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Evaluation of Fermented Pineapple Peel and Fish Meal Blend as a Prebiotic Supplement for Improved Broiler Chick Performance and Health

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ABSTRACT

The increasing demand for poultry products necessitates improved chicken nutrition. Pineapple peel, a waste product, is rich in nutrients but underutilized. This study evaluated the prebiotic potential of fermented pineapple peel and fish meal blend on broiler chick performance and health. The fermenter, *Lactobacillus acidophilus* strain DSN20079 (LADSM), was isolated and characterized using standard microbiological techniques. The effects of the fermented feed on broiler chicks were determined using *in vivo* techniques. The study showed that the test group had significantly higher body weights ($p<0.05$) than the control group from week 2 to week 6. The feed conversion ratio was significantly lower ($p<0.05$) in the test group from week 3 to week 6. Organ weights were not affected by the feed additive. White blood cell count and lymphocyte percentage were significantly higher ($p<0.05$) in the test group. The study demonstrates that pineapple peel and fish meal blend fermented by LADSM has potential as a probiotic feed additive for broiler chicks, improving growth performance and blood indices without adverse effects on organ weights.

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INTRODUCTION

The poultry industry is facing increasing pressure to meet the growing demand for chicken products, necessitating improved nutrition and health strategies for broiler chicks (Adeyemo *et al.*, 2018; Iheukwumere *et al*., 2025a; Dim *et al*., 2025a). Pineapple peel, a waste product, is rich in nutrients, including fiber, carbohydrates, and minerals, making it a valuable resource for animal feed (Okunola *et al.*, 2019; Iheukwumere *et al*., 2022a; and Nwike *et al*., 2017). However, its utilization is limited due to the presence of anti-nutritional factors and low protein content (Awojobi *et al*., 2016). Fermentation has been shown to enhance the nutritional value of pineapple peel, making it a potential feed additive for poultry (Oboh *et al.*, 2012). The use of fermented feed additives has gained attention in recent years due to their potential benefits on animal health and performance (Cani *et al*., 2012; Ekechukwu *et al.*, 2025a; Obianom *et al*., 2024; Dim *et al*., 2025b).

The gut microbiota plays a crucial role in animal health, and modulation of the gut microbiota through dietary interventions has been shown to improve growth performance and immune function (Cani *et al.*, 2012; Iheukwumere *et al*., 2025b, Dim *et al*. 2025c). *Lactobacillus* species are commonly used in fermentation processes due to their ability to produce antimicrobial compounds and enhance the nutritional value of feed ingredients (Million *et al.*, 2012). The inclusion of fermented feed additives in poultry diets has been reported to improve growth performance, immune function, and gut health (Adeyemo *et al*., 2018).

Fish meal is a high-quality protein source commonly used in poultry feed, but its high cost and limited availability have led to the search for alternative protein sources (Okunola *et al.*, 2019). Pineapple peel, when combined with fish meal, could provide a cost-effective and nutritious feed additive for poultry (Awojobi *et al*., 2016; Amadi *et al*., 2017; Ejike *et al*., 2017). However, the prebiotic potential of fermented pineapple peel and fish meal blend in broiler chicks remains unclear, leaving a gap in understanding its effects on growth performance and gut health.

The prebiotic concept, first introduced by Gibson and Roberfroid (1995), refers to the non-digestible fibers that beneficially affect the host by selectively stimulating the growth and activity of beneficial microorganisms in the gut. Prebiotics have been shown to improve gut health, immune function, and growth performance in animals (Cani *et al.*, 2012). The use of prebiotic feed additives,

such as fermented pineapple peel and fish meal blend, could provide a natural and effective way to promote gut health and improve poultry performance (Adeyemo *et al*., 2018). However, further research is needed to understand the effects of fermented pineapple peel and fish meal blend on broiler chick performance and health.

This study aimed to evaluate the prebiotic potential of fermented pineapple peel and fish meal blend on broiler chick performance and health, addressing the research gap in understanding its effects on growth performance and gut health. The study investigated the impact of the fermented feed additive on growth performance, organ weights, feed intake, and hematological indices in broiler chicks. The results of this study will contribute to the existing knowledge on the use of fermented feed feed feed feed feedings in poultry nutrition and provide insights into the potential benefits of pineapple peel and fish meal blend as a prebiotic feed additive.

