Research Article

Effect of Corn Fermented with *Saccharomyces cerevisiae* on Growth Performance, Carcass Traits, and Serum Blood Parameters of Ducks

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Abstract | This study evaluated the effects of corn fermented with *Saccharomyces cerevisiae* (*S. cerevisiae*) in the diet on growth performance, carcass traits and serum blood profiles of ducks. The study was conducted using a completely randomized design with four treatments and four replications, involving different levels of replacement of corn with fermented corn (FC) in the diet (0, 15, 30, and 45%), designated as FC1, FC2, FC3, and FC4, respectively. A total of 96 ducks were allotted to the treatments. The birds were provided feed and water *ad libitum*. The results showed that the addition of fermented corn had a positive effect on body weight, daily weight gain and it also improved the feed intake and feed conversion ratio in the FC4. In terms of carcass characteristics, the weights of the breast and thighs in FC4 increased significantly, with the maximum breast weight reaching 277.8 g ($P<0.05$). Nonetheless, the study showed no significant variations in immune organ indices ($P>0.05$). Moreover, blood biochemical indicators did not exhibit considerable changes ($P>0.05$). It can be concluded that the use of fermented corn in the diet contributes to improving growth performance in ducks without any negative effects on their health.

Keywords | Fermented corn, *Saccharomyces cerevisiae,* Growth, Health, Duck

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INTRODUCTION

Duck farming is an important sector in agriculture providing essential food sources such as meat and eggs (Pham *et al.*, 2022; Santoso *et al.*, 2023), while also generating stable income for farmers, especially in rural areas. Due to their ability to adapt well to various environments and farming systems, ducks are commonly raised in many countries, including Vietnam. However, the performance of duck farming is still greatly influenced by nutritional factors and local farming practices (Linh *et al.*, 2022). In livestock farming, feed plays a key role in determining the productivity and carcass quality of ducks. Traditional ingredients such as corn, rice, and agricultural by-products are often used, but the cost is increasing and the nutritional efficiency is limited. The enhancement of feed sources through feed fermentation is receiving more focus. Fermented feed enhances nutritional quality and feed efficiency while reducing agricultural by-products (Lee *et al.*, 2023). The fermentation process enhances nutritional value, reduces costs, and decreases the ecological footprint of feed (Predescu *et al.*, 2024), thus fostering the efficiency of sustainable animal husbandry. *Saccharomyces cerevisiae (S. cerevisiae)* is a microbial yeast frequently utilized in the fermentation of feed, owing to its capacity to enhance nutritional value and feed quality (Parapouli *et al.*, 2020). Fermentation with *S. cerevisiae* enhances protein content, essential amino acids, and enzymes, while reducing anti-nutritional compounds, thereby improving the digestibility and absorption of poultry feed (Predescu *et al.*, 2024). Furthermore, studies have confirmed that fermentation reduces mycotoxins in animal feed, enhances the nutritional value of fermented feed ingredients, and improves the digestibility of various nutrients such as organic matter, nitrogen, amino acids and minerals, in addition to increasing economic efficiency when used in animal diets (Hamza and Hammod, 2023; Mukandungutse *et al*., 2019; Zhang *et al*., 2022). In particular, the use of fermented corn is also believed to increase nutritional value, produce beneficial metabolites such as lactic acid and vitamins, help support intestinal health and enhance animal resistance. Previous studies have noted that the use of fermented corn in duck diets can significantly improve growth rate, feed conversion ratio and carcass quality (Hamza and Hammod, 2023; Predescu *et al*., 2024). In addition, the use of fermented corn also helps increase growth performance, improve blood parameters and improve egg quality for poultry (Yang *et al*., 2022).

As the duck farming industry seeks sustainable nutritional solutions, the research and application of *S. cerevisiae*-fermented corn has become increasingly essential. This study aims to evaluate the impact of *S. cerevisiae*-fermented corn on growth, carcass quality and health of ducks to identify appropriate methods for its utilization, thereby enhancing growth performance and health of ducks under farming conditions in Vietnam.

