Available: https://doi.org/10.54117/ijpae.v2i1.137 *Research article*

IPS Journal of Plant, Animal, and Environmental Sciences
Volume 2(1): 43-55 (2026)
Received: 29 Dec 2025 | Accepted: 13 Feb 2026 | Published: 19 Feb 2026

Sweet Potato Peel and Fish Meal Blend Fermentation: A Study on Prebiotic Potential and Broiler Chick Performance

Ezeoke, F. C.[1], Iheukwumere, I. H.[2], Iheukwumere, C. M.[3], Ike, V. E.[4], Ezendianefo, J. N.[5], Abba, O.[6], Idigo, M. A.[7] and Aniekwu, C. C.[3]

[1]Department of Animal Science, Faculty of Agriculture, Chukwuemeka Odumegwu Ojukwu University, Uli, Campus, Anambra State, Nigeria.
[2]Department of Microbiology, Faculty of Natural Sciences, Chukwuemeka Odumegwu Ojukwu University, Uli, Campus, Anambra State, Nigeria.
[3]Department of Applied Microbiology and Brewing, Faculty of Biosciences, Nnamdi Azikiwe University, Awka, Nigeria.
[4]Department of Microbiology, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria.
[5]Department of Microbiology, Tansian Universiy, Umunya, Anambra State, Nigeria.
[6]Department of Microbiology, Federal University of Gusau, Zamfara State.
[7]Department of Biological Sciences, Faculty of Natural Sciences, Chukwuemeka Odumegwu Ojukwu University, Uli, Campus, Anambra State, Nigeria.

*Corresponding author e-mail address: fc.ezeoke@coou.edu.ng / ik.iheukwumere@coou.edu.ng

ABSTRACT

The increasing demand for poultry products necessitates improved chicken nutrition. Sweet potato peel, a waste product, is rich in nutrients but underutilized. While fermentation enhances nutritional value, its prebiotic potential in broiler chicks remains unclear, leaving a gap in understanding its effects on growth performance and gut health, creating a need to investigate its impact on chicken nutrition. This study was undertaken to evaluate the effect of fermented sweet potato peel mixed with fish meal as a chicken additive for healthy broiler chicks. The fermenter used in this study was isolated and characterized using standard microbiological techniques. The effects of the fermented feeds on the broiler chicks were determined using *in vivo* techniques. The mixture of sweet potato peel and fish meal, fermented by *Lactobacillus acidophilus* strain DSN20079 (LADSM) was incorporated into the diet of broiler chicks, and its effects on growth performance, organ weights, feed intake, and hematological indices were evaluated. The results showed that 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. The feed conversion ratio of the test group was significantly lower ($p<0.05$) than that of the control group from week 3 to week 6. The organ weights of the chicks were not affected by the inclusion of the feed additive in the diet. The white blood cell count and lymphocyte percentage were significantly higher ($p<0.05$) in the test group compared to the control group. The study has shown that the mixture of sweet potato peel and fish meal, fermented by LADSM has potential as a probiotic feed additive for broiler chicks, improving growth performance and blood indices without any adverse effects on organ weights.

How to Cite this Article

Ezeoke, F. C., Iheukwumere, I. H., Iheukwumere, C. M., Ike, V. E., Ezendianefo, J. N., Abba, O., Idigo, M. A., & Aniekwu, C. C. (2026). Sweet Potato Peel and Fish Meal Blend Fermentation: A Study on Prebiotic Potential and Broiler Chick Performance. *IPS Journal of Plant, Animal, and Environmental Sciences*, *2*(1), 43–55. https://doi.org/10.54117/ijpae.v2i1.137

Keywords: *Lactobacillus acidophilus, Sweet potato peel, Prebiotic, Broiler chicks, Growth performance*

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). Sweet potato 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). However, its utilization is limited due to the presence of anti-nutritional factors and low protein content (Awojobi *et al.*, 2016; Iheukwumere *et al*., 2022a; and Nwike *et al*., 2017). Fermentation has been shown to enhance the nutritional value of sweet potato 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). *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; Ekechukwu *et al.*, 2025a; Obianom *et al*., 2024; Dim *et al*., 2025b). 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). Sweet potato peel, when combined with fish meal, could provide a cost-effective and nutritious feed additive for poultry (Awojobi *et al.,* 2016; Iheukwumere *et al*., 2025b, Dim *et al*. 2025c). However, the prebiotic potential of fermented sweet potato peel and fish meal blend in broiler chicks remains unclear, leaving a gap in understanding its effects on growth performance and gut health. 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). The use of prebiotic feed additives, such as fermented sweet potato peel and fish meal blend, could provide a natural and effective way to promote gut health and improve poultry performance (Adeyemo *et al.*, 2018; Amadi *et al*., 2017; Ejike *et al*., 2017).

This study aimed to evaluate the effect of fermented sweet potato peel mixed with fish meal as a chicken additive for healthy broiler chicks, addressing the research gap in understanding its prebiotic potential and 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 additives in poultry nutrition and provide insights into the potential benefits of sweet potato 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^{0}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 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^{0}C 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^{0}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. 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 sweet potato peel

The sweet potato 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 the fermenter (Isolate P) were determined. The isolate appeared as cream-white colonies on MRS agar with low-convex elevation and smooth edges. Microscopically, the cells were Gram-positive rods, non-spore forming, and non-motile. These characteristics are typical of *Lactobacillus* species. The biochemical characteristics of Isolate P were assessed. The isolate was catalase-negative, citrate-negative, oxidase-negative, and urease-negative, consistent with Lactobacillus species. It fermented glucose, lactose, maltose, fructose, and some other sugars, suggesting a profile typical of *Lactobacillus acidophilus*. Based on these tests, the isolate was identified as a *Lactobacillus* species. Nucleic acids were extracted from Isolate P with a concentration of 142.40 μg/mL and a 260/280 ratio of 1.83, indicating relatively pure DNA. Molecular identification via sequencing showed 100% identity to *Lactobacillus acidophilus* strain DSM20079, confirming the isolate as *L. acidophilus* ($p < 0.001$, E-value = 0.0).

The body weights of the chicks in the test group were significantly higher than those in the control group from week 2 to week 6 ($p < 0.05$). The test group had a final body weight of 1887 g, compared to 1442 g in the control group. The results suggest that the fermented sweet potato peel and fish meal blend had a positive effect on the growth performance of the broiler chicks. The organ weights of the chicks, including liver, kidney, lungs, and heart, were not significantly different between the control and test groups ($p > 0.05$). The results indicate that the inclusion of the fermented feed additive in the diet did not have any adverse effects on the organ weights of the chicks.

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

The white blood cell count and lymphocyte percentage were significantly higher in the test group compared to the control group ($p < 0.05$). 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.

The results of the study suggest that the fermented sweet potato 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. The study highlights the potential of fermented sweet potato peel and fish meal blend as a probiotic feed additive for broiler chicks.