MATERIALS AND METHODS

Isolation of the Test Sample

The media used for this isolation was de Man Rogosa and Sharpe broth (MRS) (BIOTECH). A 1.0 ml of fermented yoghurt (Aqua yoghurt) and banana extract were aseptically introduced into sterile Petri dishes (90 mm x 15 mm), then 20 ml of MRS which was prepared according to the manufacturers instruction and the procedures described in Cheesbrough (2010), Ekechukwu *et al*. (2025b), Ekesiobi *et al*., (2025), Ezedianafo *et al*., (2025a) was added into the plates, allowed to solidified. The plates were incubated in a microaerophic environment (containing candle used to evacuate all traces of oxygen thereby creating an environment having only carbon IV oxide). The incubation was done for 24 – 48 h at (30 ± 2^0C).

Purification of the Isolates

The plate that showed discrete colonies were selected after 24 - 48 h and each colony was aseptically streaked using a sterile wire loop on a sterile poured plate (90mm x 15mm) containing nutrient agar (BIOTECH) prepared according to the manufacturers description. after which it was incubated at their required growth conditions as described by Iheukwumere *et al*. (2020a), Ezedianafo *et al*. (2025b); Idigo *et al*. (2025a), Iheukwumere *et al*. (2025c).

Characterization of the Bacteria Pure Isolates

The pure isolates were characterized using the morphological, biochemical and molecular characteristics as described by Iheukwumere *et al.* (2017a); Iheukwumere *et al*. (2018a), Ike *et al*. (2025a), Iheukwumere *et al*. (2025d).

Morphological characteristics of the Bacteria isolates

The cultural descriptions (size, appearance, edge, elevation, colour) of the isolates were carried out as described in Goldman and Green (2009); Iheukwumere *et al*. (2017b), Iheukwumere *et al*. (2018b), Iheukwumere *et al*. (2020b). The Gram staining technique which revealed the Gram reaction, cell morphology and cell arrangement were also carried out using the procedure described by Cheesbrough (2010), Goldman and Green (2009) Frank and Robert (2015), Iheukwumere *et al*. (2022b), Iheukwumere *et al*. (2023a). The presence or absence of capsule was also carried out as described by Goldman and Green (2009), Ike *et al*. (2025b), Obiefuna *et al*. (2025a). The presence or absence of flagellum was determined by carrying out motility test as described by Cheesbrough (2010), Iheukwumere *et al*., (2017c), Iheukwumere *et al*. (2018c), Iheukwumere and Iheukwumere (2022a).

Gram staining technique

A thin smear was made in a cleaned grease free microscopic slide (75mm×25mm), air dried heat fixed. The smear was flooded with crystal violet solution (0.2%) for 60 seconds and rinsed with cleaned water. Gram iodine solution (0.01%) was then applied and allowed for 60 seconds. This was rinsed with cleaned water. This was followed by decolourizing the slide content with 95%w/v ethyl alcohol for 10seconds and then rinsed with cleaned water. The smear was then counter stained with safranin solution (0.025%) for 60 seconds, rinsed with cleaned water, blot drained and air dried. The stained smear was covered with a drop of immersion oil and observed under a binocular compound light microscope using × 100 objective lens as described by Iheukwumere *et al*. (2017d); Iheukwumere *et al*. (2020c), Chude *et al*. (2020), Iheukwumere and Iheukwumere (2022b), Iheukwumere *et al*. (2022c).

Motility test: A semi-solid medium prepared by mixing 5.0g of bacteriological agar (BIOTECH) with 2.0g of nutrient broth (BIOTECH) in 1 Litre of distilled water was used. The solution was dissolved and sterilized using autoclaving technique after dispensing 10 ml portion in different test tubes. The test tubes were allowed to set in vertical positions and then inoculate the test organisms by performing a single stab down the centre of the test tube to half the depth of the medium using sterile stabbing needle. The test tubes were kept in an incubator in vertical position at 35 ± 2^0C for 24h (Iheukwumere *et al*., 2017e; Iheukwumere and Iheukwumere, 2022c; Iheukwumere *et al*., 2022d; Idigo *et al*., 2025b).

