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MORALITY BEFORE KNOWLEDGE

Innovation of feed additive for broiler chickens: A combination of ground corn and ginger (*Zingiber officinale*) as an immunostimulator and antivirus agent for avian influenza

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ABSTRACT

Background: Indonesia, with the fourth largest population globally, faces increasing demand for animal protein, particularly from broiler chicken production. However, this industry is challenged by the avian influenza virus, which causes high mortality in both poultry and humans. The virus's hemagglutinin (HA) and neuraminidase (NA) glycoproteins are key to its infectivity. Innovative feed formulations that reduce viral titers while maintaining nutritional value are critical. This study aims to develop an innovative broiler chicken feed combining corn and bioactive compounds from ginger (*Zingiber officinale*) to inhibit avian influenza virus activity and sustain poultry health. **Methods:** This study employed a descriptive-experimental approach to develop an innovative broiler feed made from ground corn and ginger (JAZI) and to evaluate its effects on physiology, immunity, and growth. The work included research trend related, research manufacturing stage, and implementation stage to assess its practical effectiveness in enhancing broiler productivity and resilience against avian influenza. **Findings:** Ginger bioactives demonstrated the ability to inactivate viral particles by penetrating the lipid membrane, reducing HA activity, and preventing hemagglutination. Additionally, ginger supplementation was shown to enhance immune responses through activation of T-helper cells and antibody production, improving broiler performance indicators such as feed conversion ratio (FCR) and overall health. The integration of JAZI feed contributes to reduced antibiotic dependence and promotes sustainable poultry farming practices. **Conclusion:** The JAZI feed innovation provides a natural, safe, and sustainable solution for enhancing broiler immunity against avian influenza through synergistic nutritional and antiviral mechanisms. **Novelty/Originality of this article:** This study introduces JAZI as a dual-function feed innovation that not only supplies essential nutrition but also acts as an immunostimulant and antiviral agent against avian influenza, aligning with the One Health and Sustainable Development Goals (SDGs 15) frameworks.

KEYWORDS: broiler chicken; ginger; avian influenza; feed additive; immunity.

1. Introduction

Indonesia is the country with the fourth largest population in the world, with approximately 284.4 million people in 2025 (Badan Pustaka Statistik, 2025). Given this very large population, the need for animal protein becomes crucial to meet the nutritional intake of the community. Broiler chicken production in Indonesia plays a very important role in fulfilling the community's animal protein demands, especially amid rapid population

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growth and continuously increasing consumption patterns. The high demand for broiler chicken meat also drives the development of the poultry industry in Indonesia, spanning from the provision of chicks and feed to the processing and distribution of the final products. (Raharjo, 2015). Furthermore, the poultry sector supports rural economies by providing employment opportunities, contributing to food security, and promoting technological advancements in breeding and feed formulation. Government policies and private sector investments target enhanced productivity and sustainable practices to ensure the availability and affordability of poultry products. Challenges such as disease control, feed cost fluctuations, and environmental impacts drive ongoing research and innovation within the industry (Sumiati et al., 2025)

Broiler chicken farming faces various challenges, especially the risk of infectious diseases that can disrupt production, one of which is the avian influenza virus. Globally, the WHO has recorded cases of avian influenza in humans in 23 countries from 2003 to 2024 totaling 893 cases with 464 deaths. In Indonesia, cases have been recorded since 2005, with a total of around 200 cases until 2017 spread across 15 provinces and 59 regencies/cities (Kementerian Kesehatan Republik Indonesia, 2024). From that number, the death toll reached 168 people, resulting in a Case Fatality Rate (CFR) of approximately 84% (Kementerian Kesehatan Republik Indonesia, 2024). The spread of these cases shows that transmission still occurs, especially from poultry to humans. The high mortality rate underscores the need for increased vigilance, early detection, and innovation to reduce the impact of avian influenza on broiler chickens, which have the potential to transmit to humans.

The antigenicity of the avian influenza virus is primarily determined by two key transmembrane glycoproteins on its surface: hemagglutinin (HA) and neuraminidase (NA). HA plays a significant role in the virus's ability to bind to host cells and initiate infection, acting as the main target for the host immune system’s neutralizing antibodies. NA contributes by facilitating the release of new viral particles from infected cells, and its antigenic properties also invoke immune responses, though typically to a lesser extent than HA. Together, these glycoproteins undergo antigenic drift, accumulating mutations to evade host immunity, which complicates vaccine design and ongoing disease control (Dey et al., 2023). In parallel, maintaining broiler chickens' health and growth requires properly balanced feed containing essential nutrients such as proteins, fats, carbohydrates, vitamins, minerals, and water. This nutritional support is crucial for ensuring the quality and productivity of broiler chickens, enabling them to withstand infectious challenges while optimizing growth performance. Thus, the interplay between viral antigenicity and poultry nutrition is critical in managing avian influenza outbreaks and sustaining effective poultry production (An & Kong, 2025). Therefore, innovation in feed for broiler chickens infected with avian influenza is needed, with a mechanism to reduce the hemagglutinin (HA) and neuraminidase (NA) titers of the avian influenza virus, thereby inhibiting the virus's ability to attach to and infect host cells, while still maintaining the nutrition of the broiler chickens.

