

Effects of Commercial Feed and On-Farm Formulated Feed on the Gut Microbiota of Broiler Chickens

¹Wayebo H. Kehinde, ¹Sophie Stephen, ¹Rahab S. Makama and ²Collins U. Idachaba

Department of Animal Science, Faculty of Agriculture,
Kaduna State University, Kafanchan Campus, Kaduna, Nigeria

Corresponding author: yebokenny@mail.com. +2348066245044

Abstract

*The poultry industry plays a significant role in global meat production, with broiler chickens being crucial due to their efficient feed-to-meat conversion. The study investigated how commercial feeds and on-farm formulated feeds affected the gut microbiota composition of broiler chickens during the finisher phase at the Teaching and Research Farm of Kaduna State University in Kafanchan. One hundred and forty-four Cobb day-old broiler chicks were randomly assigned to four dietary treatments: T1 (Top Feeds commercial feed A), T2 (Hybrid commercial feed B), T3 (Chikun commercial feed C), and T4 (on-farm formulated feed), in a completely randomized design, with each treatment having four replicates of 12 birds each. At six weeks, samples from six different intestinal segments and cloacal swabs were collected and analyzed for microbial populations using standard microbiological techniques. Data were subjected to analysis of variance (ANOVA) using the general linear model of SAS Institute Inc. (2006), and differences between treatment means were separated using Duncan's Multiple Range Test. Results showed diverse bacterial communities across all diets, with *Escherichia coli* present in every case. Commercial feeds supported greater diversity and higher populations of beneficial bacteria such as *Bacillus* spp., likely due to their nutrient composition and the inclusion of prebiotics and probiotics. Conversely, on-farm formulated feeds promoted higher total bacterial counts in certain gut sections, indicating a more diverse microbial environment. Significant differences ($P < 0.05$) in key microbial counts, such as total bacterial, coliform, and enterococci counts, were observed among diets, reflecting variations in feed composition and additive content. Notably, commercial Feed C (Chikun) showed elevated enteric coliform counts, raising concerns about possible gut dysbiosis. These findings underscore the critical role of feed formulation in shaping gut microbial diversity and composition, with direct implications for*

nutrient absorption, immune modulation, and overall broiler performance. It is recommended that poultry producers carefully consider feed type and its additive content when targeting optimal gut health outcomes, and that future studies examine the long-term effects of feed formulation on broiler productivity under local conditions.

Keywords: Broiler chicken, Gut microbiota, Commercial feed, On-farm feed, Microbial diversity

1.0 Introduction

The poultry industry is a vital sector of global livestock production, with broiler chickens serving as a primary source of high-quality animal protein due to their rapid growth and efficient feed conversion (Sam *et al.*, 2019; Sam *et al.*, 2025; Udo *et al.*, 2025). The gut microbiota, which consists of a diverse community of microorganisms within the gastrointestinal tract, is fundamental to this efficiency because it regulates nutrient absorption, modulates the immune system, and provides a barrier against pathogenic colonization (Zhao *et al.*, 2025). Yue *et al.* (2024) emphasized that poultry accounts for more than one-third of total global meat output, making the health of these birds essential for global protein security. However, these microbial communities are highly sensitive to dietary shifts. Any imbalance, known as dysbiosis, can lead to poor weight gain and significant economic losses. Recent estimates suggest that subclinical enteric issues can reduce feed efficiency by up to 5% and increase mortality rates, leading to substantial financial drains on poultry enterprises (Adhikari and Kim, 2017).

Feeding practices in Nigeria involve a choice between commercial proprietary feeds and on-farm formulated diets. While commercial feeds are standardized and often fortified with prebiotics and probiotics, on-farm formulated feeds offer cost-saving advantages by using local ingredients (Muyyarikkandy *et al.*, 2023). Despite the importance of these feeding strategies, there is a lack of comparative data on how they specifically alter the microbial landscape during the finisher phase in North Central Nigeria. Most of the research available in the region has focused on general performance metrics or growth rates; however, no study has yet provided a detailed comparison of microbial populations across specific intestinal segments, such as the duodenum, ileum, and caecum, in Kafanchan. While studies in other regions have shown that diet can shift microbial diversity by over 20% (Cullen *et al.*, 2021), research has not been conducted in this key poultry producing region to verify these effects under local conditions.