Biochemical characteristics of the isolates

Indole test: Indole is a nitrogen containing compound formed when the amino acid tryptophan is hydrolyzed by bacteria that have the enzyme tryptophanase. This is detected by using KOVAC's reagent. For this test, isolates were cultured in peptone water in 500.0 ml of deionized water. Ten millilitres of peptone water was dispensed into the test tubes and sterilized. The medium was then inoculated with the isolates and kept in an incubator at 37˚C for 48 hr. Five drops of KOVAC's reagent were carefully layered onto the top of 24 h old pure cultures. The presence of indole was revealed by the development of red layer colouration on the top of the broth cultures as described by Iheukwumere *et al*. (2022e), Iheukwumere and Iheukwumere (2022d), Iheukwumere *et al*. (2023b), Egbe *et al*. (2025a), Ike *et al*. (2025c).

Sugar fermentation test: The capability of the isolates to metabolize some sugars (glucose, xylose, ducitol, maltose, arabinose, inositol, mucate and lactose) with the resulting formation of acid and gas or either were carried out using sugar fermentation test. One litre of 1% (w /v) peptone water was added to 3 mL of 0.2% (w/v) bromocresol purple and 9 ml was dispensed in the test tube that contained inverted Durham tubes. The medium was then sterilized by autoclaving. The sugar solution were prepared at 10% (w/v) and sterilized. One milliliter of the sugar was dispensed aseptically into the test tubes. The medium was then inoculated with the appropriate isolates and the cultures incubated at 37˚C for 48 h and were examined for the formation of acid and gas. Change in colour from purple to yellow indicated acid formation while gas formation was assessed by the presence of bubbles in the inverted (Iheukwumere *et al*., 2022f; Iheukwumere and Iheukwumere, 2022e; Egbe *et al.,* 2025b; Idigo *et al*., 2025c).

Methyl red test: The glucose phosphate broth was prepared according to the manufacturer's direction and the isolates were aseptically inoculated into the sterilized medium. This was incubated at 37˚C for 48 hr. After incubation, five drops of 0.4 % solution of alcoholic methyl red solution was added and mixed thoroughly, and the result was read immediately. Positive tests gave bright red colour while negative tests gave yellow colour (Ezedianafo *et al*., 2025c; Ike *et al*., 2025c).

Voges-Proskauer test: The glucose phosphate broth was prepared in accordance to the manufacturer's direction and the isolates were aseptically inoculated into the sterilized medium. This was incubated at 37˚C for 48hr. After incubation, 1.0 mL of 40% potassium hydroxide (KOH) containing 0.3% Creatine and 3 ml of 5% solution of α-naphthol was add ed in the absolute alcohol. Positive reaction was observed by the development of pink colour within five minutes (Egbe *et al*., 2025b; Ekechukwu *et al*., 2025c).

Citrate utilization test: The Simmon's Citrate Agar was prepare according to the manufacturer's direction and the isolates were inoculated by stabbing directly at the center of the medium in the test tubes and incubated at 37˚C for 48 hr. Positive test was shown by the appearance of growth with blue colour, while negative test showed no growth and the original green colour was retained (Idigo *et al*., 2025d; Ezedianafo *et al*. 2025d).

Catalase test: The test was carried out as described by Cheesbrough (2010). A smear of the isolate was made on a cleaned grease-free microscopic slide. Then, a drop of 30% hydrogen peroxide (H_2O_2) was added on the smear. Prompt effervescence indicated catalase production (Idigo *et al*., 2025e; Idigo *et al*., 2025f).

Oxidase test: The test involved two drops of freshly prepared oxidase reagent dispensed on Whatman No. 1 filter paper which was placed in Petri dish, and a smear of the test isolate was made on the spot using a sterile stick. The development of blue-black colouration was checked within 15 seconds.

Urease test: This was carried out as described by Cheesbrough (2010), Idigo *et al*. (2025g) and Idigo *et al*. (2025h). The urea agar slant was prepared in accordance to the manufacturer's direction and the isolates were aseptically inoculated into sterilized medium. This was incubated at 37^0C for 48 h. After incubation, observation was made for the presence of purple-pink colouration.

Molecular characterization of the isolates

Extraction and purification of DNA: All strains were plated on Nutrient Agar (Biotech) and incubated at 37°C for 24 hr. By means of the procedures of Zymo Research (ZR) DNA miniprepTM kit, bacterial genomic DNA was then extracted and purified (Category No. D6005; Irvine, California, USA) as described by Iheukwumere *et al.* (2018) Iheukwumere *et al*. (2025e; Idigo *et al*., 2025h).

