutrient availability has direct implications for optimizing broiler growth and production performance. Previous studies consistently show that feeding fermented feed is positively correlated with higher average daily gain (ADG) and more optimal final weight gain. Fermentation microbes also often synthesize additional B-complex vitamins and digestive enzymes during the process, which also support chicken metabolism and growth. This superior production performance is reflected not only in quantitative parameters such as body weight but also in the overall quality of life of the livestock, ultimately boosting business productivity (Mohan, 2023). In a competitive industry, even a slight performance advantage can yield significant market advantages.

At the macro level, the implementation of industrial-scale fermented feed opens up opportunities to reduce dependence on imported feed ingredients and growth-promoting antibiotics. Many countries, including Indonesia, rely heavily on imported corn and soybean meal, whose prices fluctuate and are vulnerable to global market fluctuations. Fermentation allows for broader utilization of non-conventional local raw materials, such as cassava pulp, coconut meal, or other agricultural waste, by increasing their nutritional value to equal or close to that of conventional raw materials. Furthermore, fermented feed serves as a natural alternative to Antibiotic Growth Promoters (AGPs), which are increasingly restricted. Natural antimicrobial compounds (such as bacteriocins) and organic acids produced during fermentation create a healthy intestinal environment, inhibit pathogens, and promote growth, thereby replacing the function of AGPs (Khalid, 2021). This aligns with the global trend toward antibiotic-free and consumer-friendly livestock farming.

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Thus, this prospect opens up opportunities for the development of innovative and locally specific feed products. The industrial scale allows for more intensive research and development (R&D) to formulate fermented feed products tailored to geographic conditions, local raw material availability , and the genetic needs of specific broilers. Feed companies can develop specialized product lines, such as starter-phase fermented feed for early gut health, or feed with specific locally dominant raw materials such as fermented tofu dregs and rice bran. This innovation not only creates product differentiation in the market but also strengthens national feed security by relying on domestic resources (Sutardi, 2020). The development of these locally specific products is a strategic step towards the independence and sustainability of the broiler livestock industry.

b. Physiological and Health Responses of Broilers to Industrial-Scale Fermented Feed

The physiological and health responses of broilers to fermented feed supplementation are the scientific foundation for all the promised benefits. The most fundamental impact occurs in the digestive tract, which is the primary organ for the body's defenses and nutrient absorption. Fermented feed has been shown to have a significant positive impact on gut health, microbiota populations, and the immune system. Live probiotic microbes that may still be present in fermented feed (if not subjected to high-temperature pelleting) can colonize the intestine, while their metabolites, such as organic acids (especially lactic, acetic, and butyric acids), lower intestinal pH. This acidic environment is unfavorable for pathogenic bacteria such as Salmonella sp. and Escherichia coli. Furthermore, the bioactive compounds in fermented feed act as prebiotics, providing substrates for beneficial bacteria (e.g., Lactobacillus and Bifidobacterium) to multiply , thus rebalancing the gut microbiota toward a healthier and more balanced composition (Ricke et al., 2020). A healthy microbiota directly stimulates the development of the mucosal immune system in the intestinal wall (Gut-Associated Lymphoid Tissue/GALT), increases the production of secretory immunoglobulin A (IgA), and strengthens the non-specific defenses of broilers.

A logical consequence of a healthy gut and a balanced microbiota is a reduced incidence of digestive diseases and drug use. Diseases such as necrotic enteritis, colibacillosis, and diarrhea are often triggered by microbiota imbalance (dysbiosis) and pathogen dominance. By reducing the pathogen load in the gut due to an unfavorable environment and competition from beneficial bacteria, the risk of digestive disease outbreaks can be significantly reduced. Data from various studies show that broiler groups fed fermented feed have a lower incidence of diarrhea and mortality. This reduced reliance on therapeutic antibiotics is crucial, not only reducing antibiotic residues in meat but also slowing the rate of emergence of antimicrobial resistance, a global threat to animal and human health (Khalid, 2021). This practice also reduces production costs associated with treatment.

The internal advantages created by an optimal digestive tract and a healthy body are manifested in the final product, namely carcass and meat quality, which are a manifestation of the end product's superiority. Well-digested nutrients and efficient metabolism not only produce more meat but also improve its quality. Research shows that broilers fed fermented feed tend to have a higher carcass percentage, with a more optimal distribution of breast meat, a high-value component. Furthermore, there are indications that the fatty acid profile of the meat can improve, for example by increasing the level of unsaturated fatty acids. Equally important, reduced oxidative stress in livestock and minimal chemical/antibiotic residues result in safer meat with the potential for a longer shelf life (Mohan, 2023). In a modern market increasingly concerned with food safety and quality, these attributes are a competitive advantage.

c. Technical and Operational Challenges in Large-Scale Fermented Feed Production and Application

Despite the bright prospects, the transition from laboratory or small-scale applications to industrial scale faces a number of complex technical and operational challenges. The first and most significant challenges are maintaining consistent quality, standardizing processes, and preventing contamination during mass production. The fermentation process is highly dependent on biological conditions, namely the activity of the starter microbes (inoculum). On an industrial scale, ensuring that each fermentation batch has identical microbial composition, activity levels, and environmental conditions (temperature, humidity, aeration) is difficult. Variations in the starting materials (moisture content, natural contaminants) can affect the final product. Cross-contamination from unwanted wild microbes during large-scale production runs also risks spoiling entire feed batches, resulting in significant financial losses. Therefore, strict process control systems, automated bioreactors, and highly rigid standard operating procedure (SOP) protocols are required, which require significant investment and technical expertise (Jinno, 2022).