MATERIALS AND METHODS

Location and time

The experiment was conducted in Ben Tre Province from September 2024 to December 2024. The experiment followed the standard procedures established by Tra Vinh University. All activities complied with local laws in Animal Science and Veterinary Medicine concerning animal health and welfare, and the study was approved by the Science and Training Council of Tra Vinh University (No: 142/2024/HD.HDKH&DT-DHTV).

Fermentation of corn by *S. cerevisiae*

Corn fermentation was carried out in three main steps. In the first step, liquid waste from the alcohol production process was prepared and used as the fermentation medium. In the second step, 15 g of *Saccharomyces cerevisiae* was added to 1 kg of the liquid waste, followed by the addition of 1 kg of corn. The mixture was then maintained under constant conditions and allowed to ferment for 24 hours. In the third step, the fermented corn was incorporated into feed formulations at different inclusion levels, resulting in four dietary treatments (FC1, FC2, FC3, and FC4) (Figure 1).

Feed and experimental design

The trial involved 96 Hoa Lan ducks, a native breed in Vietnam, aged 3 to 10 weeks. It was conducted in Mo Cay Bac district, Ben Tre province, using a completely randomized design. The ducks were divided into four treatments, each with four replications, and each experimental unit consisted of six weight-balanced ducks. The experimental method was a completely randomized design, with cages raised 0.2 meters off the ground to ensure cleanliness and minimize the risk of disease spread. The ducks were raised based on an elaborate breeding and rearing method, including full vaccination programs against diseases for the maintenance of the health status of the flock. This method was devised to enhance the efficiency of the experiment in obtaining accurate results with regard to growth and productivity parameters in ducks. The diets contained ingredients such as corn, broken rice, bran, fish meal, soybeans, dicalcium phosphate (DCP), salt, and a vitamin-mineral premix to ensure that the ducks received adequate nutrition during the study period. Table 1 presents the feed formulation, which was carefully designed to meet the nutritional requirements for ducks while maintaining uniformity among treatments. The experimental meals were formulated to maintain uniform nutritional content while varying in the degree of fermented corn addition. Fermented corn was produced through the fermentation process utilizing *S. cerevisiae*, which enhances nutritional content and improves digestibility. The four treatmentswere administered as follows:

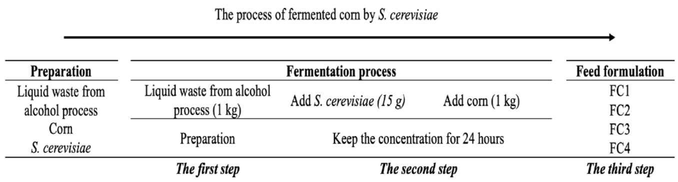

Figure 1: The fermentation process of corn using *S. cerevisiae.*

Table 1: Feed formulation of the experiment.

Ingredients	Treatments			
	FC1	FC2	FC3	FC4
Corn	33	26	20.6	12
Broken rice	15	21	24.8	30
Rice bran	29.8	25.3	23	20.6
Soybean meal	15	15.5	14.3	12.5
Fish meal	5	4	4	4
Vitamin-Mineral premix	0.3	0.3	0.3	0.3
Fermented corn	0	6	11.1	18.7
Salt	0.3	0.3	0.3	0.3
Total	100	100	100	100
CP	17.0	17.0	17.0	17.0
Lys	0.88	0.86	0.84	0.82
Met	0.40	0.44	0.47	0.53
Ca	0.86	0.88	0.93	1.01
P	0.60	0.57	0.57	0.57
ME	3096	3093	3089	3073

Treatment 1 (FC1): The diet consisted solely of ingredients, with no addition of fermented corn; treatment 2 (FC2): 15% of corn was substituted with fermented corn in the diet; treatment 3 (FC3): 30% of corn was substituted with fermented corn in the diet; treatment 4 (FC4): 45% of corn was substituted with fermented corn in the diet.

During the experiment, the disease prevention and vaccination schedule was carried out according to specific time points to ensure the health of the ducks and minimize the risk of disease infection. Ducks were vaccinated against hepatitis at 4 days of age. Vaccination against cholera was administered for the first time at 7 days of age and repeated at 21 days of age.