This study will provide valuable insights for animal scientists, feed millers, and poultry producers, by comparing the effects of different commercial brands and on farm formulated diets on the microbial diversity of broiler chickens. The value of this study lies in its ability to pinpoint which feeding patterns promote beneficial bacteria like *Bacillus spp.* and which may inadvertently foster pathogenic coliforms, which are indicators of gut health and potential disease (Morrison *et al.*, 2019). Identifying these shifts is critical for developing nutritional management protocols that reduce the risk of enteric infections and improve the economic sustainability of farms in Kaduna State.

The objective of this study therefore was to investigate and compare the effects of three commercial feeds and one on farm formulated feed on the gut microbiota composition and population across various intestinal segments of broiler chickens.

2.0 Material and Methods

2.1 Study/location

The study was conducted at the Teaching and Research Farm, Animal Science Department, Kaduna State University (KASU), Kafanchan Campus, Kaduna State. Kafanchan is located at a latitude of 9°59'N, longitude 8°29'E, and it is situated at an elevation of 733m above sea level (World Atlas, 2018). The town experiences zero rainfall at the beginning and end of the year, with an average yearly precipitation of approximately 28.1mm (1.11 inches) and an average annual rainfall of 53.7% (KMCA, 2018).

2.2 Sources of Ingredients and Experimental Birds

The ingredients, such as maize and soybeans, were purchased at Kafanchan market, while the other ingredients, such as bone meal, lysine, methionine, groundnut cake, and premix, were purchased from a reputable feed miller from Jos metropolis.

One hundred and forty (144) Cobb day-old broiler chicks were purchased from a reputable hatchery in Kaduna state.

2.3 Experimental Design and Management of Birds

A total of one hundred and forty-four (144) Cobb day-old broiler chicks were purchased from a reputable hatchery in Kaduna State. A completely randomized design (CRD) was employed, consisting of three treatments and four replicates, with each replicate containing 12 birds. The chicks were housed in a deep litter system that had been thoroughly cleaned, washed, disinfected, and left to rest for a few weeks before their arrival. Feed was provided ad libitum. The vaccination schedule for broiler chickens was followed according to the guidelines set by the National Veterinary Research Institute in Vom, Plateau State. Routine management practices were conducted properly and on schedule.

2.4 Data Collection of the Microbiomes

At 6 weeks of experiment, 2 birds were sacrificed per treatment. Segments of approximately 9 cm in length were aseptically excised from 6 segments of the intestine. The ileum, duodenum, jejunum, colon, caecum, and rectum samples of the intestine were put into an EDTA container, a cloacal swab was also carried out, and were taken to the laboratory within a few hours. The test was carried out in the National Veterinary Research Institute, Vom, Jos.

2.5 Administration of Experimental Diet

A randomized controlled trial was conducted to compare the effects of commercial feed and formulated feed on broiler chickens. The experiment was carried out over a period of six weeks. Four dietary treatments were evaluated: T1 (commercial feed A—Top Feed), T2 (commercial feed B—Hybrid), T3 (commercial feed C—Chikun), and T4 (on-farm compounded feed), all

administered at the finisher phase. The experimental diets were formulated to meet the nutrient requirements of chickens as recommended by NRC (2010).

2.6 Data Analysis

Data collected were subjected to analysis of variance (ANOVA), using the general linear model of Statistical Analysis System (SAS) Institute Inc. (2006), and differences between means of various treatments were separated using Duncan's Multiple Range Test (Duncan, 2010)

Table 2.1a: Ingredients composition of On-farm formulated feeds

Ingredients	Starter Diet	Finisher Diet
Maize	56.25	55.00
Maize offal	-	10.00
Groundnut cake (GNC)	11.00	10.00
Soybean cake (SBC)	28.30	20.55
Limestone	0.50	0.50
Bone meal	2.90	3.00
Salt	0.25	0.25
Premix	0.25	0.25
Lysine	0.25	0.20
Methionine	0.30	0.25
Biotronics Top forte (Non inclusive part of the diet)	150g	150g
Total	100	100