Ginger contains bioactive compounds in the form of phenolic compounds, namely gingerol and shogaol, which have effectiveness as immunostimulators and antiviral agents against avian influenza. These compounds are well-studied for their antioxidant, anti-inflammatory, and antiviral properties, contributing to immune system enhancement and potential inhibition of viral infections, including avian influenza (Ulfah & Mutakin, 2017). Additionally, ginger also has potential as an antiviral agent against avian influenza by penetrating the virus's double lipid membrane, resulting in virus inactivation and prevention of hemagglutination. Studies have shown that compounds in ginger, such as gingerenone A, can inhibit viral replication and interfere with key viral functions, making ginger a promising natural antiviral agent against influenza viruses (Dewi & Subarnas, 2018). This effectiveness can be combined with broiler chicken feed to form an innovation called JAZI (Corn and *Zingiber officinale*) to prevent the avian influenza virus, thus providing benefits in terms of time, labor, and treatment efficiency. This becomes an innovative solution to realize Sustainable Development Goals (SDGs) number 15, which is life on land,

aimed at protecting sustainable terrestrial ecosystems, one of which is the broiler chicken population that is crucial to meeting the nutritional needs of the Indonesian community.

1.1 Zingiber officinale

Ginger (*Zingiber officinale*) is a rhizome plant from the Zingiberaceae family that is widely used as a spice, traditional medicine, and even as an additive in animal feed. Quality ginger has specific characteristics such as fresh rhizomes, no mold, a strong aroma, smooth skin, and few wounds. Furthermore, ginger also feels harder, denser, less porous, and has a bright skin and flesh color depending on the variety. High essential oil content in quality ginger is usually characterized by a sharper aroma and spicier taste, which is related to the high gingerol and shogaol content (Valdez et al., 2023). To maintain its bioactive qualities, ginger can be stored properly at cool, dry temperatures. Microscopically, ginger has an epidermis layer that is then replaced by a periderm, followed by cortex tissue composed of large parenchymal cells with many round to oval starch granules. Within the parenchyma are oil cells and lysigenous oil cavities that contain essential oil, ginger's main active compound. The stele contains amphicribal-type vascular bundles surrounded by sclerenchyma fibers, as well as calcium oxalate crystals as diagnostic structures (Harijati & Mastuti, 2018). In older rhizomes, oil cavities increase in number while starch content decreases.

Based on the provisions of the Regulation of the Minister of Health of the Republic of Indonesia Number 55/Menkes/SK/2000, traditional herbal medicines in Indonesia must meet safety, quality, and efficacy requirements. Therefore, standardization of natural ingredient extracts, including ginger rhizomes, is essential to ensure the safety, effectiveness, and consistency of the quality of the samples used. Extract quality is determined through two groups of parameters: specific and nonspecific parameters (Reubun et al., 2024). Testing the quality of herbal medicines includes determining the level of foreign organic matter and the degree of fineness of the herbal medicines. Meanwhile, evaluation of extract quality includes identification, organoleptic examination, macroscopic and microscopic analysis, determination of water-soluble extract content, ethanol-soluble extract content, drying loss, water content, specific gravity, total ash content, water-soluble ash content, and acid-insoluble ash content. The entire series of quality tests aims to ensure the uniformity and consistency of the efficacy of natural herbal medicines, while also guaranteeing the stability and safety of the extracts so that their use can take place optimally (Departemen Kesehatan Republik Indonesia, 1978)

Organoleptic testing of ginger (*Zingiber officinale*) in animal feed is an important procedure to evaluate sensory characteristics including aroma, color, texture, and overall acceptability of the formulation. This assessment is crucial because ginger's distinctive spicy-aromatic aroma, derived from active compounds such as gingerol and shogaol, can significantly influence animal consumption preferences and the comfort of handling the material by farmers. Research by Efrilia et al. (2024) showed that ginger rhizome crude drug has distinctive organoleptic characteristics, namely a brownish-yellow color, powder form, a distinctive ginger odor, and a spicy taste, which meet the standards for crude drugs. These test results emphasize the importance of organoleptic assessment as part of the evaluation and development process of ginger bioactive enriched animal feed to ensure that the final product is not only effective but also well-accepted by animals and farmers.