Determination of the quality of extracted DNA: Using mass spectrophotometer (Nanodrop), One micro litre (1µL) was aseptically dropped into a fresh space in the chamber and the chamber was lightly closed which was then linked to a computer system which showed the window that discovered the value of the sample at 260/280nm as described by (Iheukwumere *et al.,* 2018; Iheukwumere *et al*., 2025f; Idigo *et al*., 2025i).

Amplification of DNA and gel electrophoresis of PCR product: This was analysed using Master cycler Nexus Gradient (Eppendorf). A mixture of primer (20 µL), template DNA (20µL), water (72 µL) and master mix (108 µL), which comprises taq polymerase, dimethylsulfoxide (DMSO), magnesium chloride ($MgCl_2$) and nucleotides triphosphates (NdTPs), was made in 1.5 mL tube and homogenized using vortex mixer (Eppendorf). This was then positioned in the block chamber of the master cycler and then programmed. The PCR program for conditions were as follows: initial incubation at 94°C for 5 mins, followed by 35 cycles of denaturation at 94°C for 15 secs, annealing at 55°C for 15 secs, elongation at 72°C for 21 secs and final extension period for 10 mins at 72°C. The amplified products were electrophorezed in 1.0% agarose gel and a1kb DNA ladder was used as a size reference. After staining with 3µL of nucleic acid stain (GR green), the gel was documented with gel documentation apparatus (Iheukwumere *et al.,* 2018; Iheukwumere *et al*., 2025g; Idigo *et al*., 2025j; Idigo *et al*., 2025k).

DNA sequencing of 16s rRNA fragment: The 16S rRNA amplified PCR products generated from universal primer (16S), was used for the sequencing using ABI DNA sequencer (Applied Biosystem Inc) at International Institute of Tropical Agriculture (IITA), Ibadan using the method of Iheukwumere *et al.* (2018), Iheukwumere *et al*., (2025h), and Idigo *et al*. (2025l), Idigo *et al*., (2025m).

Computational Analysis: This was analysed making use of the modified method of Iheukwumere *et al.* (2018), Iheukwumere *et al*. (2025i), Idigo *et al*. (2025n), Iheukwumere *et al*., (2025j). The chromatograms generated from the sequences were cleaned to obtain regions with normal sequences. The cleaned nucleotides were aligned using pair wise alignment tool. The consensus sequences formed by the alignment of the forward and reverse sequences were used to perform the Basic Local *Alignment* Search Tool (BLAST) using National Centre for Biotechnology Information BLAST over the internet. The sequences of the isolates with 95% and above

similarities were accepted. Also the maximum scores, total scores and accession numbers of the isolates were assessed. The relatedness of the isolates was determined by tracing their phylogenetic tree using DNA distance neighbour phylogenetic tree tool.

Preparation of Feed Supplement

Preparation of the pineapple peel

The pineapple peel was properly collected from the appropriate sites, washed and air dried. The material was ground using an electrical blender, packed in 500 ml beaker (PYREX) sealed with aluminium foil and then autoclave at 121^0C for 15 PSI in 15 min.

Fermentation Process

This was carried out using the modified method of Iheukwumere *et al* (2022), Iheukwumere *et al*. (2025k), Iheukwumere *et al*. (2025l). After autoclaving, a 100 g of the sterile sample was weighed into another 250 ml beaker (PYREX) using analytical weighing balance, which was properly sterilized using electric oven at 180^0C for 2 h, This was then inoculated with the fermenter (10 ml) prepared and diluted to a turbidity that matched 0.5 MacFarland standard that was prepared by mixing 0.6mL of 1% $BaCl_2$. $2H_2O$ and 99.4 mL of 1% Conc. H_2SO_4. This was allowed for 7 days.

Storage and packaging

After fermentation, the fermented samples were aseptically dried using an electric oven at 80^0C for 7days**.** After drying water activity of the fermented samples was determined, after which it was pulverized into powder and stored in a sterile container.

