



# Corollary of *Lactobacillus* Fermented Chicken Feather on Growth Performance of Rats

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Abstract	Article History
<p>Globally, millions of tons of chicken feathers are produced annually, representing a significant waste management challenge due to their poor biodegradability and low economic utilization. This study was undertaken to evaluate the corollary of <i>Lactobacillus</i> fermented chicken feather as a chicken feed additive on the growth performance of albino Wistar rats. The corollary of <i>lactobacillus</i> fermented feeds on the rats was determined using <i>in vivo</i> techniques. The fermenter used in the study was identified to be <i>Lactobacillus acidophilus</i> strain DSN20079 (LADSM). The study revealed that there was a significant (<math>P &lt; 0.05</math>) increase in the body weight of the test chicks fed with the mixed fermented feed starting from week 1 (136.70 g) down to week 6 (314.60 g). There was also a significant increase in the organ weight of the rats i.e liver (6.32 g), kidney (0.47g), lungs (1.02 g), and heart (0.43g) compared to the control group. The BMI of the rats was 0.64 g/cm<sup>2</sup>, which was not greater than 0.68 g/cm<sup>2</sup>, indicating good growth and not obese. Also, the organ functions of the rats revealed that there was an increase in ALT (17.180 U/L) compared to the control group (17.100 U/L), and a decrease in AST (25.180 U/L) compared to the control group (25.180 U/L). It also showed an increase in creatine, urea and LDH compared to the control group. There was also an increase in the MDA level of the rats starting from week 1 (0.024g) down to week 6 (0.045g) compared to the control group. Therefore, the study concluded that the <i>Lactobacillus</i> fermented chicken feather meal showed pronounced activity in the rats and could be used as an additive for the growth performance of the rats.</p> <p><b>Keywords:</b> Feed, <i>Lactobacillus</i>, Creatine, Urea</p>	<p>Received: 15 Aug 2025 Accepted: 18 Sept 2025 Published: 21 Sept 2025</p> <p>Scan QR code to view*</p>  <p>License: CC BY 4.0*</p>  <p>Open Access article.</p>
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## Introduction

Poultry production remains a critical component of global food security, providing affordable animal protein in the form of meat and eggs (FAO, 2021). In intensive broiler production, feed constitutes approximately 60–70% of total production costs, making the exploration of alternative, low-cost, and sustainable protein sources imperative (Adeyemi and Olorunsanya, 2018). One such potential resource is poultry feather waste, a by-product of poultry processing plants, which

is abundant, underutilized, and often poses environmental disposal challenges (Onifade et al., 1998).

Chicken feathers are primarily composed of keratin, an insoluble and fibrous protein resistant to degradation by common proteolytic enzymes due to its high disulfide bond content (Brandelli et al., 2015). However, *Lactobacillus* fermentation has been demonstrated as an effective biotechnological approach to hydrolyze keratin into bioavailable amino acids and peptides, enhancing its digestibility and nutritional value for poultry (Fakhfakh et al.,

2019). The lactic acid fermentation process not only improves protein quality but also inhibits the growth of spoilage and pathogenic microorganisms, thereby enhancing feed safety and shelf life (Yang et al., 2022).

In broiler nutrition, dietary inclusion of *Lactobacillus*-fermented feather meal could contribute to improved growth performance, feed conversion ratio (FCR), and overall health status by supplying essential amino acids such as cysteine and methionine (Adedokun et al., 2020). Moreover, lactic acid bacteria confer probiotic benefits, modulating gut microbiota, enhancing nutrient absorption, and stimulating immune responses (Hafeez et al., 2021). This dual functionality nutritional enhancement and probiotic effect makes fermented feather meal an innovative feed additive candidate in sustainable poultry production. Therefore, this study aims to assess the corollary of *Lactobacillus*-fermented chicken feather meal on the growth performance of rats.