1.2 Pharmacokinetic unggas

The digestive system in birds consists of the digestive tract and accessory organs that play a role in the physical and chemical breakdown of food, producing nutrients that are easily absorbed by the walls of the digestive tract. The avian digestive tract begins with the beak, esophagus, crop, proventriculus, gizzard, small intestine, cecum, large intestine, and finally the cloaca, where digestive waste is excreted. These organs mechanically and chemically aid in food digestion. Mechanical digestion occurs in the gizzard, with strong

muscles that grind food, while chemical digestion is supported by enzymes in the proventriculus and small intestine, which break down proteins, carbohydrates, and fats into easily absorbed molecules. Generally, the small intestinal mucosa has villi and microvilli that increase the absorption surface area. This system allows birds to digest food efficiently, despite their tooth structure being different from that of mammals (Jamaluddin, 2020).

The enzymatic and fermentative digestion processes in poultry occur in the small intestine, which plays a role in nutrient transfer. The initial digestive process takes place in the duodenum, where bile from the liver and pancreatic enzymes are transported to the duodenum and supplemented by enzymes produced by the intestine. The jejunum and ileum play a role in absorbing nutrients, amino acids, vitamins, and monosaccharides (Flores et al., 2019). The results of this absorption are transferred into the blood and lymph circulation to be distributed throughout the body. According to Sharifi-Rad et al. (2017), the essential oils contained in ginger herbal medicine can regulate gastric acid secretion, which plays a role in activating pepsinogen into pepsin. Gastric acid and pepsin can break down proteins into simpler compounds such as polypeptides, proteoses, peptones, and peptides. This results in faster nutrient absorption in the proventriculus due to the large amount of pepsin produced. Rapid nutrient absorption can accelerate gastric emptying (Huda et al., 2016).

2. Methods

2.1 Research trend related

This study employs a descriptive-experimental approach aimed at developing an innovative broiler chicken feed named JAZI (Ground Corn and *Zingiber officinale*). The research primarily focuses on exploring the potential of ginger as an immunostimulatory and antiviral agent against the avian influenza virus when combined with ground corn as the primary feed base. The study design involves observing the physiological responses of broiler chickens, including enhanced immune system function and growth performance, following the administration of JAZI feed over a specified period. Subsequently, the research will proceed to field implementation to assess the practical effectiveness of JAZI under real poultry farming conditions. This approach aligns with emerging studies emphasizing the immunomodulatory properties of ginger, its antiviral effects in poultry, and the importance of novel dietary strategies to manage avian influenza while supporting broiler productivity.

This research began by analyzing previous studies related to the theme "Intricacies: Animal Health and Invisible Lifeforms." A strategy was then employed to search various article sources in national and international scientific journals such as PubMed, Google Scholar, and Elsevier to identify relevant topics within the theme. The topic was narrowed by searching for research on the effectiveness of the combination of ground corn and ginger as a feed additive for broiler chickens, using the logical operators "AND" and "OR" with a combination of five keywords: broiler chicken, ginger, avian influenza, feed additive, and immunity. Furthermore, the search was limited to the last 10 years to ensure the novelty and relevance of the referenced research. However, for reference book sources that will be used as standardization for this research, there is no maximum limit of the last 10 years.

2.2 Manufacturing and implementation stage

The main materials used in this study include ground corn (*Zea mays* L.) as an energy source and ginger rhizomes (*Zingiber officinale*). The ginger used was thoroughly washed, thinly sliced, then dried at temperatures not exceeding 60°C to prevent degradation of its bioactive compounds. Once dried, the ginger was ground finely using a mixer or manually. The ground ginger was then mixed with water and pressed to obtain ginger juice. This ginger juice was heated on a pan or oven at approximately 50°C until it formed ginger granules, which were then ground and sieved to produce fine ginger powder. The ginger powder that has been ground is mixed with ground corn using a grinding tool at a ratio of

0.5% -- 1.5% of the total feed weight, as recommended by the study of Al-Khalaifah et al. (2022). The mixing is done manually or using an automatic feed mixer to ensure even distribution of the ginger powder.

Fig 1. JAZI animal feed processing

The implementation phase of the JAZI feed innovation is designed through five main, interconnected steps to ensure its successful implementation in the field. The activity begins with outreach on avian influenza issues and an introduction to the JAZI concept for farmers. This is followed by counseling on improving feed quality. The next stage is the direct application of JAZI supplemental feed to broiler chickens for a period of five weeks to observe the growth and health responses of the livestock. This is followed by regular monitoring. The process concludes with an evaluation phase to assess the overall results and determine the extent to which the JAZI feed innovation is able to improve production quality and broiler chicken resilience to avian influenza attacks.