Growth performance

Initial duck weights were recorded in a logbook, and measured weekly until the end of the experiment. The ducks were weighed individually in each pen on the morning before feeding. Feed intake was measured and recorded daily in the early morning before feeding and again the following morning. Body weight gain was calculated as the difference between final and initial body weight. Feed intake was calculated by subtracting the amount of feed left over from the initial feed given to the birds. Feed intake, and body weight were recorded to calculate the feed conversion ratio.

Slaughter parameters

On the last day of the experiment, ducks were randomly selected and slaughtered (each replicate consisted of one female and one male) to assess carcass characteristics, including the weight of the carcass, breast, and thigh, as well as internal organs such as gizzard, liver, heart, small intestine, and large intestine. Immune organs including thymus, spleen and bursa of Fabricius were also recorded. Ducks were fasted for 6 hours prior to slaughter to prevent meat contamination.

Serum biochemical characteristics

Duck blood was collected from the wing vein. A 2-ml blood sample was collected from each duck and placed into an EDTA anticoagulant tube. The sample was gently shaken and labeled for biochemical analysis. Blood samples were analyzed at the Department of Animal Husbandry and Veterinary Medicine, Tra Vinh using the SMT-120VP analyzer (Chengdu Seamaty Technology Co., Ltd., China). After taking the sample, the blood sample will be put into a centrifuge for 5 minutes to separate the serum. Use a pipette to withdraw 1 ml into a biochemical plate. Put the plate sample into the machine and read the results. Serum blood biochemical indicators recorded during the experiment including total cholesterol (mmol/l), total protein (g/L), albumin (g/L), globulin (g/L), aspartate aminotransferase (AST; U/L), alanine aminotransferase (ALT; U/L), and alkaline phosphatase (ALP; U/L).

Data analysis

Data were initially processed using Microsoft Excel software (2010) and analyzed using analysis of variance (ANOVA) in SPSS software v.21 (SPSS Inc., Chicago, IL, USA). Tukey test was used to compare the mean values of the treatments at 95% confidence level. Mean values were considered statistically significant when $P < 0.05$.

RESULTS

Effect of fermented corn with *Saccharomyces cerevisiae* on growth performance

Table 2 indicates that diets containing fermented corn with *S. cerevisiae* significantly affected the growth performance of ducks ($P<0.05$). The final body weight of ducks significantly increased with the addition of fermented corn, with the FC4 group achieving a significantly higher final weights compared to FC1. Daily weight gain showed a similar pattern, indicating a notable improvement in the FC4 group compared to the FC1 group. Feed intake was significantly reduced in the FC4 group relative to the FC1 group ($P < 0.05$), suggesting that the incorporation of fermented corn may improve feed efficiency. The feed conversion ratio was significantly enhanced ($P < 0.05$), with the FC4 group exhibiting the lowest FCR of 3.742, suggesting that the digestion and absorption of nutrients from the meal enriched with fermented corn were optimized.

Table 2: Growth performance of ducks in the 3-10-week period.

Criteria	Treatments				SEM	P
	FC1	FC2	FC3	FC4		
Initial weight, g/bird	313.1	321.4	329.4	332.4	8.492	0.407
Final weight, g/bird	1986^{b}	2025^{ab}	2071^{a}	2103^{a}	19.26	0.005
Daily weight gain, g/bird/day	34.13^{b}	34.76^{ab}	35.54^{ab}	36.14^{a}	0.463	0.046
Feed intake, g/bird	140.8^{a}	139.5^{ab}	136.9^{ab}	135.1^{b}	1.210	0.025
Feed conversion ratio	4.125^{a}	4.017^{ab}	3.853^{ab}	3.742^{b}	0.087	0.041

$^{a, b}$: Different letters in the same row indicate significant differences at $P<0.05$.

Table 3: Carcass characteristics of ducks at 10 weeks of age.