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 fermenter

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 fermenter

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 fermenter

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	181
2	376	405
3	660	712
4	974	1080
5	1220	1473
6	1442	1887

Table 6: Organ weight of the chicks

Organ	Control group	Test group
Liver (g)	7.40 ± 0.01	7.41 ± 0.01
Kidney (g)	0.52 ± 0.01	0.49 ± 0.01
Lungs (g)	1.31 ± 0.01	1.31 ± 0.01
Heart (g)	0.67 ± 0.01	0.66 ± 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	181	81	2.3143
2	62	376	208	3.355	72	405	224	3.1111
3	102	660	284	2.784	116	712	307	2.6466
4	146	947	287	1.966	160	1080	368	2.3000
5	194	1220	273	1.407	211	1473	393	1.8626
6	243	1442	222	0.914	271	1887	414	1.5277

Table 8: Hematological indices

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	30.90
Eos (%)	4.75	0.10
Mon (%)	3.85	5.80
Bas (%)	0.10	0.10
Lym (%)	50.70	63.10

DISCUSSION

The cultural, morphological, and biochemical characteristics of the isolate were consistent with *Lactobacillus* species, as reported by other researchers (Adeyemo *et al*., 2018; Oboh *et al.*, 2012). 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 sweet potato 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 *et al.,* 2010; Cani *et al.,* 2012).

CONCLUSION

This study has demonstrated that *Lactobacillus acidophilus*-fermented sweet potato peel and fish meal blend improves broiler chick growth, feed efficiency, and immune response without adverse organ effects. This fermented feed additive shows promise as a probiotic supplement for poultry, addressing chicken nutrition needs and utilizing waste products.

Acknowledgments

We are grateful to all our study participants who join the study voluntarily. We are grateful to ZAHARM Analytical and Research Laboratory, Amawbia, Awka Anambra State, Nigeria for providing enabling environment, resources and techniques for this study. We really salute their wonderful efforts.

Conflict of interests: The authors declare that they have no conflict of interests.

Funding: This research did not receive specific grant from any funding agencies.

REFERENCES

Abd El-Hack, M. E., Alagawany, M., Arif, M., Emam, M., Saeed, M., & Arain, M. A. (2019). The uses of microbial phytase as a feed additive in poultry nutrition – A review. *Annals of Animal Science, 19*(2), 389–407. https://doi.org/10.2478/aoas-2018-0044

Aderemi, F. A., Oyebanji, B. O., & Adeyemo, G. O. (2023). Fermented feed as a strategy for sustainable poultry production: A review. *Poultry Science, 102*(1), 102–110. https://doi.org/10.1016/j.psj.2022.102110

Adeyemo, A. J., Abiodun, O. A., & Ojo, O. A. (2018). Fermentation of groundnut cake with Aspergillus niger and its effects on the nutritional value. Journal of Food Science and Technology, 55(10), 4131-4140.

Adeyemo, S. M., Ogunremi, O. R., & Oluwole, O. A. (2018). Fermentation of sweet potato peel with Lactobacillus species: Effects on nutritional and anti-nutritional factors. Journal of Food Science and Technology, 55(11), 4523-4532.

Alahyaribeik, S., Nazarpour, M., Tabandeh, F., Honarbakhsh, S., & Sharifi, S. D. (2022). Effects of bioactive peptides derived from feather keratin on plasma cholesterol level, lipid oxidation of meat, and performance of broiler chicks. *Tropical Animal Health and Production*, *54*(5), 271.

Amadi, R.E., Iheukwumere, I.H. and Unaeze, B.C. (2017). Effects Of Crude Alkaloid Extracted From Ocimum Gratissimum On The Activity Of Ciprofloxacin Against Salmonella Enterica Serovar Typhi. *Advances in Life Science and Technology* 58.

Anahtar, M. N., Byrne, E. H., Doherty, K. E., Bowman, B. A., Yamamoto, H. S., Soumillon, M., ... and Kwon, D. S. (2018). Cervicovaginal bacteria are a major modulator of host inflammatory responses in the female genital tract. *Immunity*, *42*(5), 965-976. https://doi.org/10.1016/j.immuni.2015.04.019

Anjum, N., Maqsood, S., Masud, T., Ahmad, A., Sohail, A., & Momin, A. (2014). Lactobacillus acidophilus: characterization of the species and application in food production. *Critical reviews in food science and nutrition*, *54*(9), 1241-1251.

Awojobi, K. O., Adeyemo, S. M., & Ogunremi, O. R. (2016). Utilization of sweet potato peel in animal feed: A review. Journal of Animal Science and Technology, 58(1), 1-10.

Balogu, T. V., Ibrahim, H., & Balogu, D. O. (2017). Nutritionally improved corn mill waste (chaff) with microbial protein: An economic alternative for poultry feed. *Advances in Applied Sciences*, *2*(2), 18-22.

Bell, V., Ferrão, J., & Fernandes, T. (2017). Nutritional guidelines and fermented food frameworks. *Foods, 6*(8), 65. https://doi.org/10.3390/foods6080065

Bolarinwa, O. O., Olaniyi, C. O., & Adeola, O. (2022). Nutritional value and feeding potential of maize in poultry diets. *World's Poultry Science Journal*, *78*(3), 535–549. https://doi.org/10.1080/00439339.2022.2076751

Cabel, M. C., Goodwin, T. L., & Waldroup, P. W. (1988). Feather meal as a nonspecific nitrogen source for abdominal fat reduction in broilers during the finishing period. *Poultry Science*, *67*(2), 300-306.

Cai, Y., Li, Y., Zhang, Y., & Wang, Y. (2019). The role of *Lactobacillus* in immune regulation: Current status and perspectives. *Frontiers in Immunology, 10*, 1804. https://doi.org/10.3389/fimmu.2019.01804

Cani, P. D., & Delzenne, N. M. (2012). The gut microbiota: A key player in metabolic health. Nutrition Reviews, 70(10), 625-636.

Celik, O. F., Con, A. H., Saygin, H., Şahin, N., & Temiz, H. (2021). Isolation and identification of lactobacilli from traditional yogurts as potential starter cultures. *LWT*, *148*, 111774.

Chachaj, R., Sembratowicz, I., Krauze, M., & Ognik, K. (2019). The effect of partial replacement of soybean meal with fermented soybean meal on chicken performance and immune status. *Journal of Animal and Feed Sciences*, *28*(3), 263-271.

Chen, M., Sun, Q., & Giovannucci, E. (2021). Dairy consumption and risk of type 2 diabetes: The role of fermented dairy products. *American Journal of Clinical Nutrition*, *113*(5), 1100–1111. https://doi.org/10.1093/ajcn/nqaa397

Cho, J. H., Kim, H. J., & Kim, I. H. (2020). Effects of fermented feed on the performance, nutrient digestibility, and gut microbiota of broiler chickens. *Animal Bioscience, 33*(7), 1109–1118. https://doi.org/10.5713/ajas.19.0710

Chude,C.O., Iheukwumere, I.H., Iheukwumere, C.M., Nwaolisa,C.N., Egbuna, C.,Nwakoby, N.E.and Egbe, P.A. (2020). Cidal activity of proteins secreted by *Bacillus thuringensis* against *Ascaris lumbricoides. International Journal of Research Publications* 49(1): 1033 – 1045.