Table 2.1b Calculated analysis of commercial and formulated on-farm feed

Calculated Analysis	Starter			Finisher			
	T1	T2	T3	T1	T2	T3	T4
Crude protein	23.01	22.00	22.00	20.00	18.00	18.00	18.00
ME (kcal/kg)	2901.0	2950	3000	2905.16	3150	2986	3000
Ether extract	4.69	4.00	5.10	4.47	5.00	4.89	4.65
Crude fiber	4.25	5.00	4.30	4.57	5.00	4.10	4.42
Calcium	1.02	1.00	1.20	1.03	0.85	1.31	1.10
Available Phosphorus	0.5	0.50	0.45	0.52	0.42	0.40	0.40
Lysine	1.36	1.33	1.30	1.11	1.05	1.26	1.08
Methionine + Cyst	0.96	0.60	0.56	0.83	0.46	0.52	0.70

ME= metabolizable energy, Cyst= Cysteine

3.0 Results

3.1 Microbial Communities Present in the Gut of Broiler Chickens Fed with Different Feeds

Figure 3.1 shows the microbial communities in the segment of the intestine of broiler finisher chickens fed with different diets: commercial and on-farm formulated feeds. The results revealed a variety of bacterial isolates across different gut sections, with *Escherichia coli*, *Bacillus* spp., and *Proteus mirabilis* being the most frequently identified. Notably, *E. coli* was present in all feed types, suggesting its resilience in the gut environment, while other isolates varied significantly based on the type of feed provided.