Once fermented feed is successfully produced, logistical challenges arise, including storage, distribution, and stability. Unlike conventional feed, which is dry and stable, fermented feed generally has a higher moisture content and is a "live" product containing active metabolites. This makes it more susceptible to spoilage, especially if there is continued microbial growth or fungal contamination during storage and transportation. A cold chain or airtight packaging is required to maintain its stability, which significantly increases the cost and complexity of distribution. Furthermore, the shelf life of fermented feed is typically shorter than that of conventional feed, necessitating precise inventory management, with a strict first-in-first-out system to prevent spoilage (Sutardi, 2020). This poses a serious obstacle to distribution to farms located far from the factory.

At the farm level, adapting feeding management systems to modern farms also presents a challenge. Modern broiler housing systems often utilize automatic feeders and mechanical feed conveying systems designed for dry pelleted or crumbled feed. Fermented feed, which may have a wetter, damper, or clumpy texture, can cause problems in these automated systems, such as clogging of feeder lines. Farmers also need to adapt to potentially more frequent feeding frequencies to avoid feed remaining in the cage for too long, which can lead to further fermentation or spoilage. Training for cage operators on the handling, storage, and feeding of fermented feed at the farm level is essential to optimally achieve its benefits (Windria, 2024).

d. Economic Analysis and Feasibility of Industrial Scale Fermented Feed Business

The success of industrial-scale commercialization of fermented feed is ultimately determined by a thorough economic and business feasibility analysis. This analysis begins with an evaluation of production costs, infrastructure, and Return on Investment (ROI). The initial investment required to build or modify a feed mill equipped with fermentation facilities (such as stainless steel tank bioreactors, temperature and pH control systems, and controlled fermentation areas) is substantial. Operational costs also increase, including the purchase of high-quality starter cultures , energy for stirring and temperature control, and the costs of more intensive quality testing. Careful economic calculations must weigh these increased costs against the potential savings from using cheaper local raw materials , improving feed efficiency (FCR), and reducing livestock health costs. Only if the resulting ROI is attractive and the payback period is competitive compared to investments in conventional feed product lines will the industry be willing to allocate funds (Yusdja, 2023).

Another determining factor is market response and farmers' perceptions of commercial fermented feed. Farmers, as end consumers, are inherently rational and highly sensitive to price and measurable results. They need to be convinced that the potential premium price for fermented feed is commensurate with improved performance and reduced treatment costs. Education and field-based proof-of-concept demonstrations are key to shifting the perception from simply "alternative feed" to "superior feed" that delivers real economic value. Furthermore, ease of handling and compatibility with existing farm management systems will significantly influence the adoption of this technology (Windria, 2024). Without widespread acceptance by farmers, market demand will not achieve profitable economies of scale.

Therefore, the sustainability of this business requires an integration strategy with the existing broiler farming supply chain and business model. Vertical integration, where a feed company also has a broiler farming division or partners closely with plasma farmers, can be an effective model. In this model, the implementation of fermented feed can be more closely controlled and monitored, and the benefits of improved performance can be fully enjoyed by the parent company. Another alternative is to build strategic partnerships with local raw material suppliers, such as agricultural cooperatives or agricultural processing plants, to create a stable, high-quality, and competitively priced supply chain for fermented raw materials. In this way, fermented feed becomes not just an additional product, but part of an integrated and sustainable livestock business ecosystem (Yusdja, 2023).

CONCLUSION

The industrial-scale application of fermented feed for modern broiler farms promises significant and multidimensional benefits, but is accompanied by significant implementation challenges. Technically, fermented feed has been scientifically proven to increase production efficiency by improving nutrient digestibility and feed conversion, leading to optimal broiler growth performance. These advantages are further enhanced by positive physiological impacts, particularly on gut health, microbiota balance, and immune system stimulation, ultimately reducing disease incidence and antibiotic use, resulting in superior carcass and meat quality. This prospect also aligns with long-term strategic goals, namely reducing dependence on imported feed ingredients and growth-promoting antibiotics and opening up innovation for locally sourced feed products. However, realizing this potential on an industrial scale faces complex obstacles. The main challenges lie in the technical-operational aspects, namely maintaining consistent quality, product stability, and preventing contamination during mass production, which require sophisticated technology and process control. Logistical aspects, such as storage, distribution, and limited shelf life, add complexity and cost. At the farm level, adaptation of feed management systems is required, which may not be compatible with existing automated facilities.

The results of this research can be implemented through strategic and collaborative actions from various stakeholders. The national feed industry is encouraged to initiate pilot projects by investing in small-scale fermentation facilities equipped with automated control systems, focusing on the development of one or two superior products based on the most abundant local raw materials, such as fermented rice bran or cassava pulp. Partnerships with universities and research institutions need to be strengthened to refine process standardization protocols and field performance trials. The government can encourage adoption through fiscal incentives for investment in fermentation technology, synergize feed self-sufficiency programs with the strengthening of local raw material supply cooperatives , and design massive educational campaigns and demonstration plots (demfarms) to demonstrate the economics of fermented feed to livestock farmers. Livestock associations play a role in disseminating best practices for handling fermented feed and negotiating fair partnerships with feed companies. With these concrete and integrated steps, the prospects for fermented feed can be translated into real, sustainable solutions for increasing the competitiveness and independence of the national broiler industry.

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