## 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), Iheukwumere et al. (2020a), Iheukwumere and Iheukwumere, (2022a) and Iheukwumere et al. (2022b), was added into the plates, allowed to solidified. The plates were incubated in a microaerophilic environment (containing a candle used to evacuate all traces of oxygen, thereby creating an environment with only carbon dioxide). The incubation was done for 24 – 48 h at (30±2°C).

### 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 (Iheukwumere and Iheukwumere, 2022c; Iheukwumere et al., 2022d; and Iheukwumere and Iheukwumere, 2022e).

### Characterization of the Bacteria Pure Isolates

The pure isolates were characterized using the morphological, biochemical and molecular characteristics as described by Iheukwumere et al. (2018), Iheukwumere et al. (2022f), Iheukwumere et al. (2023a) and Iheukwumere et al. (2023b).

### Morphological characteristics of the Bacteria isolates

The cultural descriptions (size, appearance, edge, elevation, colour) of the isolates were carried out as described in Iheukwumere et al. (2024) and Iheukwumere et al. (2022g). The Gram staining technique which revealed the Gram reaction, cell morphology and cell arrangement were also carried out using the procedure described by Obianom et al., (2024), Egbe et al. (2025a) and Manasseh et al. (2025). The presence or absence of capsule was also carried out as described by Ekechukwu et al. (2025a). The presence or

absence of flagellum was determined by carrying out motility test as described by Ekechukwu et al. (2025b).

### 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 decolorizing 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 Ekechukwu et al. (2025c), Egbe et al. (2025b) and Egbe et al. (2025c).

**Motility test:** This was done using the method described by Iheukwumere et al. (2025a), Iheukwumere et al. (2025b) and Iheukwumere et al. (202c). 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°C for 24h.T.

### 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. This was done using the method described by Iheukwumere et al. (2025d), Iheukwumere et al. (2025e) and Iheukwumere et al. (2025f). The 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.

**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 as described by Dim et al. (2025a) and Dim et al. (2025b). 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.

**Methyl red test:** Using the method described by Dim *et al.* (2025c), Iheukwumere *et al.* (2025g). 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.

**Voges-Proskauer test:** Using the method described by Iheukwumere *et al.* (2025h), Ike *et al.* (2025a). 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  $\alpha$ -naphthol was added in the absolute alcohol. Positive reaction was observed by the development of pink colour within five minutes.

**Citrate utilization test:** The Simmon's Citrate Agar was prepared 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 as described by Ike *et al.* (2025b) and Ike *et al.* (2025c).

**Catalase test:** The test was carried out as described by Ike *et al.* (2025d) and Ike *et al.* (2025e). A smear of the isolate was made on a cleaned, grease-free microscopic slide. Then, a drop of 30% hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) was added on the smear. Prompt effervescence indicated catalase production.

**Oxidase test:** The test was carried out using the method described by Ugwu *et al.* (2025a). 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 Ugwu *et al.* (2025b). 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°C 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. Using the Zymo Research (ZR) DNA miniprep™ kit

(Category No. D6005; Irvine, California, USA), bacterial genomic DNA was extracted and purified as described by Iheukwumere *et al.* (2018), Iheukwumere *et al.* (2020) with the procedures outlined in the kit.

**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.*, 2017a; Chude *et al.*, 2020).

**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<sub>2</sub>) 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 electrophoresed in 1.0% agarose gel and a 1kb 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.*, 2017b; Iheukwumere *et al.*, 2017c; and Iheukwumere *et al.*, 2018b).

**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.* (2017d), and Iheukwumere *et al.* (2018c).

**Computational Analysis:** This was analysed making use of the modified method of Iheukwumere *et al.* (2025i) and 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 chicken feather

The chicken feather 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°C for 15 min at 15psi.

### Fermentation Process

This was carried out using the modified method of Iheukwumere *et al.* (2017), Iheukwumere *et al.* (2022) and Iheukwumere *et al.* (2025k). 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°C 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<sub>2</sub> · 2H<sub>2</sub>O and 99.4 mL of 1% Conc. H<sub>2</sub>SO<sub>4</sub>. This was allowed for 7 days.