Criteria	Treatments				SEM	P
	FC1	FC2	FC3	FC4		
Live weight, g	1973[b]	2028[ab]	2071[a]	2103[a]	19.68	0.008
Carcass weight, g	1365[c]	1385[bc]	1435[ab]	1458[a]	13.32	0.004
Carcass percentage %	69.19	68.28	69.28	69.35	0.847	0.790
Breast weight, g	257.0[b]	262.1[ab]	261.5[ab]	277.8[a]	4.403	0.044
Breast percentage, %	18.83	18.92	18.23	19.06	0.304	0.302
Thigh weight, g	195.3[b]	197.0[ab]	200.5[ab]	209.0[a]	2.859	0.039
Thigh percentage, %	14.32	14.23	13.98	14.34	0.284	0.796
Liver weight, g	49.17[b]	49.17[b]	51.17[b]	54.17[a]	0.634	0.002
Heart weight, g	16.43	16.75	16.63	16.90	0.202	0.461
Gizzard weight, g	66.83[b]	66.00[b]	68.00[ab]	74.50[a]	1.615	0.022

[a, b]: Different letters in the same row indicate significant differences at P<0.05.

Effect of fermented corn with *S. cerevisiae* on carcass parameters

As shown in Table 3, live weight and carcass weight were significantly (P<0.05) higher in the groups supplemented with fermented corn, with the highest live weight recorded in the FC4 group (2103 g). In terms of carcass composition, the FC4 group exhibited significant increases in breast and thigh weights when compared to the FC1 group (P<0.05). Notably, the highest recorded breast weight was 277.8 g, suggesting that fermented corn could aid in enhancing the growth of important muscle groups, particularly the pectoral muscle, thereby improving meat quality. However, the percentages of carcass, breast, and thigh were not significantly different among the groups (P > 0.05), indicating that the improvement was mainly related to the increase in total body weight. In addition, liver and gizzard weights increased significantly in the FC4 group, which may be related to the enhancement of digestive function and nutrient metabolism when using fermented corn. These results confirm that the use of fermented corn in the diet provides significant benefits on carcass performance, digestibility, and overall health of ducks.

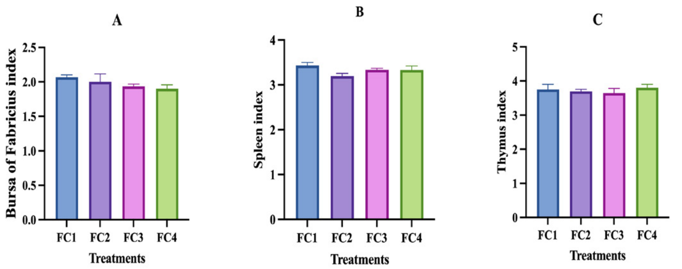

Figure 2: The effect of fermented corn (FC) by *S. cerevisiae* on immune organ indices; A: A non-significant effect of FC by *S. cerevisiae* on Bursa of Fabricius index (P>0.05); B: A non-significant effect of FC by *S. cerevisiae* on Spleen index (P>0.05); C: A non-significant effect of FC by *S. cerevisiae* on Thymus index (P>0.05).

Effects of fermented corn with *S. cerevisiae* on immune organ indices

The supplementation with fermented corn containing *S. cerevisiae* maintained stable immune organ indices (Figure 2), with no significant difference (P > 0.05). The supplementation with fermented corn did not significantly affect the development of Bursa of Fabricius. The FC4 group showed a higher trend in spleen index than the other groups, although the difference was not very obvious (P>0.05). The results of thymus index between the groups were quite similar (P>0.05).

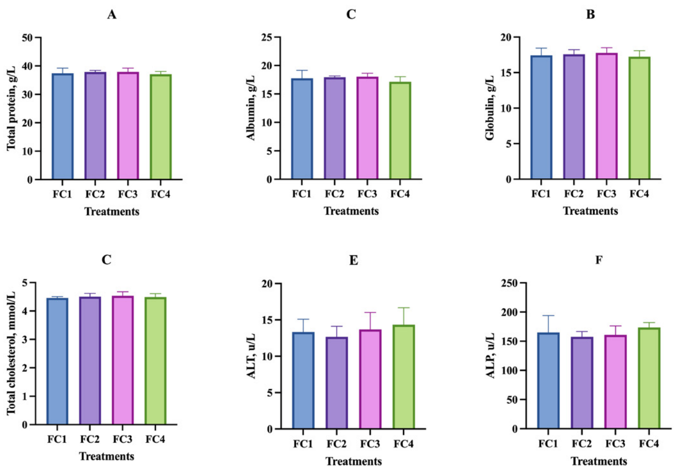

Figure 3: The effect of fermented corn (FC) by *S. cerevisiae* on serum biochemical characteristics; A, B, C, D, E, F: A non-significant effect of FC by *S. cerevisiae* on total protein, albumin, globulin, total cholesterol, ALT and ALP (P>0.05). Noted: The study recorded AST was less than 5 (due to threshold of the machine is < 5).