Fig 2. Implementation of JAZI animal feed

3. Results and Discussion

Currently, in Indonesia, avian influenza remains a major challenge in the poultry industry. This virus is highly contagious and easily spreads through the air, direct contact, and contaminated feed and water (OIE, 2021). Broilers are particularly susceptible to avian influenza because their immune systems are not yet fully developed as a result of their rapid growth. This immature immune system makes them less able to resist viral infections. Infection with avian influenza virus in broilers can lead to a range of severe effects beginning with decreased appetite, which reduces their nutrient intake, and subsequently

stunted growth due to insufficient nutrients required for development. In severe cases, avian influenza causes mass mortality within a short period (Gupta et al., 2022). Co-infections with other pathogens such as E. coli can exacerbate these impacts by weakening immune responses and elevating inflammatory mediators, resulting in more severe clinical signs and higher mortality rates (Zalizar et al., 2022). Furthermore, avian influenza can significantly reduce broiler farmers' incomes due to high chicken mortality rates, increased veterinary and medication costs, and disruptions in market distribution channels. These consequences not only lead to decreased productivity but also pose a substantial threat to the sustainability of farmers' livelihoods and business operations. Economic assessments in Indonesia have shown that avian influenza outbreaks cause sharp declines in poultry production, forcing many smallholder farmers to halt operations temporarily or permanently. Loss of income from poultry often translates into reduced household expenditures on essential needs such as education and daily consumption, thereby affecting overall community welfare.

To prevent avian influenza from attacking and minimize broiler mortality, we offer an innovative solution utilizing natural ingredients with a potential approach: the combination of ground corn and ginger (*Zingiber officinale*) in broiler feed formulations. This innovation focuses on developing chicken feed so that before avian influenza strikes, the metabolite compounds found in ginger are activated. This will provide broiler chickens with protection against the virus and provide additional nutrition for their future health.

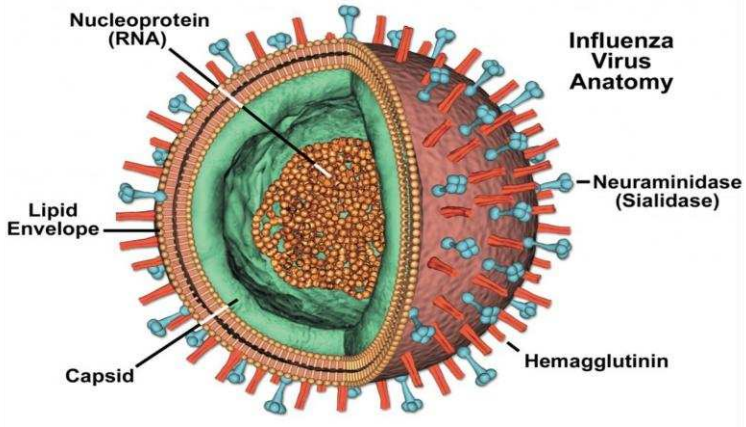
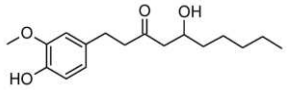
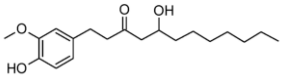
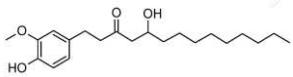
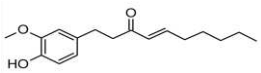


Fig 3. Anatomy of avian influenza virus

Avian influenza is a virus belonging to the Orthomyxoviridae type A family. Based on its virulence level, avian influenza viruses are classified into two categories: Highly Pathogenic Avian Influenza (HPAI), characterized by high morbidity and mortality and the potential to cause epidemics, and Low Pathogenic Avian Influenza (LPAI), which generally causes mild clinical symptoms or even no symptoms in infected birds. The main factors that determine the antigenicity of avian influenza viruses are the transmembrane glycoprotein hemagglutinin (HA), which functions in the process of binding the virus to host cell receptors, and neuraminidase (NA), which has sialidase enzyme activity that is essential for the release of progeny virus particles from the surface of host cells (Rachmawati et al., 2020). Avian influenza antigenicity and virulence factors can help determine appropriate treatment targets for virus spread. Determination of suitable metabolite compounds can be predicted by testing the HA and NA titers of avian influenza viruses. Compounds that are able to degrade the HA and NA of avian influenza viruses can act as immunostimulators for the bodies of broiler chickens (Indarto & Humaidah, 2023). Ginger (*Zingiber officinale*) is an herbal plant containing bioactive compounds such as gingerol and shogaol. The percentages of these active compounds vary depending on where the ginger is sourced. However, the differences are not significant. In research by Sandrasari et al. (2023), the active compound content of ginger extract is as follows.