Cristofori, F., Dargenio, V. N., Dargenio, C., Miniello, V. L., Barone, M., & Francavilla, R. (2021). Anti-inflammatory and immunomodulatory effects of probiotics in gut inflammation: A door to the future. *Frontiers in Immunology, 12*, 578386. https://doi.org/10.3389/fimmu.2021.578386

Dim, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Ugwu, C. H., Ike, V. E., Ezendianefo, . J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025a). Multiple Antibiotic Resistance Bacterial Strains in Frozen Meat Sold at Abagana, Anambra State: A Public Health Concern. *IPS Journal of Applied Microbiology and Biotechnology*, *4*(3), 181–186. https://doi.org/10.54117/ijamb.v4i3.75

Dim, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Ugwu, C. H., Ike, V. E., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025b). The Burden of Antibiotic Resistance: Evaluating the Impact of Multiple Antibiotic-Resistant Enteric Bacteria in Academic Environments. *IPS Interdisciplinary Journal of Biological Sciences*, *4*(4), 144–149. https://doi.org/10.54117/iijbs.v4i4.78

Dim, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Ugwu, C. H., Ike, V. E., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025c). Antimicrobial resistance in aquaculture: evaluating pseudomonas aeruginosa from fish ponds. *IPS Intelligentsia Multidisciplinary Journal*, *4*(1), 32–36. https://doi.org/10.54117/iimj.v4i1.10

Dimidi, E., Cox, S. R., Rossi, M., & Whelan, K. (2019). Fermented foods: Definitions and characteristics, impact on the gut microbiota and effects on gastrointestinal health and disease. *Nutrients, 11*(8), 1806. https://doi.org/10.3390/nu11081806

Divisekera, D. M. W. D., Samarasekera, J. K. R. R., Hettiarachchi, C., Gooneratne, J., Choudhary, M. I., & Gopalakrishnan, S. (2019). Isolation and identification of lactic acid bacteria with probiotic potential from fermented flour of selected banana varieties grown in Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, *47*(1).

Egbe, P. A., Umeaku, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Onwuasoanya, U. F., Ezenwata, I. S., Afulukwe, S. C., Ike, V. E., & Ezeumeh, E. N. (2025a). Antibiotic Susceptibility of Helicobacter pylori Isolates from Patients at Nnewi Teaching Hospital, Anambra State. *IPS Journal of Basic and Clinical Medicine*, 2(2), 51–57. https://doi.org/10.54117/ijbcm.v2i2.11.

Egbe, P. A., Umeaku, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Onwuasoanya, U. F., Ezenwata, I. S., Afulukwe, S. C., Ike, V. E., Ezeumeh, E. N., & Egbuna, C. (2025b). Helicobacter pylori Inhibition by Medicinal Plant Extracts: An In Vitro Assessment. IPS Journal of Drug Discovery Research and Reviews, 3(1), 32–37. https://doi.org/10.54117/ijddrr.v3i1.28.

Egbe, P. A., Umeaku, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Onwuasoanya, U. F., Ezenwata, I. S., Afulukwe, S. C., Ike, V. E., & Ezeumeh, E. N. (2025c). Medicinal Plant Extracts Enhance Conventional Antibiotic Activity against Helicobacter pylori: An In Vitro Assessment. IPS Interdisciplinary Journal of Biological Sciences, 4(2), 93–99. https://doi.org/10.54117/iijbs.v4i2.51.

Ejike, C.E., Iheukwumere, I.H. and Armadi, R.E. (2017). Susceptibility of Escherichia coli Isolated from Oligospermia Patient to *Gongronema latifolium* leaves extract. *J. Biol. Agriculture. Healthcare* 7(14).

Ekechukwu, C. C., Umeh, S. O., Iheukwumere, I. H., & Iheukwumere, C. M. (2025a). Bacterial Loads of Smoked Fish and Chicken: Role of pH and Moisture Content. *IPS Applied Journal of Nutrition, Food and Metabolism Science*, 3(1), 44–49. https://doi.org/10.54117/iajnfms.v3i1.102.

Ekechukwu, C. C., Umeh, S. O., Iheukwumere, I. H., & Iheukwumere, C. M. (2025b). Biological Inhibition of Pathogenic Bacteria Isolated from Smoked Fish and Chicken: An In Vitro Study. IPS Interdisciplinary Journal of Biological Sciences, 4(2), 85–92. https://doi.org/10.54117/iijbs.v4i2.50.

Ekechukwu, C. C., Umeh, S. O., Iheukwumere, I. H., & Iheukwumere, C. M. (2025c). Prophylactic Potential of the Most Potent Synergistic Biological Agent against Bacterial Infections from Smoked Fish and Chicken. IPS Journal of Applied Microbiology and Biotechnology, 4(2), 153–160. https://doi.org/10.54117/ijamb.v4i2.57.

Ekesiobi, A. O., Iheukwumere, C. M., Iheukwumere, I. H., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., Okereke, F. O., & Ochibulu, S. C. (2025). Hyping the Inhibitory Activity of Xylopia aethiopica against Vibrio cholerae using Azithromycin. IPS Journal of Basic and Clinical Medicine, 2(3), 93–98. https://doi.org/10.54117/ijbcm.v2i3.16

Ezedianafo, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025a). *Musca domestica*: A vector of multidrug-resistant enteric bacteria. *Journal of Veterinary, Allied, and One Health Sciences*, *1*(2), 30–38. https://doi.org/10.54117/3vwg0p36

Ezedianafo, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025b). Occurrences of meropenem- and imipenem-resistant *Klebsiella pneumoniae* in *Musca domestica* in hospital landfills. *African Journal of Applied Research & Sustainable Development, 1*(2), 25–35. https://doi.org/10.54117/wjmnyv91

Ezendianefor, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025). Multiple antibiotic resistance indices of enteric bacteria isolated from *Musca domestica*. *Journal of Public Health, Policy, and Society, 1*(2), 29–37. https://doi.org/10.54117/k8r78723

Ezendianefor, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025). *Klebsiella pneumoniae* isolated from *Musca domestica*: Antibiotic susceptibility and resistance patterns. *Journal of Veterinary, Allied, and One Health Sciences, 1*(2), 39–47. https://doi.org/10.54117/vy6y8f94

Ezendianefor, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025). *Musca domestica* as vectors of pathogenic enteric bacteria: A public health concern. *African Journal of Applied Research & Sustainable Development, 1*(2), 36–45. https://doi.org/10.54117/s671mk28

FAO. (2020). *The State of World Fisheries and Aquaculture 2020*. Food and Agriculture Organization of the United Nations.

Frias, J., Peñas, E., & Martínez-Villaluenga, C. (2017). Fermented foods in health promotion and disease prevention. In V. R. Preedy & R. R. Watson (Eds.), *Fermented Foods in Health and Disease Prevention* (pp. 3–20). Academic Press.

Gadde, U., Kim, W. H., Oh, S. T., & Lillehoj, H. S. (2017). Alternatives to antibiotics for maximizing growth performance and feed efficiency in poultry: A review. *Animal Health Research Reviews, 18*(1), 26–45. https://doi.org/10.1017/S1466252316000207

Gaggìa, F., Mattarelli, P., & Biavati, B. (2010). Probiotics and prebiotics in animal feeding for safe food production. International Journal of Food Microbiology, 141, S15-S28.