Effects of fermented corn with *S. cerevisiae* on serum lipid profile

The results of blood biochemical analysis presented indicate that the addition of fermented corn with *S. cerevisiae* to the diet did not affect the hematological parameters of ducks

(Figure 3). In particular, there was no significant difference in total serum protein levels between the treatment groups (P>0.05). Likewise, globulin and albumin levels remained steady, indicating that the nutritional condition and liver function were not adversely impacted. In terms of total cholesterol, the findings indicated no significant difference between the treatment groups (P>0.05). Liver enzyme markers like ALT and ALP also showed no significant changes between the groups. These findings validate the safety and potential benefits of fermented corn as a dietary supplement, supporting not just physiological well-being but also enhancing ducks growth performance.

DISCUSSION

Corn fermented with *S. cerevisiae* has demonstrated enhanced growth performance in poultry, yielding a better average daily weight gain relative to diets without fermented corn. This performance was also observed in research conducted by (Ali, 2019; Linh *et al*., 2020; Qui and Linh, 2023; Zhu *et al*., 2023). Fermentation enhances crude protein levels (Zhang *et al*., 2024), essential amino acids such as lysine and methionine (Stas *et al*., 2022), and the synthesis of digestive enzymes such as amylase (Yang *et al*., 2022) and protease (Li *et al*., 2023), thereby improving poultry's digestion and nutrient absorption efficiency. Additionally, metabolites such as lactic acid and various organic acids produced during fermentation play a role in maintaining the balance of intestinal microbiota, thereby improving digestive health (Li *et al*., 2024) and promoting growth. Previous studies have shown that diets supplemented with fermented corn improve the digestion of difficult feed components such as starch and fiber. Enzymes produced by *S. cerevisiae* during fermentation break down these compounds, improving digestibility for poultry and consequently reducing feed intake (Aktar *et al*., 2024). A study by (Soren *et al*., 2024) indicated that greater growth performance in poultry can be linked to taller villi, which enhance nutrient absorption, increases the release of supportive digestive enzymes, and provides anti-inflammatory effects from *S. cerevisiae*. In addition, substances such as lactic acid and β-glucan in fermented corn not only support the digestive process but also strengthen poultry's immune system (Azrinnahar *et al*., 2021; Qui and Linh, 2023), reduce stress levels and the risk of disease, thereby maintaining good health and improving feed more effectively. Lactic acid generated during fermentation supports stable intestinal pH, preventing the proliferation of harmful bacteria like *E. coli* and *Salmonella* (Sirisopapong *et al*., 2023). β-glucan, another bioactive compound derived from *S. cerevisiae*, activates the innate immune system, enhancing poultry' disease resistance and reducing energy loss due to inflammatory responses (Qui and Linh, 2023; Soren *et al*., 2024). The mechanism by which small peptides produced by fermentation improve villous morphology may be due to the stimulatory role of amino groups and the activity of two peptidases which stimulate the brush border of the small intestinal villi. These mechanisms may increase the number of peptide carriers and decrease intestinal permeability, stimulating and inducing the development and growth of the small intestinal villi, thereby improving the protein utilization rate and promoting the synthesis of body proteins, which may help explain the improvement in average daily weight gain (Wang *et al*., 2019). Dietary supplementation of fermented corn with *S. cerevisiae* can increase carcass weight and breast muscle yield due to its ability to improve protein utilization efficiency and increase lean muscle accumulation. Essential amino acids such as lysine and methionine (Predescu *et al*., 2024), which are increased during fermentation, support muscle protein synthesis, especially in the breast region (Linh *et al*., 2022; Zhai *et al*., 2012). In addition, bioactive compounds such as β-glucan promote overall health, supporting muscles develop optimally (Amer *et al*., 2023). This is related to increased digestive efficiency and energy absorption, providing adequate nutrition for the development of large muscle groups, including the thigh muscles (Qui and Linh, 2023).