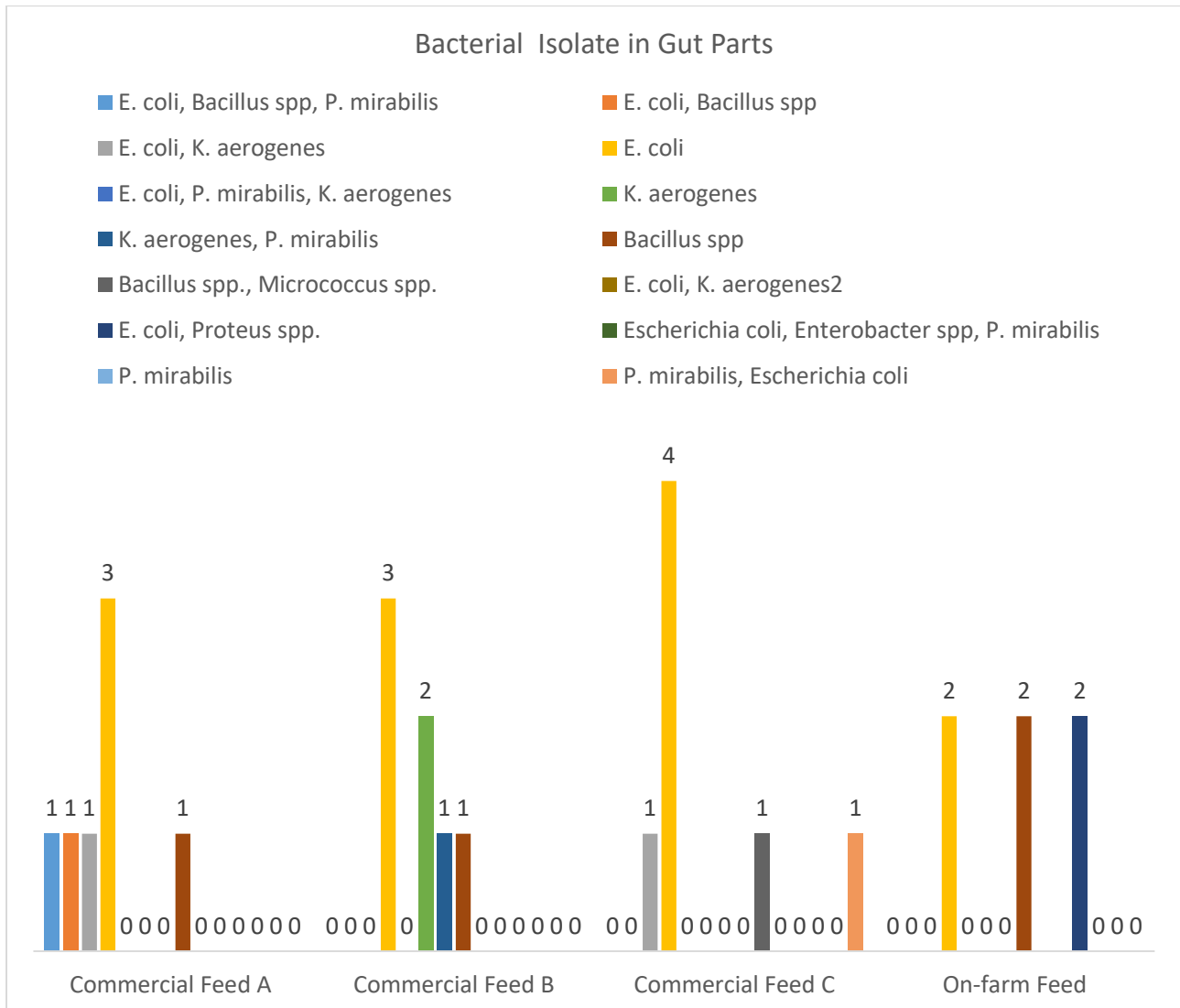


Figure 3.1: Bacterial Isolate in Gut Parts

3.2 Diversity and Composition of the Gut Microbiota between Feeds

Table 3.1 reveals the microbial diversity across different gut parts of broiler chickens fed with three types of commercial feeds and one on-farm formulated feed. The parameters measured included Total Bacterial Count (TBC), Total Coliform Count (TCC), Total E. coli Count (TEcC), Total Klebsiella Count (TkaC), Total Salmonella Count (TSalC), and Total Proteus Count (TPrC). The result indicates significant variations ($P < 0.05$) in microbial populations depending on the type of feed administered. Results indicated that the on-farm feed group showed significantly higher microbial diversity than the commercial feed groups, especially in the duodenum and jejunum sections. The TBC in the duodenum for on-farm feed reached 1.17×10^5 CFU/g, while commercial feeds ranged from 6.75×10^4 to 2.23×10^5 CFU/g. This suggests that on-farm feeds may promote a more diverse microbial environment conducive to gut health. The p-values for TBC and TCC in the on-farm feed were significantly lower than those in commercial feeds, indicating a statistically significant difference in microbial composition ($p < 0.05$).

3.3 Cloacal Swabs: Diversity and Composition of the Gut Microbiota between Feeds

The findings of cloacal swabs provided important insights into the diversity and composition of gut microbiota in broiler chickens on various diets (Table 3.2). The results indicate that while the overall microbial counts are relatively similar across the different feed types, there are significant differences in the composition of specific bacterial populations. The total bacterial count (TBC) for cloacal swabs across different feed types ranged from 3.65×10^4 to 3.90×10^4 CFU/g. There were no statistically significant differences among the various feed types ($p = 0.9957$).

4.0 Discussion

The gut microbiota of broiler chickens is a complex ecosystem that plays a vital role in their health and growth performance. For instance, certain commercial feeds promoted a higher diversity of beneficial bacteria than on-farm formulated feeds, which exhibited a more limited microbial profile (de Souza *et al.*, 2022; Bullon *et al.*, 2023). The differences observed in microbial composition can be attributed to the commercial feeds nutritional content and additives (Figure 3.1). Commercial feeds are often designed to meet specific nutrient requirements and may include probiotics and prebiotics that enhance gut health. These additives can selectively promote beneficial bacteria, such as *Bacillus* spp., which are known for their probiotic properties. These bacteria can inhibit pathogens and improve nutrient absorption (Adhikari and Kim, 2017). Conversely, on-farm formulated feeds may lack these enhancements, leading to a less diverse microbiota that could compromise gut health and overall performance (Bishop and Scholey, 2023). The findings align with previous studies indicating that dietary interventions significantly influence gut microbiota composition and functionality (So *et al.*, 2018; Leeming *et al.*, 2019).