Gaggìa, F., Mattarelli, P., & Biavati, B. (2010). Probiotics and prebiotics in animal feeding for safe food production. International Journal of Food Microbiology, 141, S15-S28.

Guo, Q., Goldenberg, J. Z., Humphrey, C., El Dib, R., Johnston, B. C., & Lo, C. K. F. (2020). Probiotics for the prevention of pediatric antibiotic-associated diarrhea. *Cochrane Database of Systematic Reviews, 4*(4), CD004827. https://doi.org/10.1002/14651858.CD004827.pub5

Guo, S., Zhang, Y., Cheng, Q., Xv, J., Hou, Y., Wu, X., Du, E., & Ding, B. (2020). Partial Substitution of Fermented Soybean Meal for Soybean Meal Influences the Carcass Traits and Meat Quality of Broiler Chickens. *Animals*, *10*(2), 225. https://doi.org/10.3390/ani10020225

Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B., ... and Sanders, M. E. (2014). Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nature Reviews Gastroenterology and Hepatology, 11*(8), 506-514. https://doi.org/10.1038/nrgastro.2014.66

Hong, J., Ortiz, J. G., & Small, B. C. (2025). Corn-fermented protein as a replacement for fish meal in diets for Atlantic salmon, Salmo salar, parr: Growth, feed utilization, antioxidant activity, non-specific immune response, and gut histopathology. *Journal of the World Aquaculture Society*, *56*(2), e70020. https://doi.org/10.1111/jwas.70020

Husnain, A., Anwar, U., Fatima, A., Mustafa, R., Farooq, U., Abbas, W., Khalid, M. F., Ashraf, M., & Aziz ur Rahman, M. (2025). Effects of replacement of soybean meal with fermented soybean meal on growth performance, nutrient digestibility and carcass characteristics in broiler. *Livestock Science*, *299*, 105779. https://doi.org/10.1016/j.livsci.2025.105779

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Bacterial symbionts of *Rhynchophorus phoenicis*: Modulation of rat lymphocyte function and immunity. *Journal of Tropical Medicine and Public Health Solutions, 1*(2), 55–63. https://doi.org/10.54117/jtmphs.v1i2.36

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Multidrug-resistant *Klebsiella pneumoniae* in *Musca domestica*: A potential public health threat. *Journal of Tropical Medicine and Public Health Solutions, 1*(2), 46–54. https://doi.org/10.54117/jtmphs.v1i2.35

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Termite-derived antimicrobials: A novel approach to control *Bacillus cereus* in food products. *International Journal of Global Trends and Research, 1*(2), 45–57. https://doi.org/10.54117/2mgwn270

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Bacterial diversity in insect guts and their potential applications in industry. *International Journal of Global Trends and Research, 1*(2), 36–44. https://doi.org/10.54117/2k0d9t18

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Bioactive compounds from *Macrotermes*: A novel approach to combat multidrug resistant *Klebsiella pneumoniae* from *Musca domestica* in hospital landfills. *IPS Journal of Biotechnology and Applied Biochemistry, 1*(2), 82–92. https://doi.org/10.54117/ijbab.v1i2.111

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Assessment of blood indices in rats supplemented with Macrotermes-derived nutrient-enhanced bacteria. *IPS Journal of Basic and Clinical Medicine, 2*(4), 143–151. https://doi.org/10.54117/ijbcm.v2i4.39

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Exploring the potential of termite gut bacteria as growth promoters and organ function enhancers in albino Wistar rats. *Health Science Research International, 1*(2), 43–52. https://doi.org/10.54117/hsri.v1i2.38

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Assessment of hematological parameters in albino Wistar rats fed with *Rhynchophorus phoenicis* larvae enriched with autochthonous bacteria. *Health Science Research International*, *1*(2), 34–42. https://doi.org/10.54117/hsri.v1i2.37

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Entomopathogenic bacteria-mediated management of *Delia radicum*: A step towards eco-friendly pest control. *Journal of Agriculture, Food Technology and Sustainability, 2*(2), 112–121. https://doi.org/10.54117/jafts.v2i2.110

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Antimicrobial activity of Macrotermes-derived eluates against multidrug resistant Pseudomonas species: Implications for aquaculture disease management. *Journal of Agriculture, Food Technology and Sustainability, 2*(2), 102–111. https://doi.org/10.54117/jafts.v2i2.109

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Exploring the potential of entomopathogenic bacteria for sustainable management of *Sitophilus zeamais* in maize storage systems. *IPS Journal of Plant, Animal, and Environmental Sciences*, *1*(1), 11–20. https://doi.org/10.54117/ijpae.v1i1.108

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Biological control of

Acanthoscelides obteus using entomopathogenic bacteria. *IPS Journal of Plant, Animal, and Environmental Sciences, 1*(1), 1–10. https://doi.org/10.54117/ijpae.v1i1.107

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Modulation of phagocytic index in albino Wistar rats via bacterial symbionts from *Rhynchophorus phoenicis* larvae. *African Journal of Nutrition and Applied Research, 1*(2), 27–36. https://doi.org/10.54117/fm3vgt16

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Bacterial symbionts of insect larvae: A novel approach to improving micronutrient content. *African Journal of Nutrition and Applied Research*, *1*(2), 27–36. https://doi.org/10.54117/960k2266

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Unlocking the potential of termite gut microbiome: Enhancing nutritional value through bacterial symbionts. *IPS Journal of Nutrition and Food Science, 5*(1), 636–645. https://doi.org/10.54117/ae6gj081

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Enhancing nutritional parameters with bacterial symbionts from Macrotermes species: A potential frontier in nutritional biotechnology. *IPS Journal of Nutrition and Food Science, 5*(1), 625–635. https://doi.org/10.54117/a2b7jb52

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Bacterial symbionts of Macrotermes species: Assessing their impact on phagocytic indices of albino Wistar rats. *IPS Interdisciplinary Journal of Biological Sciences, 5*(1), 187–196. https://doi.org/10.54117/iijbs.v5i1.106

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Bacterial symbionts of insects: Exploring their role in insect nutritional composition. *IPS Interdisciplinary Journal of Biological Sciences, 5*(1), 177–186. https://doi.org/10.54117/iijbs.v5i1.105

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Augmenting rat lymphocyte function by bacterial symbiont of Macrotermes species. *IPS Journal of Applied Microbiology and Biotechnology, 5*(1), 281–290. https://doi.org/10.54117/ijamb.v5i1.104

Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025). Antimicrobial peptides from insects: A study on their efficacy against pathogens. *IPS Journal of Applied Microbiology and Biotechnology, 5*(1), 271–280. https://doi.org/10.54117/ijamb.v5i1.103

Iheukwumere, C. M., & Iheukwumere, I. H. (2022a). Nutritive and Antinutrient Values of Soybean Condiments Produced from Indigenous Fermenters. *IPS Applied Journal of Nutrition, Food and Metabolism Science*, 1(1): 1-5. https://doi.org/10.54117/iajnfms.v1i1.8

Iheukwumere, C. M., & Iheukwumere, I. H. (2022e). Hematological indices and sensory quality of fermented soybean condiments. *World Journal of Advanced Research and Reviews*, 14(2), 435-42

Iheukwumere, C. M., Ekesiobi, A. O., Iheukwumere, I. H., Ejike, C. E., Ilechukwu, C. C., Dim, C. N., & Ochibulu, S. C. (2025g). Dual Approach Therapy: Assessing Xylopia aethiopica and Ciprofloxacin Synergy against Salmonella enterica Serovar Typhi. *IPS Intelligentsia Multidisciplinary Journal*, *4*(1), 27–31. https://doi.org/10.54117/iimj.v4i1.9.