The weights of immune organs such as thymus, spleen and Bursa of Fabricius following supplementation of diets with corn fermented with *S. cerevisiae* may be explained by the fermentation process producing bioactive compounds such as β-glucan, mannan-oligosaccharides (Azrinnahar *et al*., 2021; Soren *et al*., 2024), which are known to stimulate the immune system. These substances can activate innate immune receptors located on immune cell surfaces, thus stimulating cytokine production and improving lymphocyte activity. Additionally, these compounds support the development and differentiation of lymphocytes within immune organs, enhancing their function (Amer *et al*., 2023). However, the current study did not observe this change, which may be due to the following reasons. First, the concentration and composition of bioactive compounds in fermented corn, such as β-glucans and mannan-oligosaccharides, may not be large enough or at optimal doses to strongly stimulate the immune system. These substances frequently exhibit immunomodulatory effects by enhancing immune cell activity; nevertheless, if the level of supplementation is minimal, the effect may be limited. Moreover, the capacity to trigger an immune response may vary based on several factors, such as species, breed, age, and overall nutritional status (Wlaźlak *et al*., 2023), resulting in the effectiveness of fermented corn not being definitively proven in the experiment. In several previous studies, *S. cerevisiae* fermented corn not only improved growth performance but also positively affected blood indices, reflecting the physiological health and metabolic state of poultry. Corn fermentation increases the essential amino acid content (Predescu *et al*., 2024; Stas *et al*., 2022), supporting protein synthesis (Zhai *et al*., 2012), especially serum protein. Increased total protein is also associated with improved growth performance and overall health of poultry. Blood glucose levels remain stable or are slightly reduced by digestive enzymes from fermented corn (Li *et al*., 2023). The use of fermented corn in the diet increases serum albumin levels due to the provision of high-quality amino acids from the fermentation process. The balance between albumin and globulin is also improved, reflecting simultaneous support for both nutrition and immunity. This was observed in the study by (Yang *et al*., 2022), when studying the use of fermented corn on blood parameters of laying hens. However, the current study did not find an effect of fermented corn on the blood profiles of meat ducks. This may be explained by the differences in species, rearing environments, nutritional conditions, food, stress, etc., (Kareem *et al*., 2024; Sabater and Forbes, 2015) which may influence blood parameter changes in ducks during the experiment. In addition, this study suggests a potential avenue for further research to evaluate changes in duck blood parameters when supplementing fermented foods.

CONCLUSION

This study demonstrated that supplementing duck diets with *S. cerevisiae*-fermented corn positively influenced growth performance, feed efficiency, carcass quality and blood parameters. Fermented corn enhanced body weight, improved daily weight gain and reduced feed intake, thereby improving feed conversion ratio. Additionally, it promoted the development of major muscle groups, particularly the pectoral muscles, contributing to increasing the value of duck meat. The indices of immune organs and serum blood biochemistry were not adversely impacted, confirming the safety and potential applicability of fermented corn in duck farming. Therefore, *S. cerevisiae*-fermented corn can be considered a valuable nutritional supplement of additional nutrition in duck farming, supporting both growth performance and overall duck health.

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NOVELTY STATEMENT

The fermentation of corn by Saccharomyces cerevisiae may enhance the growth performance of birds This study was among the first to provide information about native ducks in Vietnam

AUTHOR'S CONTRIBUTION

Conceptualization, NTL, and NHQ. Methodology, NHQ, and NTL. Software, NHQ. Validation, NHQ and NTL. Formal analysis, NHQ. Investigation, NTL. Writing original draft preparation, NHQ. Writing review and editing, NHQ, and NTL. Supervision, NHQ and NTL.