Table 3.1: Diversity and composition of the gut microbiota between feeds

Feed type	Gut Part	Parameters					
		TBC	TCC	TEcC	TkaC	TSalC	TPrC
Commercial Feed A	Duodenum	1.51×10 ⁵	4.80×10 ⁵	7.15×10 ⁴	0.00	-	8000
	Jejunum	5.20×10 ⁴	2.10×10 ⁴	1.25×10 ⁴	0.00	-	0.00
	Ileum	3.25×10 ⁴	4.00×10 ⁴	3.00×10 ⁴	0.00	-	0.00
	Colon	1.07×10 ⁵	6.85×10 ⁴	3.70×10 ⁴	6500	-	4500
	Caecum	5.80×10 ⁴	5.50×10 ⁴	2.15×10 ⁵	5500	-	1000
	Rectum	3.95×10 ⁴	1.40×10 ⁴	1.15×10 ⁴	0.00	-	0.00
	SEM	48864	247973	29109	5379	-	5722
	p-value	0.2697	0.4716	0.4319	0.6642	-	0.6643
Commercial Feed B	Duodenum	6.75×10 ⁴	4.40×10 ⁴	0.00	2700 ^a	-	14000 ^a
	Jejunum	8.00×10 ⁴	3.25×10 ⁴	0.00	19000 ^{ab}	-	0.00 ^b
	Ileum	2.30×10 ⁴	1.20×10 ⁴	0.00	4500 ^{bc}	-	0.00 ^b
	Colon	3.45×10 ⁴	1.05×10 ⁴	8.00×10 ³	0.00 ^c	-	0.00 ^b
	Caecum	7.55×10 ³	1.25×10 ⁴	7.00×10 ³	0.00 ^c	-	0.00 ^b
	Rectum	5.95×10 ⁴	0.00	0.00	0.00 ^c	-	0.00 ^b
	SEM	31924	10425	2886.8	3840.6	-	2886.8
	p-value	0.3223	0.0530	0.0920	0.0030 [*]	-	0.0206
Commercial Feed C	Duodenum	2.23×10 ⁵	6.15×10 ⁴	6.80×10 ^{4a}	12500	-	-
	Jejunum	1.42×10 ⁵	6.40×10 ⁴	3.50×10 ^{4ab}	0.00	-	-
	Ileum	8.30×10 ⁴	1.60×10 ⁴	9.50×10 ^{3b}	3000	-	-
	Colon	4.00×10 ⁴	2.15×10 ⁵	5.00×10 ^{3b}	0.00	-	-
	Caecum	2.00×10 ⁵	2.75×10 ⁴	2.15×10 ^{4ab}	0.00	-	-
	Rectum	4.65×10 ⁴	0.00	0.00 ^b	0.00	-	-
	SEM	75866	35887	11150	7751.3	-	-
	p-value	0.2126	0.4887	0.0114 [*]	0.5767	-	-
On-farm feed	Duodenum	1.17×10 ^{5a}	6.95×10 ⁴	5.15×10 ^{4a}	-	-	-
	Jejunum	2.02×10 ^{5b}	5.20×10 ⁴	2.35×10 ^{4ab}	-	-	-
	Ileum	4.25×10 ^{4cd}	1.45×10 ⁴	1.20×10 ^{4b}	-	-	-
	Colon	6.30×10 ^{4c}	1.05×10 ⁴	1.00×10 ^{3b}	-	-	-
	Caecum	2.65×10 ^{4cd}	9.50×10 ³	8.50×10 ^{3b}	-	-	-
	Rectum	1.45×10 ^{4d}	6.00×10 ³	6.00×10 ^{3b}	-	-	-
	SEM	8688.1	15503	7660.5	-	-	-
	p-value	0.0000 [*]	0.0356	0.0088 [*]	-	-	-

* TBC = Total bacterial count, TCC = Total coliform count, CFU/g = Colony Forming Unit per gram
 Values are presented as means ^{a, b, c} were different (p<0.05) within the same row.