Table 1. Contents of [6]-,[8]-,[10]-gingerol and [6]-shogaol

Bioactive Compounds	Molecular Formula	Molecular Structure	Content (mg/gextract)
[6]-Gingerol	$C_{17}H_{26}O_4$		88.61 ± 0.52
[8]-Gingerol	$C_{17}H_{26}O_4$		23.58 ± 0.41
[10]-Gingerol	$C_{17}H_{26}O_4$		21.85 ± 0.63
[6]-Shogaol	$C_{17}H_{24}O_3$		9.64 ± 0.51

Gingerols, such as 6-gingerol, 8-gingerol, and 10-gingerol, are the major constituents of fresh ginger. When ginger is dried or stored for long periods, gingerols can transform into 6-shogaol, which is more heat-stable and has stronger bioactive potential (Kim et al., 2024). Studies show that the use of ginger as a feed additive in livestock, even with increased shogaol content, is safe and actually provides positive effects such as improved growth performance, feed efficiency, and immune system stimulation. No significant toxic effects were found within normal usage limits, indicating that changes in the bioactive compound variation are not harmful. Thus, this structural variation actually enriches ginger's pharmacological effects, making it a beneficial supplement in livestock feed (Semwal et al., 2015).

The gingerol compounds found in ginger extract have been proven to possess immunostimulatory effects. In the study by Megawati (2023), antibody titer tests in rabbits showed that the immunostimulatory activity of ginger extract produced highly significant results compared to the negative control using 1% Na-CMC, confirming ginger's ability to enhance the immune response. However, this immunostimulatory activity was not significantly different from the positive control using Levamisole suspension at 25 mg/kg body weight, which is a standard immunostimulant. This indicates that ginger extract has a potential comparable to conventional immunostimulant agents and can therefore be used as a natural alternative for modulating the immune system, especially as an effective and possibly safer immunostimulatory agent for strengthening the body's immune response.

The immunostimulatory effect of gingerol compounds in ginger extract plays a crucial role in enhancing the activity and function of the immune system in broiler chickens by stimulating key components of their immune system (Handayani et al., 2022). Gingerol increases the activity of T helper (Th) cells, especially the Th2 subtype, which acts as the main regulator in stimulating and enhancing B cell function to produce antibodies. When Th2 activity increases, these cells release various cytokines such as interleukin-4 (IL-4), interleukin-5 (IL-5), and interleukin-13 (IL-13), which stimulate the proliferation and differentiation of B cells into plasma cells that produce antibodies. Increased antibody production strengthens the body's defense mechanisms against infections, especially those caused by extracellular pathogens (Jafarzadeh et al., 2021). In broiler chickens, this increase in antibody production is crucial because antibodies play a role in recognizing and binding to infection-causing antigens, which are often sources of disease in intensive rearing systems. The complex interaction between antigens and antibodies indicates an effective humoral immune response stimulation, providing better protection against pathogens. Therefore, ginger extract can trigger and enhance the humoral immune response in broiler chickens, making it a potential natural alternative to improve poultry immune resilience against infections and reduce reliance on antibiotics, simultaneously supporting sustainable production quality and animal health (Megawati, 2023).

Besides that, ginger extract also shows antiviral effects against avian influenza. This is evident from the research by Dewi & Subarnas (2018), which used the hemagglutinin (HA) titer test showing that the control in chicken embryos had low HA values. The HA titer test

measures hemagglutination or blood clotting caused by antigen-antibody interaction in the positive control embryos infected with the virus without antiviral treatment (Perkasa et al., 2016). In the HA titer test, hemagglutination occurs when the virus binds to erythrocytes, forming a hemagglutinin complex. If an antiviral active compound is present in the sample, it works by penetrating the viral double lipid membrane, inactivating the virus and preventing hemagglutination. This aligns with the mechanism of gingerol, which can interact with viral lipids before the virus enters cells, thereby enhancing natural killer cell activity in lysing the virus (Dewi & Subarnas, 2018).