### Storage and packaging

After fermentation, the fermented samples were aseptically dried using an electric oven at 80°C 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 W<sub>1</sub>). Then, 2.0 grams of the sample was added to the crucible, and its weight was recorded as W<sub>2</sub>. 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 W<sub>3</sub>). 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 Rats:** A total of twenty four (24) rats (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 rats 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 H5N1 virus 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 chicken feather and the feed in a ratio of 1:20. This mixture was properly and thoroughly mixed and administered to the rats. The rats were divided into two groups (A and B). Group A was given the *Lactobacillus* fermented feed, 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.

**Experimental protocols for the *in vivo* models:** A total of 36 albino Wistar rats were used for this study. The rats were grouped into six groups, and each group comprises 6 rats. The

body weights and blood absolute lymphocytes were assessed from the blood samples drawn from the rats after 11 days.

**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 Ejike *et al.* (2017), Nwobodo *et al.* (2018).

**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). Pairwise comparison was analyzed using student “t” test as described by Okeke *et al.* (2017), Iheukwumere *et al.* (2014), Iheukwumere *et al.* (2017e), Nwike *et al.* (2017), Amadi *et al.* (2017), and Iheukwumere *et al.* (2025l).

## Results

The cultural and morphological characteristics of the fermenter are shown in Table 1. The result revealed that isolate P showed cream white appearance on MRS agar with a low convex elevation, smooth edge, and surface. The isolate has a Gram-positive rod, non-sporing and non-motile rods.

The biochemical characteristics of the fermenters revealed that isolate P was catalase, citrate, oxidase, urase, gelatin, methyl red, Voges Proskauer negative. The isolate showed complex utilization to glucose, lactose, maltose and fructose while it was unable to utilize xylose and sorbitol. The isolate showed varying utilization to D mannitol, inositol, Trehalose and Dulcitol as shown in table 2.

The nucleic acid extracted from the fermenters revealed that it was deoxyribonucleic acid (DNA) at the ratio of 260nm/280nm ranging from 1.80-1.83 as shown in Table 3.

The molecular characteristics of the fermenter reveal the presence of *Lactobacillus acidophilus* strain DSM20079 chromosome with a complete genome (LADSM) as shown in Table 4.

The body weight of the rats when feed with fermented chicken feather revealed that there was a significant (P<0.02) increase in the body weight of the rats compared to the control group and this was very pronounced at week six of feeding the rats with the fermented feed supplement as shown in Table 5.

The result of the organ weight of the chicken feather after been feed with fermented supplement (chicken feather) revealed that there was an increase in the organ weights (Liver, Kidney, Lungs, Heart) of the test rats compared to the control group and these changes were statistically significant (P<0.05) as shown in Table 6.

The result of the body mass indices of the rats revealed that compared to the control group there was a slight increase of about 0.02 in the test group after been fed with the *Lactobacillus* fermented chicken feather this was statistically significant (P<0.05) as shown in Table 7. The organ function of the rats revealed that there was a slight increase in the level of alanine transaminase, creatine, urea and lactate dehydrogenase and also decrease in the aspartate transaminase of the test group compared to the control group but these changes were statistically non-significant (P>0.05) as shown in Table 8. The Malondialdehyde (MDA) level of the rats revealed that there were increase in the

levels of MDA starting from the first week down to the six week compared to the control group as shown in Table 9.