Table 3.2: Cloacal swabs diversity and composition of the gut microbiota between feeds

Feed type	Parameters					
	TBC	TCC	TEcC	TkaC	TSalC	TPrC
Commercial Feed A	3.75×10^4	3.30×10^4	2.50×10^4	-	-	0.00
Commercial Feed B	3.65×10^4	1.55×10^4	5.50×10^3	-	-	2000
On-farm feed	3.90×10^4	3.35×10^4	1.55×10^4	-	-	6500
SEM	27230	26947	15911	-	-	1870.8
p-value	0.9957	0.7755	0.5711	-	-	0.7399

*TBC = Total bacterial count, TCC = Total coliform count, CFU/g = Colony Forming Unit per gram

The consistent presence of *E. coli* across all feed types raises important questions regarding its role within the gut microbiota. While often associated with pathogenicity, certain strains of *E. coli* can be commensal and contribute positively to gut homeostasis (Feng *et al.*, 2015). The presence of beneficial bacteria such as *Bacillus* spp. in commercial feed diets suggests that these formulations may enhance gut health by promoting microbial diversity and inhibiting harmful pathogens (Elshaghabe *et al.*, 2017). This competitive exclusion mechanism is crucial for maintaining a balanced gut microbiome, essential for optimal nutrient absorption and immune function.

The absence or reduced prevalence of specific bacteria like *Klebsiella aerogenes* in commercial feed groups could indicate that beneficial bacteria outcompete potential pathogens for resources and colonization sites (Morrison *et al.*, 2019). This competitive advantage may be due to specific prebiotics in commercial feeds that stimulate the growth of advantageous microbial populations. In contrast, the limited diversity observed in on-farm formulated feeds suggests that these diets may not provide adequate substrates for robust microbiota, potentially leading to compromised gut health and increased susceptibility to infections (Huang *et al.*, 2020).

The findings on the diversity and composition of gut microbiota between feeds (Table 3.1) align with the findings of Cullen *et al.* (2021), who reported that diet influences gut microbiota diversity, with natural or less processed diets often leading to greater microbial richness. The differences in microbial diversity and composition observed between broiler chickens fed commercial feeds and those fed on-farm formulated feeds can be attributed to several factors. Commercial feeds often contain specific additives, such as antibiotics and probiotics, which are intended to enhance growth performance and suppress pathogenic bacteria. However, these additives can also lead to a reduction in microbial diversity over time, as they selectively inhibit certain bacterial populations while promoting others (Yadav and Jha, 2019). The lower diversity seen in commercial feeds could result from this selective pressure, which may compromise overall gut health by reducing the resilience of the microbiota against disturbances. On-farm formulated feeds usually consist of locally sourced ingredients that not only provide a wider range of nutrients but also support a more diverse microbiota due to their variability (Glencross *et al.*, 2023). The significant differences noted in parameters such as TBC and TCC highlight how dietary composition can directly influence microbial populations within the gut. The high levels of beneficial bacteria associated with on-farm feeds could contribute positively to gut health by enhancing nutrient absorption and immune function (Chen *et al.*, 2021). The presence of higher levels of *Proteus* species in some commercial feed groups raises concerns about

potential pathogenicity and its implications for chicken health. Elevated levels of coliforms can indicate fecal contamination or an imbalance within the gut microbiome, which may lead to increased susceptibility to infections (Feng *et al.*, 2015).

Commercial feed C exhibited a significantly higher total enteric coliform count (TEcC) in the ileum, measuring 9.50×10^4 CFU/g, in comparison to the other feed types. This suggests that specific formulations may promote the growth of *E. coli* in certain segments of the gut. This is concerning, as elevated levels of *E. coli* can indicate dysbiosis or an imbalance in gut health, potentially leading to health issues in poultry (Morrison *et al.*, 2019). In contrast, pathogenic bacteria such as *Klebsiella* and *Salmonella* were found in much lower quantities in on-farm feeds. This may be attributed to their formulations lacking certain additives that encourage pathogen growth.

The findings of cloacal swabs which revealed diversity and composition of gut microbiota in broiler chickens on various diets (Table 3.2) indicates a consistent level of bacterial presence in the cloaca, irrespective of dietary variations. However, the total coliform count (TCC) and total enterococci count (TEcC) showed more variability. As shown from Table 3.2, commercial feed B had a notably lower TCC of 1.55×10^4 CFU/g compared to 3.30×10^4 CFU/g for commercial feed A and 3.35×10^4 CFU/g for on-farm feed. This variability may reflect how each diet influences coliform populations, which are important indicators of gut health and potential pathogenicity (Morrison *et al.*, 2019).