Iheukwumere, C. M., Ekesiobi, A. O., Iheukwumere, I. H., Ejike, C. E., Ilechukwu, C. C., Dim, C. N., Ochibulu, S. C., Unegbu, C. C., & Egbuna, C. (2025h). Food Safety Implications: Assessing the Potential of Desmodium velutinum Leaves Extracts to Control the Most Predominant Fungal Contamination in Ready-To-Eat Fried Chicken. *IPS Journal of Nutrition and Food Science*, *4*(3), 494–500. https://doi.org/10.54117/ijnfs.v4i3.111

Iheukwumere, C. M., Iheukwumere, I. H., Nwakoby, N. E., Idigo, M. A., & Ike, V. E. (2025m). Evaluation of fermented chicken feather meal as a dietary supplement on rat lipid metabolism and immune response. *African Journal of Nutrition and Applied Research, 1*(1), 17–26. https://doi.org/10.54117/qbwbpp15

Iheukwumere, C. M., Iheukwumere, I. H., Okoli, U. O., & Ugwu, C. H. (2023a). Immunological Impact of Fermented Soybean Condiments Produced from Indigenous Fermenters. *Journal of Advances in Microbiology* 23(10): 27-37

Iheukwumere, C. M., Iheukwumere, I. H., Ugwu, C. H., & Okoli, U. O. (2023b). Toxicity of Prepared Fermented Soybean Condiments from Indigenious Fermenters. *Journal of Advances in Microbiology* 23(10): 38 – 51.

Iheukwumere, C. M., Umeaku, C. N., Chukwura, E. N., & Iheukwumere, I. H. (2022f). Characterization of the indigenous fermenters for the production of fermented condiments from soybean seeds. *World Journal of Advanced Research and Reviews*, *14*(2), 423-434.

Iheukwumere, I. H., & Ejike, C. E. (2017b). Comparative study of the inhibitory activities of Ocimum gratissimum and Nepeta cataria against Salmonella enterica serovar Typhi and their larvicidal effect against Anopheles gambiae. *African Journal of Education, Science and Technology (AJEST)*, *3*(4), 16-24

Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A. ., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnadozie, C. H., Agbaugo, C. F., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025c). Exploring the Phytochemical and Antimicrobial Properties of Fruit Vinegar: A Study on Phoenix Dactylifera and Malus Sylvestris. *IPS Journal of Applied Microbiology and Biotechnology*, 4(1), 115–122. https://doi.org/10.54117/ijamb.v4i1.48

Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnadozie, C. H., Agbaugo, C. F., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025d). Microbial Quality and Sensory Assessment of Vinegar from Date Palm and Apple Fruits: Implications for Consumer Preference. IPS Journal of Nutrition and Food Science, 4(2), 410–417. https://doi.org/10.54117/ijnfs.v4i2.100.

Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnadozie, C. H., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025f). Safety Evaluation of Vinegar from Phoenix Dactylifera and Malus Sylvestris: Toxicity and Acetic Acid Content. IPS Journal of Applied Microbiology and Biotechnology, 4(1), 123–131. https://doi.org/10.54117/ijamb.v4i1.49

Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A. ., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnadozie, C. H., Agbaugo, C. F., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025k). Exploring the Phytochemical and Antimicrobial Properties of Fruit Vinegar: A Study on Phoenix Dactylifera and Malus Sylvestris. *IPS Journal of Applied Microbiology and Biotechnology*, 4(1), 115–122. https://doi.org/10.54117/ijamb.v4i1.48

Iheukwumere, I. H., Amadi, E. R., & Chude, C. (2018b). Synergistic Effects of Probiotics and Autogenous Bacterin Against Inositol Negative Motile Salmonella Species. *Journal of Biology, Agriculture and Healthcare* 8(6).

Iheukwumere, I. H., Amadi, R. E., Unaeze, B. C., & Campus, N. (2017c). Enterotoxigenicity Profile of Salmonella Enterica Serovar Typhimurium in Suckling Albino Mice. Journal of Natural Sciences Research 7(14).

Iheukwumere, I. H., Chukwura, E. I., & Chude, C. (2018c). In vivo activities of some selected antimicrobial agents against enteric bacteria isolated from chicken feeds on broiler layers. *Journal of Biology, Agriculture and Healthcare*, *8*(6).

Iheukwumere, I. H., Ejike, C. E., & Okeke, C. E. (2017d). A trial to prevent sorbitol negative Escherichia coli infections in chicks using autogenous bacteria and probiotics. *Journal of Natural Sciences Research*, *7*, 56-63.

Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., … Ihenatuoha, U. A. (2025a). Cross-Sectional Study of Different Strains of Bacillus cereus among Pap Sold in Major Towns in Ihiala LGA, Anambra State. IPS Journal of Public Health, 5(2), 199–204. https://doi.org/10.54117/ijph.v5i2.39.

Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., … Destiny, E. C. (2025b). Cross-Sectional Study of Major Strains of Salmonella enterica Subspecies Enterica Serovar Typhi among Borehole Used in Uli Community. IPS Journal of Public Health, 5(2), 205–210. https://doi.org/10.54117/ijph.v5i2.40.

Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., Udeagbara, O. E., Unaeze, B. C., Obiefuna, O. H., Ike, V. E., Onyemekara, N. N., & Ihenatuoha, U. A. (2025e). Quotidian of Substantial Strain of Shigella dysenteriae among Ready To-Eat Fruit Salad Sold in Uli Community. Journal of Pollution Monitoring, Evaluation Studies and Control, 4(1), 95–99. https://doi.org/10.54117/jpmesc.v4i1.17

Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., … Ihenatuoha, U. A. (2025i). Cross-Sectional Study of Different Strains of Bacillus cereus among Pap Sold in Major Towns in Ihiala LGA, Anambra State. IPS Journal of Public Health, 5(2), 199–204. https://doi.org/10.54117/ijph.v5i2.39.

Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., … Destiny, E. C. (2025j). Cross-Sectional Study of Major Strains of Salmonella enterica Subspecies Enterica Serovar Typhi among Borehole Used in Uli Community. IPS Journal of Public Health, 5(2), 205–210. https://doi.org/10.54117/ijph.v5i2.40.

Iheukwumere, I. H., Iheukwumere, M. C., & Nwakoby, N. E. (2022d). Sequential Pathogenicity Study of SOR+ and SOR-Escherichia coli Isolated from Roasted Meat. *IPS Intelligentsia Multidisciplinary Journal*, *1*(1), 1-11.