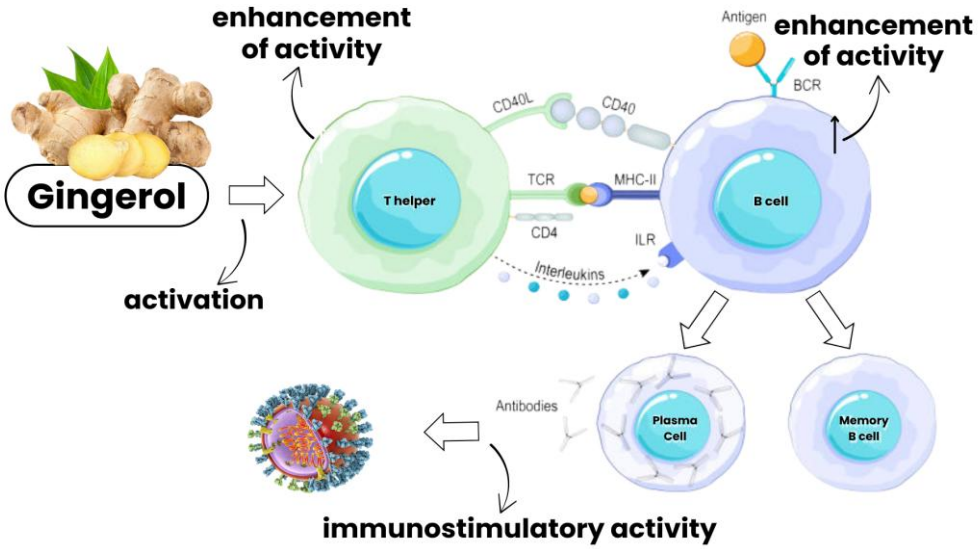


Fig 4. Immunostimulant activity of gingerol against avian influenza antigen

JAZI animal feed, an innovative product combining ground corn and ginger extract (*Zingiber officinale*), is designed to improve the quality and efficiency of broiler chicken farming with several advantages. First, it prioritizes disease prevention over treatment, promoting healthier chickens from the start without relying on antibiotics or chemical drugs. Second, by using natural ingredients, JAZI feed leaves no harmful residues in the chickens or their environment, complying with WHO safety standards (2017), making it safer for consumers and farmers. Third, the corn-ginger formulation facilitates easier feed mixing and optimizes production costs, enhancing economic efficiency in farming. Fourth, the bioactive compounds in ginger strengthen the immune system, improve growth performance, and reduce disease risk. Lastly, JAZI feed contributes significantly to environmental benefits by reducing harmful gas emissions such as ammonia (NH_3) and carbon dioxide (CO_2) from chicken waste, promoting a cleaner and more sustainable farming environment (Riaz et al., 2024). Therefore, JAZI feed not only boosts the health and productivity of broiler chickens but also supports food safety, cost efficiency, and integrated environmental conservation.

3.1 Pathophysiological consequences and food safety risks resulting from improper antibiotic management in broiler chicken production

3.1.1 Risk of accelerating pathogen resistance and antibiotic administration risks without proper knowledge of dosage-method

These ideas are important to realize sustainable feed in facing the negative impacts of antibiotic use in broiler chickens. Antibiotics are indeed therapeutic and metaphylactic/prophylactic agents for microbes in broiler farming (Sattar et al., 2023). However, the negative impacts of antibiotic use extend beyond pathogen resistance and immune system disorders to include biological disruptions. Unwise use of antibiotics,

particularly in inappropriate doses or given without clear indications, can accelerate the emergence of resistance in pathogens. Antimicrobial resistance occurs when microorganisms such as bacteria or fungi develop the ability to withstand exposure to previously effective antibiotics. This is a serious problem because it causes infections that are difficult to treat, requiring stronger, more expensive treatments, and potentially causing more severe side effects. In the livestock context, this resistance can also be transmitted to humans through the food chain, the environment, or direct contact, posing a threat to global public health (Nurbiyanti et al., 2022).

Lack of knowledge about the correct dosage and administration methods for antibiotics can lead to ineffective or even dangerous drug use. Antibiotics given in doses that are too low may not be able to completely kill bacteria, while doses that are too high can cause toxicity and side effects in animals. Furthermore, incorrect administration methods—such as mixing them with inappropriate feed or drinking water—can cause an imbalance in drug concentrations in the animal's body. This not only reduces the effectiveness of treatment but also increases the likelihood of the emergence of antibiotic-resistant bacterial strains (Sumambang et al., 2019).

Furthermore, long-term antibiotic use can negatively impact the immune system. Antibiotics not only kill pathogenic bacteria but can also disrupt the balance of beneficial microorganisms that play a vital role in maintaining the body's resistance. As a result, the immune system becomes less responsive to natural infections due to its dependence on the drugs. In the long term, this condition makes animals more susceptible to new diseases and slows the recovery process. Therefore, antibiotic use should be balanced with strategies to boost natural immunity, such as providing a balanced diet or natural ingredients with immunostimulant effects (Ramanda & Agustina, 2024).

3.1.2 Causes dysbacteriosis, disease, or secondary infection and residues in poultry products

Another impact of inappropriate antibiotic use is dysbacteriosis, a disruption of the normal microflora balance in the digestive tract. Antibiotics work without distinguishing between good and bad bacteria, thus killing beneficial bacteria as well. This imbalance can lead to digestive disorders, decreased nutrient absorption, and an increased risk of secondary infections due to the growth of opportunistic microorganisms. In some cases, this condition can worsen animal health and reduce productivity. Therefore, monitoring antibiotic use and maintaining a balanced microbiota is crucial (Ramanda & Agustina, 2024).

The use of antibiotics in poultry also poses a risk of residues in products such as meat and eggs. These residues can occur if the drug withdrawal period is not observed before the product is consumed or marketed. Antibiotics in food can have negative impacts on consumers, such as causing allergic reactions, disrupting the gut microbiota, and accelerating the spread of antibiotic resistance in humans. Furthermore, the presence of antibiotic residues in poultry products also raises concerns about food safety and can undermine consumer confidence in livestock products. Therefore, implementing good livestock practices and strict monitoring of antibiotic use are crucial steps in ensuring food safety (Ramanda & Agustina, 2024).