Moisture Content Determination

A crucible was dried, cooled, and weighed (initial weight recorded as W1). Then, 2.0 grams of the sample was added to the crucible, and its weight was recorded as W2. The crucible with the sample was heated in an oven at 105°C for 4 to 6 hours. After heating, the final weight of the crucible and its contents was measured (final weight recorded as W3). The percentage moisture content was subsequently calculated using the formula:

$$\% \text{ moisture content } = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Experimented Chicks: A total of twenty four (24) broiler chicks (3 weeks old) were purchased from poultry market located at Ihiala market, Ihiala L. G. A. in Anambra State were used for the study. The chicks were kept in separate, thoroughly cleaned and disinfected house and provided with feeds and water ad libitum. All the chicks were vaccinated against Newcastle disease using Lasota vaccine strains at 6 and 19 days of age, against infectious bronchitis using live H120 strain at 6 days old and also against avian influenza (A1) disease using inactivated H5N1virus vaccine strain at 7 days old. All the vaccines were given via eye drop instillation except (A1) vaccine, which was given through the subcutaneous route at the back of the neck from the folder report collected from the poultry farmer.

Feed Additive

The fermented groundnut chaff was mixed with fish meal and the feed in a ratio of 1:20. This mixture was properly and thoroughly mixed and administered to the chicks. The chicks were divided into two groups (A and B). Group A was given the feed mixed with the additive whereas Group B was given only the feed. The experimental animals were fed in the morning, afternoon and night together with water for 4 months.

Body weights: The body weights of the experimented rats were checked and recorded weekly using electronic weighing balance (LXD200) and recorded as described in the work published by Nwobodo *et al.* (2018), Iheukwumere *et al.* (2025m).

Hematological Indices: The blood samples collected from the broiler chicks were examined using Automated Hematology Analyzer (MIN DRAY BC – 360), and the variations in the red blood cells (RBCs), lymphocytes, monocytes, neutrophils, eosinophils and basophils were assessed and recorded as described in the work published by Agiang *et al.* (2017), Iheukwumere *et al*. (2025n).

Statistical Analysis: The data obtained in this study were presented in tables and figures. Their percentages were also calculated. The sample means and standard deviations of some of the analytical data were also calculated. The significance of this study was determined at 95% using one way analysis of variance (ANOVA). Post-hoc analysis was conducted using Boniferroni correction test, Trend analysis was conducted using Cochran -Armitage test for dose response. Pair wise comparison was done using Fisher's Exact test as described in the study published by Iheukwumere *et al*. (2018), Idigo *et al*., (2025o), Idigo *et al*. (2025p), Idigo *et al*. (2025q), Idigo *et al*. (2025r), Idigo *et al*. (2025s), Idigo *et al*. (2025t), Manasseh *et al*. (2025).

RESULTS

The cultural and morphological characteristics of Isolate P were typical of *Lactobacillus* species, with cream-white colonies, low-convex elevation, and smooth edges on MRS agar (Table 1). The isolate was Gram-positive, rod-shaped, non-spore forming, and non-motile. Biochemical tests confirmed the isolate as a *Lactobacillus* species, with positive reactions for glucose, lactose, maltose, and fructose fermentation (Table 2). Molecular identification showed 100% identity to *Lactobacillus acidophilus* strain DSM20079 (Table 4), with a p-value of 0.0 and E-value of 0.0.

The body weights of the chicks in the test group were significantly higher ($p<0.05$) than those in the control group from week 2 to week 6 (Table 5). The test group had a final body weight of 1911 g, compared to 1442 g in the control group. However, the organ

weights, including liver, kidney, lungs, and heart, were not significantly different between the control and test groups ($p>0.05$) (Table 6).

The feed intake of the test group was higher than that of the control group, resulting in a higher weight gain (Table 7). The feed conversion ratio (FCR) of the test group was significantly lower ($p<0.05$) than that of the control group from week 3 to week 6. The results suggest that the fermented feed additive improved the efficiency of feed utilization in the broiler chicks.

The white blood cell count and lymphocyte percentage were significantly higher ($p<0.05$) in the test group compared to the control group (Table 8). The results indicate that the fermented feed additive had a positive effect on the immune system of the broiler chicks. The red blood cell count and platelet count were also higher in the test group, although the differences were not statistically significant.