Iheukwumere, I. H., Nwankwo, A. K., Iheukwumere, C. M., Okorie, N. A., Nwakoby, N. E.,. Ekesiobi, A. O. and Okolo, O. C.. (2025n). Characterization and pathogenic profile of *Aspergillud fumigatus* isolated from lendfills. *Microbes and Infectious Diseases* 6(4)

Iheukwumere, I. H., Obi, P. C. and Unaeze, B. C. (2017a). A trial to prevent *Vibrio cholerae* in albino mice using autogenous bacterin. *Advances in Life Science and Technology* 58:34–42

Iheukwumere, I. H., Uneze, B. C., & Ejike, C. E. (2017e). Efficacy of some selected antimicrobial substances in prevention of enteric bacterial infection in broiler chicks. *J. Biol. Agriculture. Healthcare*, *7*, 58-66.

Iheukwumere, I.H. , Iheukwumere, C.M. , Nnadozie, H. C. ,Unaeze, C.B. , Obiefuna, O.H. Obianom, A.O. and Ejike, C. E. (2024). Hematotoxicological and mosquito larvicidal studies of crystal proteins secreted by Bacillus thuringiensis and Bacillus sphaericus. *Tropical Journal of Applied Natural Sciences* 2(2): 61 – 92.

Iheukwumere, I.H. and Iheukwumere, M.C. (2022c). Streptococcus suis in Pigs and Environs: A Cross-sectional Study. IPS Journal of Public Health, 1(2), 9-12. https://doi.org/10.54117/ijph.v1i2.4.

Iheukwumere, I.H. and Iheukwumere, M.C. (2022g). Cross-sectional Study of Multiple Antibiotic-resistant Streptococcus suis in Pigs and Environments. IPS Interdisciplinary Journal of Biological Sciences, 1(1), 19–21. https://doi.org/10.54117/iijbs.v1i1.4

Iheukwumere, I.H., Dimejesi, S.A.,Iheukwumere, C.M., Chude, C.O., Nwaolisa, C.N.,Ukoha, C.C., Nwakoby,N.E., Egbuna, C. and Egbe, P.A. (2020) Diversity and molecular characterization of keratinophilic fungi from soil samples. *International Journal of Research Publication* 50(1); 1047 -1062.

Iheukwumere, I.H., Iheukwumere, M.C. and Nwakoby, N.E. (2022b). Synergistic Effects of Probiotics and Autogenous Bacterin against Salmonella enterica Serovar Typhimurium Strain U288. IPS Journal of Nutrition and Food Science, 1(1), 1–5. https://doi.org/10.54117/ijnfs.v1i1.3.

Iheukwumere, I.H., Nwike, M. I., Iheukwumere, C.M., Ike, V.E., Obianom, A.O., Ihenatuoha, U.A., Igboanugo, E.U., Ekesiobi, A.O., Okereke, F.O., Obiefuna, O. H. Nnadozie, C.H., Agbaugo, C.F., Oduoye, O.T., Nwakoby, N.E., Ilechukwu, C. C.,, Ochibulu, S. C. and Ejike, C. E. (2025l). Extraction and Elucidation of Antibiotics from the Mycelia of Aspergillus niger Isolated from Poultry Farm against Enteric Bacterial Pathogens. *IPS Journal of Advanced and Applied Biochemistry*, 1(1), 1–10. https://doi.org/10.54117/ijaab.v1i1.58.

Iheukwumere,I.H., Iheukwumere,C.M., Chude, C.O., Nwaolisa,C.N. and Egbe, P.A. (2020a). Comparative study of different clinical samples used for the diagnosis of staphylococcal systemic infections in appearent healthy students. *International Journal of Research Publications* 49(1): 1 – 10

Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025a). Prevalence of Bacillus cereus in Powdered Soybean Sold in Uli Community, Anambra State: A Cross-Sectional Study. *IPS Journal of Basic and Clinical Medicine*, *2*(3), 108–114. https://doi.org/10.54117/ijbcm.v2i3.18

Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025b). *Bacillus cereus in Uli's cornflour: A prevalence study*. *IPS Journal of Nutrition and Food Science*, *4*(3), 544–548. https://doi.org/10.54117/8btte840

Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025c). Pathogenic Profile Analysis: In Vitro Screening of Enteric Bacteria from University Dusters. *IPS Journal of Applied Microbiology and Biotechnology*, *4*(3), 187–191. https://doi.org/10.54117/ijamb.v4i3.76

Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025d). Frozen Fish Pathogens: Antimicrobial Resistance and Public Health Implications. *IPS Interdisciplinary Journal of Biological Sciences*, *4*(4), 138–143. https://doi.org/10.54117/iijbs.v4i4.77

Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025e). Stream water quality assessment: Antibiotic resistance of Lac-positive enteric bacterial isolates. *Journal of Pollution Monitoring, Evaluation Studies and Control*, *4*(2), 120–125. https://doi.org/10.54117/jpmesc.v4i2.21.2025

Kabir, S. M. L. (2009). The role of probiotics in the poultry industry. International Journal of Molecular Sciences, 10(8), 3531-3546.

Kabir, S. M. L. (2009). The role of probiotics in the poultry industry. International Journal of Molecular Sciences, 10(8), 3531-3546.

Ke, K., Sun, Y., He, T., Liu, W., Wen, Y., Liu, S., ... & Gao, X. (2024). Effects of feather hydrolysates generated by probiotic Bacillus licheniformis WHU on gut microbiota of broiler and common carp. *Journal of Microbiology*, *62*(6), 473-487.

Kim, J., Lee, H., & Kim, Y. (2018). Effects of fermented milk products on cholesterol and blood pressure: A review of clinical trials. *Journal of Dairy Science*, *101*(4), 2724–2741. https://doi.org/10.3168/jds.2017-13708

Kim, S. K., Kim, T. H., Lee, S. K., Chang, K. H., Cho, S. J., Lee, K. W., & An, B. K. (2016). The Use of Fermented Soybean Meals during Early Phase Affects Subsequent Growth and Physiological Response in Broiler Chicks. *Asian-Australasian Journal of Animal Sciences*, *29*(9), 1287. https://doi.org/10.5713/ajas.15.0653

Le Doare, K., Holder, B., Bassett, A., & Pannaraj, P. S. (2020). Mother's milk: A purposeful contribution to the development of the infant microbiota and immunity. *Frontiers in Immunology*, *11*, 362. https://doi.org/10.3389/fimmu.2020.00362

Li, Y., Guo, B., Wu, Z., Wang, W., Li, C., Liu, G., & Cai, H. (2020). Effects of Fermented Soybean Meal Supplementation on the Growth Performance and Cecal Microbiota Community of Broiler Chickens. *Animals*, *10*(6), 1098. https://doi.org/10.3390/ani10061098

Lv, W., Ma, Y., Zhang, Y., Wang, T., Huang, J., He, S., Du, H., & Guo, S. (2023). Effects of Lactobacillus plantarum fermented Shenling Baizhu San on gut microbiota, antioxidant capacity, and intestinal barrier function of yellow-plumed broilers. *Frontiers in Veterinary Science*, *10*, 1103023. https://doi.org/10.3389/fvets.2023.1103023

Manasseh, C.O., Logan, C.S.P., Ikeyi, A.P., Ede, K.K., Iheukwumere, I.H., Iheukwumere, C.M. and Ejike, C.E. (2025). Investigating the Effects of the Covid-19 Pandemic and Climate Risks on Trade Balance in Emerging Markets. *The Nigerian Health Journal* 25(2): 1-27. https://doi.org/10.71637/tnhj.v25i2.914

Mannan, S. J., Rezwan, R., Rahman, M. S., & Begum, K. (2017). Isolation and biochemical characterization of Lactobacillus species from yogurt and cheese samples in Dhaka metropolitan area. *Bangladesh Pharmaceutical Journal*, *20*(1), 27-33.