3.2 JAZI innovation: Processing techniques and nutritional benefits of bioactive corn-ginger feed

JAZI (Ground Corn and *Zingiber officinale*) animal feed processing is the material that will be demonstrated in JAZI classes or mentoring programs. It is relatively easy to implement, both on a small and large scale. The processing process begins with drying the ginger, then grinding it into a powder and mixing it directly into the ground corn, either using an automatic feed mixer or manually by hand stirring. This mixing process ensures an even distribution of ginger in the feed so that each chicken receives the same benefits from ginger's bioactive content. Ginger, as a natural feed additive, can improve chicken health,

strengthen the immune system, and potentially reduce the use of synthetic antibiotics in aquaculture.

Research by Al-Khalaifah et al. (2022) demonstrated that supplementing broiler chicken feed with ginger powder at levels between 0.5% and 1.5% significantly improves growth performance and feed utilization. The studies showed enhanced body weight gain and reduced total feed consumption at these supplementation levels, indicating better feed efficiency and nutrient absorption. This improvement in gut health is attributed to ginger's ability to promote digestive enzyme activity and maintain a balanced gut microbiota, which enhances nutrient digestibility and utilization. In addition to growth benefits, ginger supplementation positively affects the immune system by increasing white blood cell counts and stabilizing physiological parameters, thereby improving the chickens' overall health and disease resistance (Olivia et al., 2017). These combined effects make ginger a valuable natural additive to corn-based broiler feeds, offering improved productivity and health with potential reductions in reliance on antibiotics. The JAZI (Ground Corn and *Zingiber officinale*) livestock feed innovation can be implemented by broiler farmers to upgrade their feed with better quality, nutrition, and quality compared to conventional livestock feed. This implementation will progress through several stages for broiler farmers.

3.2.1 Socialization about avian influenza issues, JAZI efforts, and extension regarding upgrading animal feed

The rationale behind this activity is the importance of raising awareness among broiler farmers about the dangers of the Avian Influenza (AI) virus, which can cause significant economic losses, both through decreased productivity and increased poultry mortality. Many farmers still lack a thorough understanding of the mechanisms of AI virus transmission and effective preventative measures. Therefore, this outreach program aims to provide a comprehensive understanding of the characteristics of the AI virus, risk factors for transmission, and preventative strategies that can be implemented through the innovative JAZI (Ground Corn and *Zingiber officinale*) feed. This will provide farmers with a strong knowledge base to support concrete actions to suppress potential AI outbreaks in their farms.

After understanding the urgency of the Avian Influenza problem, the activity continued with counseling on improving animal feed quality through the JAZI feed innovation. The premise of this stage is that feed plays a crucial role in supporting the chicken's immune system, so the right feed can help prevent viral infections. In this session, farmers were given complete instructions on making JAZI feed, from preparing raw materials such as ground corn and ginger (*Zingiber officinale*), mixing them in the appropriate proportions, to storage techniques and how to feed them to broilers. The counseling also included classroom activities or practical mentoring so farmers could directly practice making the feed. Thus, this activity did not stop at providing information, but encouraged real-world implementation.

3.2.2 Application of JAZI animal feed, monitoring, and evaluation

This phase is a follow-up to the outreach program, focusing on the direct application of JAZI feed in broiler farms. Farmers are expected to begin replacing or combining some conventional feed with JAZI feed as the initial implementation step. Feeding is carried out routinely according to the recommended schedule to ensure optimal results. The JAZI feed innovation not only aims to improve chicken health through the immunostimulant bioactive gingerol content in ginger but also supports chicken growth naturally without the use of synthetic antibiotics. This implementation is clear evidence of changes in farmer behavior in implementing the concept of preventive feeding, namely preventing disease through proper nutrition.

Furthermore, monitoring is a crucial step after JAZI feed is introduced to ensure successful implementation in the field. Routine monitoring is conducted to monitor the

broiler chickens' condition, including appetite, body weight gain, and health signs such as diarrhea or avian influenza symptoms. Furthermore, farmers are taught how to keep simple records of daily observations so that the data can be systematically analyzed. The primary objective of this monitoring is to evaluate the effectiveness of JAZI feed in improving livestock performance and chickens' resistance to disease. Monitoring results serve as the basis for corrective action if any obstacles are encountered during implementation.