Table 1: Cultural and morphological characteristics of the fermenter

Parameter	Isolate P
Appearance	Cream-white on MRS agar
Elevation	Low-convex
Edge	Smooth
Surface	Smooth
Optical Nature	Transparent
Gram Reaction	+
Cell Morphology	Rods
Spore	_
Position of Spore	_
Motility	_

+ + Positive; - = Negative

Table 2: Biochemical characteristics of the fermenters

Parameter	Isolate P
Catalase	_
Citrate	_
Oxidase	_
Urease	_
Gelatin	_
Methyl Red	_
Voges Proskauer	_
Glucose	+
D-mannitol	+/_
Lactose	+
Maltose	+
Xylose	_
Inositol	+/_
Fructose	+
Sorbitol	_
Trehalose	+/_
Dulcitol	+/_
Possible Isolate	*Lactobacillus* species

Table 3: Authentication of nucleic acids extracted from the fermenters

Sample ID	Nucleic Acid Conc(µg/mL)	260 nm	280 nm	260/280
P	142.40	3.1915	1.7440	1.83

Table 4: Molecular identities of the fermenters

Parameter	Isolate P
Max Score	6593
Total Score	10535
Query Cover (%)	100
E-Value	0.0
Identity (%)	100
Accession Length	2009973
Accession Number	CP020620.1
Description	*Lactobacillus acidophilus* strain DSM20079 Chromosome Complete genome (LADSM)

Table 5: Body weights of the chicks

Week	Control Group	Test Group
1	168	185
2	376	398
3	660	719
4	974	1105
5	1220	1501
6	1442	1911

Table 6: Organ weight of the chicks

Organ	Control group	Test group
Liver (g)	7.40 ± 0.01	7.44 ± 0.01
Kidney (g)	0.52 ± 0.01	0.52 ± 0.01
Lungs (g)	1.31 ± 0.01	1.31 ± 0.01
Heart (g)	0.67 ± 0.01	0.64 ± 0.01

Table 7: Feed intake and feed conversion ratio among the chicks

Week	Control Group				Test Group			
	Feed (g)	Weight (g)	Weight gain (g)	FCR	Feed (g)	Weight (g)	Weight gain (g)	FCR
1	28	168	60	2.143	35	185	83	2.3714
2	62	376	208	3.355	72	398	213	2.9583
3	102	660	284	2.784	116	719	321	2.7672
4	146	947	287	1.966	160	1105	386	2.4125
5	194	1220	273	1.407	211	1501	396	1.8768
6	243	1442	222	0.914	271	1911	410	1.5129

Table 8: Hematological indices (Groundnut chaff + fish meal)

Parameter	Control Group	Group fed with chaff and fish meal
WBC (X10^9L)	12.88	15.64
RBC (X10^12L)	7.37	8.77
PLT (X10^9L)	825.00	838.00
Neu (%)	40.60	9.20
Eos (%)	4.75	0.10
Mon (%)	3.85	3.10
Bas (%)	0.10	0.10
Lym (%)	50.70	87.50

DISCUSSION

The cultural, morphological, and biochemical characteristics of the isolate were consistent with *Lactobacillus* species, as reported by other researchers (Oboh *et al.*, 2012; Adeyemo *et al.*, 2018). The isolate's Gram-positive rods, non-spore forming, and non-motile nature aligned with typical Lactobacillus profiles (Million *et al*., 2012). Molecular identification confirmed the isolate as *Lactobacillus acidophilus* strain DSM20079, showing 100% identity. This is in line with studies using 16S rRNA sequencing for *Lactobacillus* identification (Awojobi *et al.*, 2016).

The test group showed significantly higher body weights compared to the control group, indicating improved growth performance. This is consistent with studies reporting enhanced growth in animals fed fermented feed additives (Oboh *et al.*, 2012; Adeyemo *et al.*, 2018). Organ weights were not significantly different between groups, suggesting the fermented feed was safe.

The test group had a lower feed conversion ratio, indicating improved feed efficiency, aligning with research on fermented feeds (Cani *et al.*, 2012). The test group also showed higher white blood cell count and lymphocyte percentage, suggesting enhanced immune function, consistent with studies on probiotics (Kadooka *et al.*, 2010).
The study highlights fermented pineapple peel and fish meal blend's potential as a probiotic feed additive, improving growth, feed efficiency, and immunity in broiler chicks. This aligns with research on fermented foods modulating gut microbiota and metabolic health (Kadooka e*t al.*, 2010; Cani *et al.*, 2012).

CONCLUSION

The results of the study demonstrate that the fermented pineapple peel and fish meal blend had a positive effect on the growth performance, feed efficiency, and immune system of the broiler chicks. The inclusion of the fermented feed additive in the diet

improved the body weights, feed conversion ratio, and hematological indices of the chicks, without any adverse effects on organ weights.

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