**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	<i>Lactobacillus</i> species

**Table 3:** Authentication of nucleic acids extracted from the fermenters

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

**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	<i>Lactobacillus acidophilus</i> strain DSM20079 Chromosome Complete genome (LADSM)

**Table 5:** Body weights of the rats

Week	Control Group	Test Group
1	127.10	136.70
2	169.20	184.80
3	198.10	216.60
4	221.40	247.50
5	237.60	283.30
6	248.10	314.60

**Table 6:** Organ weight of the rats

Organ	Control group	Test group
Liver (g)	6.29 ± 0.01	6.32 ± 0.01
Kidney (g)	0.46 ± 0.01	0.47 ± 0.01
Lungs (g)	1.00 ± 0.01	1.02 ± 0.01
Heart (g)	0.42 ± 0.01	0.43 ± 0.01

**Table 7:** Body mass indices (BMI) of the rats

Parameter	Control group	Test group
Body weight (g)	248.00 ± 1.47	314.60 ± 1.51
Length (cm <sup>2</sup> )	20.06 ± 0.03	22.12 ± 0.07
BMI (g/cm <sup>2</sup> )	0.62	0.64

BMI of 0.68 g/cm<sup>2</sup> or greater is generally considered overweight or obese

**Table 8:** Organ functions of the rats

Parameter	Control	Test
ALT (U/L)	17.100	17.180
AST (U/L)	25.660	25.180
Creatine (mg/dL)	0.3901	0.3914
Urea (mg/dL)	7.9461	7.9466
LDH (U/L)	12.716	12.719

**Table 9:** Malondialdehyde (MDA) level in experimental rats

Week	MDA (Nm/mL)	
	Control conc	Test
1	0.020	0.024
2	0.024	0.038
3	0.023	0.040
4	0.018	0.041
5	0.018	0.044
6	0.017	0.045
	1.7440	1.83

## Discussion

*Lactobacillus* is a diverse genus of Gram-positive, non-spore-forming, rod-shaped bacteria that are facultative anaerobes and predominantly produce lactic acid through the fermentation of carbohydrates (Tufail *et al.*, 2011). Their ability to ferment carbohydrates by producing beneficial metabolites, which aid and support gut health and boost immune response, has gained significant insight (Mannan *et al.*, 2017). This present study targets the corollary of *Lactobacillus* fermented chicken feather on the growth performance of rats. The cultural, morphological and biochemical characteristics of the *Lactobacillus* species agree with the findings of many researchers (Tufail *et al.*, 2011; Mannan *et al.*, 2017; Divisekera *et al.*, 2019; and Celik *et al.*, 2021) who isolated and characterized *Lactobacillus* species from yoghurt and

banana. The ability of the isolates to utilize common sugars such as glucose, lactose, sucrose, maltose and some alcoholic sugars such as mannitol, sorbitol and xylitol indicates their potential to produce beneficial metabolites which support gut health and aid food fermentation. These potentials were also described by many researchers (Tufail *et al.*, 2011; Mannan *et al.*, 2017; Divisekera *et al.*, 2019; and Celik *et al.*, 2021). The molecular characterization of the *Lactobacillus* species revealed the presence of *Lactobacillus acidophilus* strain DSM20079 (LADSM). The occurrence of *Lactobacillus acidophilus* in strains had been reported by Li *et al.* (2011), Anjum *et al.* (2014), and Mannan *et al.* (2017), who stated that the occurrence may be due to antagonism.

The results obtained from the study revealed that *Lactobacillus* fermented chicken feathers had a significant effect on the body weight, organ weight, organ function, MDA level and which improved growth performance of the albino Wistar rats. These findings corroborated with the findings of many researchers (Wang *et al.*, 2023; Lv *et al.*, 2023; and Yu *et al.*, 2023) who evaluated the effect of fermented chicken feather on the growth performance of rats but disagrees with the findings Yeh *et al.* (2023), who reported that the fermented chicken feather meal did not improve the growth performance of the rats.

## Conclusion

This study has demonstrated that *Lactobacillus* fermented chicken feather meal significantly improved growth performance in albino Wistar rats, with notable increased in body weight, organ weight, and biochemical parameters. The findings suggest that fermented chicken feather meal can be a valuable feed additive for promoting growth and health in animals.

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