Generative AI and AI-assisted technology statement

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

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Aktar J, Islam KMS, Chowdhury R, Debi MR, Emon AI (2024). Effect of baker's yeast fermented moist feed on the growth and bone mineralization in broiler. J. Adv. Vet. Anim. Res., 11: 78–84. https://doi.org/10.5455/javar.2024.k750

Ali JH (2019). Effect of corn fermented by *Saccharomyces cerevisiae* in diets on production performance of broiler chicks. J. Pure Appl. Microbiol., 13: 1025–1030. https://doi.org/10.22207/JPAM.13.2.40

Amer SA, Behairy A, Gouda A, Abdel-Warith A-WA, Younis EM, Roushdy EM, Moustafa AA, Abd-Allah NA, Reda R, Davies SJ (2023). Dietary 1, 3-β-glucans affect growth, breast muscle composition, antioxidant activity, inflammatory response, and economic efficiency in broiler chickens. Life, 13: 751. https://doi.org/10.3390/life13030751

Azrinnahar M, Islam N, Shuvo AAS, Kabir AA, Islam KMS (2021). Effect of feeding fermented (*Saccharomyces cerevisiae*) de-oiled rice bran in broiler growth and bone mineralization. J. Saudi Soc. Agric. Sci., 20: 476–481. https://doi.org/10.1016/j.jssas.2021.05.006

Hamza ZR, Hammod AJ (2023). Evaluate the efficiency of fermented local corn by *Saccharomyces cerevisiae* on the productive performance of broiler. Kufa J. Agri. Sci., 15: 46–60. https://doi.org/10.36077/kjas/2023/v15i1.10276

Kareem DU, Amos AT, Idowu OPA, Bonagurio LP, Idowu OMO (2024). Blood profile as a health indicator in broiler chickens fed diets of different particle sizes supplemented with multienzyme. Agric. Trop. Subtrop., 57: 45–59. https://doi.org/10.2478/ats-2024-0005

Lee S, Ryu CH, Back YC, Lee SD, Kim H (2023). Effect of fermented concentrate on ruminal fermentation, ruminal and fecal microbiome, and growth performance of beef cattle. Animals (Basel), 13: 3622. https://doi.org/10.3390/ani13233622

Li C, Li S, Zhu Y, Chen S, Wang X, Deng X, Liu G, Beckers Y, Cai H (2023). Improving the nutritional value of plant protein sources as poultry feed through solid-state fermentation with a special focus on peanut meal advances and perspectives. Fermentation, 9: 364. https://doi.org/10.3390/fermentation9040364

Li Z, Zhou H, Liu W, Wu H, Li C, Lin F, Yan L, Huang C (2024). Beneficial effects of duck-derived lactic acid bacteria on growth performance and meat quality through modulation of gut histomorphology and intestinal microflora in Muscovy ducks. Poult. Sci., 103: 104195. https://doi.org/10.1016/j.psj.2024.104195

Linh NT, Dong NTK, Thu NV (2022). A survey of Muscovy duck production in rural areas of Tra Vinh Province, Vietnam. J. Indones. Trop. Anim. Agric., 47: 138–145. https://doi.org/10.14710/jitaa.47.2.138-145

Linh NT, Guntoro B, Qui NH, Anh Thu N (2020). Effect of sprouted rough rice on growth performance of local crossbred chickens. Liv. Res. Rural Dev., 32: 156.

Linh NT, Dong NTK, Thu NV (2022). A survey of Muscovy duck production in rural areas of Tra Vinh Province, Vietnam. J. Indonesian Trop. Anim. Agric., 47(2): 138-145. https://doi.org/10.14710/jitaa.47.2.138-145

Mukandungutse B, Tuitoek J, King'ori A, Obonyo M (2019). The effect of fermentation with and without *Saccharomyces cerevisiae* on the levels of aflatoxin in maize. Liv. Res. Rural Dev., 31: 172.

Parapouli M, Vasileiadis A, Afendra AS, Hatziloukas E (2020). *Saccharomyces cerevisiae* and its industrial applications. AIMS Microbiol., 6: 1–31. https://doi.org/10.3934/microbiol.2020001

Pham LD, Do DN, Nam LQ, Van Ba N, Ninh PH, Thuy DP, Son PV, Thieu PC (2022). Evaluation of genetic diversity and population structure in four indigenous duck breeds in Vietnam. Anim. Biotechnol., 33: 1065–1072. https://doi.org/10.1080/10495398.2020.1868485