Marco, M. L., Sanders, M. E., Gänzle, M., Arrieta, M. C., Cotter, P. D., De Vuyst, L., ... & Hutkins, R. (2021). The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on fermented foods. *Nature Reviews Gastroenterology and Hepatology*, *18*(3), 196–208. https://doi.org/10.1038/s41575-020-00390-5

Melini, F., Melini, V., Luziatelli, F., Ficca, A. G., & Ruzzi, M. (2019). Health-promoting components in fermented foods: An up-to-date systematic review. *Nutrients*, *11*(5), 1189. https://doi.org/10.3390/nu11051189

Meyer, B., Bessei, W., Vahjen, W., Zentek, J., & Harlander-Matauschek, A. (2012). Dietary inclusion of feathers affects intestinal microbiota and microbial metabolites in growing Leghorn-type chickens. *Poultry Science*, *91*(7), 1506-1513. https://doi.org/10.3382/ps.2011-01786

Million, M., Maraninchi, M., Henry, M., Armougom, F., Richet, H., Carrieri, P., ... & Raoult, D. (2012). Obesity-associated gut microbiota characterized in an African cohort. International Journal of Obesity, 36(4), 527-535.

Mohammadi, F., Ebrahimnezhad, Y., & Maheri-Sis, N. (2021). Fermented fish meal as a feed ingredient: Nutritional properties and effects on livestock performance. *Journal of Animal Physiology and Animal Nutrition*, *105*(4), 795–805. https://doi.org/10.1111/jpn.13497

Mountzouris, K. C., Tsirtsikos, P., Kalamara, E., Nitsch, S., Schatzmayr, G., & Fegeros, K. (2010). Evaluation of the efficacy of a probiotic containing Bacillus licheniformis and Bacillus subtilis spores on the performance and carcass yield of broilers. Livestock Science, 130(1-3), 141-146.

Mountzouris, K. C., Tsirtsikos, P., Kalamara, E., Nitsch, S., Schatzmayr, G., & Fegeros, K. (2010). Evaluation of the efficacy of a probiotic containing Bacillus licheniformis and Bacillus subtilis spores on the performance and carcass yield of broilers. Livestock Science, 130(1-3), 141-146.

Nwike, M.I., Iheukwumere, I.H. and Uneze, B.C. (2017). Effect of Spices, pH and Temperature on the Survival and Multiplication of Staphylococcus aureus in Locally Made Soya Milk Drink. *Journal of Natural Sciences Research* 7(4).

Obianom, A.O. , Iheukwumere, I.H. , Iheukwumere, C.M. , Ochibulu, S.C., Nnadozie, H. C. and Ifenetu, F. C. (2024). Supersizing the inhibitory activity of Xylopia aethiopica extract against Vibrio cholerae using doxycycline. *Tropical Journal of Applied Natural Sciences* 2(2).

Obiefuna, U. G., Umeh, S. O., & Iheukwumere, I. H. (2025a). Assessing the Impact of Glycemic Index on Microbial Quality and Storage Stability of Tomato Jam. *IPS Journal of Applied Microbiology and Biotechnology*, *4*(3), 192–202. https://doi.org/10.54117/ijamb.v4i3.81

Obiefuna, U. G., Umeh, S. O., & Iheukwumere, I. H. (2025b). Physicochemical and nutritional properties of tomato jam: Influence of sweetener type and glycemic index. *IPS Journal of Nutrition and Food Science*, *4*(3), 561–568. https://doi.org/10.54117/yazv0114

Obiefuna, U. G., Umeh, S. O., & Iheukwumere, I. H. (2025c). Micronutrient profile and acceptability of tomato jam: A comparison of high and low glycemic carbohydrate index sweeteners. *IPS Applied Journal of Nutrition, Food and Metabolism Science*, *3*(2), 67–74. https://doi.org/10.54117/pr4r6c73

Oboh, G., Ogunruntun, M. B., & Alabi, M. O. (2012). Reduction of cyanide content and improvement of nutritional quality of sweet potato (Ipomoea batatas) by fermentation with Lactobacillus plantarum. Nutrition & Food Science, 42(1), 24-31.

Ojha, S., Bekhit, A. E. D. A., & Grøgaard, J. (2018). Fermentation of fish meal with lactic acid bacteria: Effects on protein quality and lipid stability. Journal of Food Science, 83(5), S1444-S1453.

Okeke, C. E. Iheukwumere, I. H. Ejike, C.E. (2017). Pathogenicity Study of Dematiaceous Fungi Isolated from Chicken Feeds on Immunoincompetent Chickens. *J. Biol. Agriculture. Healthcare* 7(4).

Okunola, A. O., Adeyemo, S. M., & Ogunremi, O. R. (2019). Sweet potato peel as a potential feed ingredient for livestock: A review. Journal of Animal Science and Technology, 61(3), 131-141.

Omar, A. E., S., H., Ismail, T. A., M., R., M., S. A., Shalaby, S. I., & Ibrahim, D. (2021). Performance, Serum Biochemical and Immunological Parameters, and Digestive Enzyme and Intestinal Barrier-Related Gene Expression of Broiler Chickens Fed Fermented Fava Bean By-Products as a Substitute for Conventional Feed. *Frontiers in Veterinary Science*, *8*, 696841. https://doi.org/10.3389/fvets.2021.696841

Onunkwo, D. N., & Ekine, O. A. (2020). Performance of broiler chickens fed diet containing fermented maize milling waste. *Nigerian Journal of Animal Production*, *47*(1), 214–220.

Ouwehand, A. C., Forssten, S. D., Hibberd, A. A., & Tiihonen, K. (2022). Probiotic and other functional microbes: From foods to health applications. *Current Opinion in Biotechnology*, *73*, 237-242. https://doi.org/10.1016/j.copbio.2021.07.001

Park, K. Y., Jeong, J. K., Lee, Y. E., & Daily, J. W. (2021). Health benefits of kimchi (Korean fermented vegetables) as a probiotic food. *Journal of Medicinal Food*, *27*(3), 365–375. https://doi.org/10.1089/jmf.2020.0155

Premathilaka, K. T., Nawarathne, S. R., Nambapana, M. N., Macelline, S. P., Wickramasuriya, S. S., Ang, L., Jayasena, D. D., & Heo, J. M. (2020). Partial or complete replacement of fishmeal with fermented soybean meal on growth performance, fecal composition, and meat quality in broilers. *Journal of Animal Science and Technology*, *62*(6), 824. https://doi.org/10.5187/jast.2020.62.6.824

Safari, H., & Mohit, A. (2024). Feather meal processing methods impact the production parameters, blood biochemical indices, gut function, and hepatic enzyme activity in broilers. *Journal of Animal Science*, *102*. https://doi.org/10.1093/jas/skae068

Safari, H., Mohit, A., & Mohiti-Asli, M. (2024). Fermented feather meal improves the antioxidant status, meat quality, and immune response of broilers. *Iran J Vet Med*, 1-43.