The absence of *Klebsiella* and *Salmonella* in all but one instance further emphasizes the potential health implications of dietary choices. The presence of *Proteus* was only noted in commercial feed B at a count of 2.00×10^3 CFU/g, indicating that this feed may support certain opportunistic pathogens more than others. The result revealed no significant differences for these parameters either ($p = 0.7399$), suggesting that while there may be trends in microbial populations, they do not reach statistical significance across the different feeds.

The findings indicate that while there is a general consistency in total bacterial counts among cloacal swabs from chickens fed different diets, specific populations such as coliforms and *E. coli* show variability that could have implications for gut health. The lack of significant differences in TBC suggests that all diets provide a suitable environment for bacterial colonization; however, the differences observed in TCC and TEcC highlight how specific dietary components can influence microbial composition.

The higher TCC associated with commercial feed A suggests that this diet may foster a more favorable environment for coliform bacteria, which can be beneficial or detrimental depending on their abundance and strain type (Fallata, 2023). Conversely, the lower TCC in commercial feed B could indicate a less favorable environment for these bacteria or possibly reflect the effects of dietary additives intended to suppress pathogenic growth. The analysis of cloacal swabs provides valuable insights into the diversity and composition of gut microbiota in broiler chickens across various diets (Table 3.2). The results indicate that, while the overall microbial counts are relatively similar among the different feed types, there are significant differences in the composition of specific bacterial populations. The total bacterial count (TBC) for cloacal swabs from different feed types ranged from 3.65×10^4 to 3.90×10^4 CFU/g, showing no

statistically significant differences ($p = 0.9957$). This suggests a consistent level of bacterial presence in the cloaca, regardless of dietary variations.

In contrast, the total coliform count (TCC) and total enterococci count (TEcC) exhibited more variability. Commercial feed B had a notably lower TCC of 1.55×10^4 CFU/g, compared to 3.30×10^4 CFU/g for commercial feed A and 3.35×10^4 CFU/g for on-farm feed. This variability may reflect how each diet influences coliform populations, which are important indicators of gut health and potential pathogenicity (Morrison *et al.*, 2019).

The absence of *Klebsiella* and *Salmonella* in all but one instance further highlights the health implications of dietary choices. The presence of *Proteus* was only detected in commercial feed B, with a count of 2.00×10^3 CFU/g, suggesting that this particular feed may support certain opportunistic pathogens more than others. No significant differences were found for these parameters either ($p = 0.7399$), indicating that while trends in microbial populations exist, they do not reach statistical significance across the different feeds.

The higher TCC associated with commercial feed A suggests that this diet may provide a more favorable environment for coliform bacteria, which can have beneficial or detrimental effects depending on their abundance and strain type (Fallata, 2023). In contrast, the lower TCC in commercial feed B could indicate a less favorable environment for these bacteria or possibly reflect the impact of dietary additives intended to suppress pathogenic growth.

The presence of *Proteus* only in commercial feed B raises concerns about potential opportunistic infections, as elevated levels of this genus can be linked to dysbiosis or an imbalance within the gut microbiome (Rajeev *et al.*, 2021). This finding highlights the importance of monitoring not only total counts but also the composition of gut microbiota when evaluating poultry health.

The presence of *Proteus* only in commercial feed B raises concerns about potential opportunistic infections, as elevated levels of this genus can be associated with dysbiosis or an imbalance within the gut microbiome (Rajeev *et al.*, 2021). This finding underscores the importance of monitoring not just total counts but also the composition of gut microbiota when evaluating poultry health.

5.0 Conclusion

This study investigated the gut microbiota of broiler chickens fed commercial feeds and on-farm formulated feed. Results showed significant differences in microbial composition between feed types. Commercial feeds supported greater diversity and higher populations of beneficial bacteria such as *Bacillus* spp., attributed to their additive content including prebiotics and probiotics. On-farm formulated feeds, while promoting higher total bacterial counts in certain gut sections, lacked the targeted additives that foster specific beneficial microbial populations. Commercial Feed C (Chikun) raised concerns due to elevated enteric coliform counts suggestive of gut dysbiosis. These findings underscore the critical role of feed formulation in shaping gut health and overall broiler performance. It is recommended that poultry producers prioritize feeds with evidence-based prebiotic and probiotic supplementation, and that on-farm feed formulations be enhanced with targeted additives to promote beneficial gut microbiota and reduce the risk of enteric infections in Kafanchan and similar production environments.

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