Predescu NC, Stefan G, Rosu MP, Papuc C (2024). Fermented feed in broiler diets reduces the antinutritional factors, improves productive performances and modulates gut microbiome. A review. Agriculture, 14: 1752. https://doi.org/10.3390/agriculture14101752

Qui NH, Linh NT (2023). Effects of dietary β-glucan and rice fermented on growth performance, fatty acids, and Newcastle disease immune response in turkey broilers. Saudi J. Biol. Sci., 30: 103736. https://doi.org/10.1016/j.sjbs.2023.103736

Sabater M, Forbes N (2015). Avian haematology and biochemistry 2. Biochemistry. Pract., 37: 139–142. https://doi.org/10.1136/inp.g6976

Santoso S, Setiadi A, Prastiwi W (2023). Sustainability performance of indonesian duck farming and the related determinants. Adv. Anim. Vet. Sci., 11: 1176–1182. https://doi.org/10.17582/journal.aavs/2023/11.7.1176.1182

Sirisopapong M, Shimosato T, Okrathok S, Khempaka S (2023). Assessment of lactic acid bacteria isolated from the chicken digestive tract for potential use as poultry probiotics. Anim. Biosci., 36: 1209–1220. https://doi.org/10.5713/ab.22.0455

Soren S, Mandal GP, Mondal S, Pradhan S, Mukherjee J, Banerjee D, Pakhira MC, Amla, Mondal A, Nsereko V, Samanta I (2024). Efficacy of *Saccharomyces cerevisiae* fermentation product and probiotic supplementation on growth performance, gut microflora and immunity of broiler chickens. Animals, 14: 866. https://doi.org/10.3390/ani14060866

Stas EB, Chance JA, Goodband RD, Tokach MD, Woodworth JC, DeRouchey JM, Gebhardt JT (2022). Evaluation of fermented corn protein and its effects in either high or low branch chain amino acid to leucine ratio diets on nursery pig performance and feed intake preference. Trans. Anim. Sci., 6: txac134. https://doi.org/10.1093/tas/txac134

Wang Y, Liu X, Jin L, Wen Q, Zhang Y, Narasimha K, Yan E, Wang C, Zheng Y (2019). Effects of fermented corn gluten meal on growth performance, serum parameters, intestinal morphology, and immunity performance of three-yellow broilers. Can. J. Anim. Sci., 99: 408–417. https://doi.org/10.1139/cjas-2017-0007

Wlaźlak S, Pietrzak E, Biesek J, Dunislawska A (2023). Modulation of the immune system of chickens a key factor in maintaining poultry production. A review. Poult. Sci., 102: 102785. https://doi.org/10.1016/j.psj.2023.102785

Yang R, Khalid A, Khalid F, Ye M, Li Y, Zhan K, Li Y, Liu W, Wang Z (2022). Effect of fermented corn by-products on production performance, blood biochemistry, and egg quality indices of laying hens. J. Anim. Sci., 100: skac130. https://doi.org/10.1093/jas/skac130

Zhai W, Araujo LF, Burgess SC, Cooksey AM, Pendarvis K, Mercier Y, Corzo A (2012). Protein expression in pectoral skeletal muscle of chickens as influenced by dietary methionine1. Poult. Sci., 91: 2548–2555. https://doi.org/10.3382/ps.2012-02213

Zhang AR, Wei M, Yan L, Zhou GL, Li Y, Wang HM, Yang YY, Yin W, Guo JQ, Cai XH, Li JX, Zhou H, Liang YX (2022). Effects of feeding solid-state fermented wheat bran on growth performance and nutrient digestibility in broiler chickens. Poult. Sci., 101: 101402. https://doi.org/10.1016/j.psj.2021.101402

Zhang S, Huang Z, Li Q, Zheng X, Liu J (2024). Two-stage solid-state fermentation to increase the nutrient value of corn processing waste and explore its efficacy as a feed protein source. Food Chem., 23101656. https://doi.org/10.1016/j.fochx.2024.101656

Zhu X, Tao L, Liu H, Yang G (2023). Effects of fermented feed on growth performance, immune organ indices, serum biochemical parameters, cecal odorous compound production, and the microbiota community in broilers. Poult. Sci., 102: 102629. https://doi.org/10.1016/j.psj.2023.102629