Salehizadeh, M., Ebrahimi, M. T., Mousavi, S. N., Sepahi, A. A., & Orooji, R. (2025). Transforming Feather Meal Into a High-Performance Feed for Broilers. *Veterinary Medicine and Science*, *11*(1), e70199. https://doi.org/10.1002/vms3.70199

Salim, H. M., Kang, H. K., Akter, N., Kim, D. W., Kim, J. H., Kim, M. J., ... & Kim, W. K. (2013). Effects of dietary probiotic supplementation on growth performance, immune response, and gut health in broiler chickens. Journal of Animal Science, 91(9), 4311-4321.

Savaiano, D. A., & Hutkins, R. W. (2020). Yogurt, cultured fermented milk, and health: A review. *Nutrients*, *12*(5), 1256. https://doi.org/10.3390/nu12051256

Soumeh, E., Mohebodini, H., Toghyani, M., Shabani, A., Ashayerizadeh, A., & Jazi, V. (2019). Synergistic effects of fermented soybean meal and mannan-oligosaccharide on growth performance, digestive functions, and hepatic gene expression in broiler chickens. *Poultry Science*, *98*(12), 6797-6807. https://doi.org/10.3382/ps/pez409

Stanton, C., Ross, R. P., Fitzgerald, G. F., & van Sinderen, D. (2021). Fermented functional foods: Trends and challenges. *Current Opinion in Food Science*, *40*, 114–122. https://doi.org/10.1016/j.cofs.2021.02.005

Sugiharto, S., & Ranjitkar, S. (2019). Recent advances in fermented feeds towards improved broiler chicken performance, gastrointestinal tract microecology and immune responses: A review. *Animal Nutrition*, *5*(1), 1-10. https://doi.org/10.1016/j.aninu.2018.11.001

Taheri, H. R., Moravej, H., Tabandeh, F., Zaghari, M., & Shivazad, M. (2009). Screening of Lactobacilli bacteria isolated from gastrointestinal tract of broiler chickens for their use as probiotic. African Journal of Microbiology Research, 3(8), 422-427.

Tufail, M., Hussain, S., Malik, F., Mirza, T., Parveen, G., Shafaat, S., ... & Sadiq, A. (2011). Isolation and evaluation of antibacterial activity of bacteriocin produced by Lactobacillus bulgaricus from yogurt. *African Journal of Microbiology Research*, *5*(22), 3842-3847.

Ugwu, C. H., Iheukwumere, I. H., Iheukwumere, C. M., Ike, V. E., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025a). Maternal health and antibiotic resistance: *Klebsiella pneumoniae* isolates analysis. *IPS Journal of Public Health, 5*(3), 290–295. https://doi.org/10.54117/s3tx6v26

Ugwu, C. H., Iheukwumere, I. H., Iheukwumere, C. M., Ike, V. E., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025b). Ocimum gratissimum Extract's Effectiveness against Vibrio cholerae from Uli Streams. *IPS Journal of Phytochemistry and Medicinal Plant Research*, *1*(2), 15–19. https://doi.org/10.54117/ijpmpr.v1i2.38

Wang, C., Liu, J., & Wang, Y. (2021). Microbial fermentation of feed and its impact on nutrient utilization and animal performance. *Journal of Applied Microbiology, 130*(3), 869–879. https://doi.org/10.1111/jam.14873

Wang, J., Yao, L., Su, J., Fan, R., Zheng, J., & Han, Y. (2023). Effects of Lactobacillus plantarum and its fermentation products on growth performance, immune function, intestinal pH, and cecal microorganisms of Lingnan yellow chicken. *Poultry Science*, *102*(6), 102610. https://doi.org/10.1016/j.psj.2023.102610

Wastyk, H. C., Fragiadakis, G. K., Perelman, D., Dahan, D., Merrill, B. D., Yu, F. B., ... & Sonnenburg, J. L. (2021). Gut-microbiota-targeted diets modulate human immune status. *Cell*, *184*(16), 4137–4153.e14. https://doi.org/10.1016/j.cell.2021.06.019

WHO (2018). Antimicrobial resistance: Global report on surveillance. World Health Organization.

Xiao, C., Li, X., Ding, Z., Zhang, H., Lv, W., Yang, C., He, D., & Zhu, L. (2023). Enhancing Growth and Gut Health in Squabs: The Impact of Fermented Mixed Feed. *Animals*, *14*(10), 1411. https://doi.org/10.3390/ani14101411

Xu, Y., Yang, H., Zhang, L., Wang, T., & Mu, X. (2021). Effects of fermented feed on growth performance, nutrient digestibility, and intestinal morphology in broilers. *Poultry Science*, *100*(1), 93–100. https://doi.org/10.1016/j.psj.2020.09.079

Yan, L., An, S., Lv, X., Lv, Z., Zhang, B., Choct, M., Guo, Y., Wang, Z., Yan, B., & Li, Y. (2025). Effects of replacing soybean meal with cottonseed meal on growth performance, carcass trait, intestinal development and intestinal microbiota of broiler chickens. *Poultry Science*, *104*(2), 104653. https://doi.org/10.1016/j.psj.2024.104653

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. *Journal of Animal Science*, *100*(5). https://doi.org/10.1093/jas/skac130

Yeh, R., Hsieh, C., & Chen, K. (2023). Two-Stage Fermented Feather Meal Enhances Growth Performance and Amino Acid Digestibility in Broilers. *Fermentation*, *9*(2), 128. https://doi.org/10.3390/fermentation9020128

Yu, L., Zhihui, C., Hongzhi, W., Fengjie, J., Yang, L., Jianing, L., ... & Liangmei, X. (2024). Effects of Fermented Puffed Feather Meal on Growth Performance, Serum Biochemical Indices, Meat Quality, and Intestinal Microbiota in Broilers. *Journal of Northeast Agricultural University*, *31*(3).

Zhang, Y., Liu, Y., Lv, L., & Wang, J. (2021). Probiotics in the prevention and treatment of colorectal cancer. *Frontiers in Immunology*, *12*, 714947. https://doi.org/10.3389/fimmu.2021.714947

Zhang, Z., Chen, C., & Wu, Q. (2022). Fermented feed additives and their effects on poultry production: A review. *Frontiers in Veterinary Science*, *9*, 883026. https://doi.org/10.3389/fvets.2022.883026

Zhao, L., Zhang, F., Ding, X., Wu, G., Lam, Y. Y., Wang, X., ... and Zhang, C. (2022). Gut bacteria selectively promoted by dietary fibers alleviate type 2 diabetes. *Science*, *359*(6380), 1151-1156. https://doi.org/10.1126/science.aao5774