In addition, the evaluation phase was conducted after 3–5 weeks of monitoring to assess the overall success of the JAZI feed innovation. The evaluation was conducted by measuring several broiler performance parameters, including Feed Conversion Ratio (FCR), daily weight gain, and immune indicators such as disease resistance. Reduced mortality rates, increased chicken vitality, and improved meat quality are additional indicators of the successful implementation of JAZI feed. Furthermore, this evaluation also serves as a reflection for farmers to assess the effectiveness of the innovation and consider the sustainability of its long-term use. The evaluation results are expected to strengthen the evidence that JAZI feed is a natural, economical, and sustainable solution for preventing Avian Influenza and increasing poultry productivity.

3.3 Involvement of strategic stakeholders for sustainable implementation of JAZI innovation

The implementation of JAZI's animal feed innovation will thrive if supported by key stakeholders who will ensure its sustainability. Stakeholders are individuals or groups who have an interest in and are influenced by the outcomes of implementation decisions. The successful adoption and ongoing growth of JAZI's animal feed innovation depend on the active engagement and collaboration of these groups, as they play critical roles in supporting, facilitating, and sustaining the innovation within the animal feed industry. Stakeholders supporting the implementation of JAZI's animal feed include as follows.

3.3.1 Broiler farmers, corn, ginger, and supplier agents

Broiler farmers and supply agents are primary stakeholders in this program because they directly implement policies related to the development and implementation of the JAZI (Ground Corn and *Zingiber officinale*) feed innovation. They are the parties most impacted and most influential in the program's success, given that broiler chicken farming activities depend on the quality and efficiency of the feed used. Through the active involvement of farmers and supply agents, JAZI innovations can be widely and sustainably implemented in the field. Furthermore, they are also a crucial source of feedback for evaluating the program's success, particularly in terms of increasing productivity, cost efficiency, and controlling diseases such as Avian Influenza.

Corn and ginger suppliers act as key facilitators supporting the availability of raw materials for JAZI feed production. They contribute to ensuring a continuous supply of high-quality ingredients, ensuring the smooth flow of feed production. Ground corn serves as the primary energy source for broiler chickens, while ginger (*Zingiber officinale*) acts as a bioactive ingredient that boosts their immune system. Collaboration with raw material suppliers is also crucial to ensure that the ingredients used are free from contaminants and produced sustainably. Therefore, corn and ginger suppliers serve not only as ingredient providers but also as strategic partners in maintaining the sustainability of JAZI feed innovation.

3.3.2 Department of animal husbandry and animal health

The Department of Animal Husbandry and Animal Health is a key stakeholder, acting as a policy creator. This institution plays a role in formulating, directing, and overseeing policies that support the development and implementation of natural feed innovations such as JAZI. Through regulations, training, and technical assistance, the department ensures that alternative feed implementation complies with animal safety and health standards.

Furthermore, the Department of Animal Husbandry also provides certification, monitors livestock health, and facilitates inter-agency collaboration to support food security programs. With strong policy support, JAZI innovations can develop into part of a sustainable national livestock system.

3.3.3 Business and public figures

Business leaders act as facilitators in the business world, helping expand the reach and sustainability of JAZI programs, both in terms of investment and market development. They are influential in connecting livestock innovations with the commercial sector, such as feed distribution, packaging, and marketing of poultry products. Support from business leaders can also help create a strong value chain, from raw material production to marketing of livestock products. With their involvement, JAZI feed innovations not only provide technical solutions for farmers but also have the potential to become profitable and sustainable business models in the long term.

Public figures are accelerator stakeholders who play a crucial role in accelerating the implementation and acceptance of the program at the local level. They serve as social mobilizers who can motivate, educate, and encourage local communities to actively participate in the JAZI program. Support from community leaders—such as village leaders, heads of farmer groups, or influential residents—will strengthen the program's legitimacy and increase public trust. Furthermore, they also play a role in maintaining smooth communication between program implementers and the community so that goals and objectives can be effectively achieved. With strong collaboration between community leaders and other stakeholders, the JAZI feed development program can run more quickly, be more targeted, and have a real impact on the welfare of local farmers.

4. Conclusions

This section presents the main conclusions of the study. The development of the JAZI feed innovation, combining ground corn and bioactive compounds from ginger (*Zingiber officinale*), offers a comprehensive and effective strategy to address the challenge of avian influenza in broiler chickens in Indonesia. The immunostimulatory and antiviral properties of ginger's compounds, such as gingerol and shogaol, enhance poultry immunity and inhibit viral activity, leading to improved feed quality and the activation of protective mechanisms within the birds. Moreover, JAZI's implementation supports the reduction of synthetic antibiotics, thereby lowering risks of resistance and side effects, which aligns with sustainable livestock practices. The structured approach to dissemination through socialization, mentoring, monitoring, and evaluation ensures the feasibility and sustainability of JAZI adoption by broiler farmers. This study contributes original insight into integrating natural bioactive compounds in animal feed to control viral diseases, presenting a practical, economical, and environmentally sound solution that can positively impact public health and poultry productivity in Indonesia.

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