Comparative Evaluation of Feed Forms for Antibiotic-Free Sustainable Broiler Production in Bangladesh

Abdullahi Abshir Ahmed[1*], Syed Sarwar Jahan[2], Abdisamad Hassan Hussein[3], Md. Mehedi Hasan[2], Jafor Raihan[2], Md. Sumon Ali[2], and Md. Shariful Islam[2*]

Abstract

Background: The rising demand for antibiotic-free broiler meat emphasizes the need for sustainable and healthy poultry production systems. This study investigates the impact of different feed forms on the growth performance, feed conversion ratio (FCR), and microbiological quality of antibiotic-free broilers. Methods: A total of 150 one-day-old Lohman broiler chicks were randomly allocated into three feeding groups: hand-mixed mash (T1), pellets (T2), and crumble (T3), with five replications of 10 chicks each. The birds were raised for 35 days without the use of antibiotics, and various parameters such as feed intake, water intake, body weight gain, FCR, dressing percentage, survivability, and microbiological content were measured. Results: Significant differences ($p<0.05$) were observed in feed and water intake among the treatment groups. The pellet-fed group (T2) exhibited the highest body weight gain and superior FCR (1.34), compared to crumble (T3) and hand-mixed mash (T1), where FCR was inferior (2.09). No significant differences were found in dressing percentages or survivability between groups. Microbiological analysis revealed the presence of Staphylococcus spp. in T1 and T2, and both Staphylococcus spp. and Streptococcus spp. in T3. The cost-benefit ratio was significantly higher in pellet (T2) and crumble (T3) groups compared to hand-mixed mash (T1). Conclusion: Pellet feed proved to be the most efficient and cost-effective choice for antibiotic-free broiler production, offering better growth performance and a favorable FCR. This feeding method holds promise for sustainable and profitable poultry production in Bangladesh, contributing to a safe and healthy meat supply.

Keywords: Antibiotic-free, broiler, feed forms, growth factors, production, sustainable.

Significance | This study highlights pellet feed as the optimal choice for sustainable, profitable, and antibiotic-free broiler production in Bangladesh

*Correspondence. Md. Shariful Islam, Department of Veterinary and Animal Sciences, University of Rajshahi, Rajshahi-6205, Bangladesh. msips06@ru.ac.bd Abdullahi Abshir Ahmed, Ministry of Livestock in Puntland, Somalia. E-mail: cabdallasuldan320@gmail.com

Editor Muhammad Jahangir Hossen, Ph.D., And accepted by the Editorial Board March 28, 2024 (received for review January 15, 2024)

1. Introduction

Livestock is an integral component of the complex farming system in Bangladesh, as it is not only a source of meat protein but also a major source of farm power services and employment. The livestock sub-sector provides full-time employment for 20% of the total population and part-time employment for another 50% (Rahman et al., 2014). The poultry industry has become an important economic activity here in Bangladesh, and broiler meat production has become the most profitable one. Broiler production has grown dramatically in the past two decades; these improvements are largely due to numerous research and breeding programs, which further enhanced feed utilization, growth rate, and low levels of activity (Begum et al., 2010). The broiler is produced

Author Affiliation.
[1] Ministry of Livestock in Puntland, Somalia.
[2] Department of Veterinary and Animal Sciences, University of Rajshahi, Rajshahi-6205, Bangladesh.
[3] Faculty of Veterinary and Animal Husbandry, Somali National University, Mogadishu, Somalia.

Please Cite This:
Ahmed, A. A., Jahan, S. S., Hussein, A. H., Hasan, M. M., Raihan, J., Ali, M. S., Islam, A. M. S. (2024). "Comparative Evaluation of Feed Forms for Antibiotic-Free Sustainable Broiler Production in Bangladesh", Livestock Research Today, 2(1),1-9,10106

/© 2024 LIVESTOCK RESEARCH, a publication of Eman Research, USA.
This is an open access article under the CC BY-NC-ND license.
(http.//creativecommons.org/licenses/by-nc-nd/4.0/).
(https.//publishing.emanresearch.org).

specifically for meat production; these include small fryers to large roaster-type chickens (Begum et al., 2010). The importance of the physical structure of diet as a tool to improve broiler live performance, especially feed efficiency, has become increasingly recognized by the poultry industry. It was previously thought that finely ground ingredients enhanced nutrient utilization and growth efficiency owing to the greater surface area being made available for digestive enzymes and improved pellet quality (Behnke, 2002). The physical form of feed (mash, pellet, and crumble) is a crucial factor in the meat yield of the broiler. Different types of feed forms have evolved in broiler production at present. Various feed forms—pellets, mash, or crumbles—that are supplied to broilers are the most important factor that directly influences the cost of mixed feed and production performance of broilers. The major objective of poultry feeding is the conversion of feedstuffs into human food. Physical feed form is considered to have a very significant impact on broiler growth and feed intake (Dozier *et al.,* 2010). Feed form and feed particle size of cereals require a significant amount of attention when producing broiler feed. Today, commercial feed mills are producing different forms of broiler feed for birds at different ages (Jahan *et al.*, 2006). While feed processing to change feed form increases the cost of feed, it can be balanced out by improved performance. Broilers fed pelleted diets have higher body weight (BW) and improved feed conversion than those fed mash feed (McKinney and Teeter, 2004; Amerah *et al.,* 2008; Chewning *et al.*, 2012), and with regards to feeding particle size, one traditional view was that a smaller particle size would be associated with a larger surface area of the grain, possibly resulting in higher digestibility in poultry due to greater interaction with digestive enzymes in the gastrointestinal tract (Preston *et al.,* 2000). Hand-mixed feed or mash is a form of complete feed that is finely ground and mixed so that birds cannot easily separate ingredients; each mouthful provides a well-balanced diet. Mash diet gives greater unification of growth and less death loss, and is more economical. However, ground feed is not so palatable and does not retain its nutritive value as well as unground feed (Jahan *et al.*, 2006). Mash feed is the simplest solid feed form that can be manufactured. It consists of grinding and mixing all raw materials into the correct proportions to meet the nutritional requirements of the feed. No additional heat or compaction treatments are conducted on the feed; hence, energy-saving to prepare the feed is low compared to pellets and extruded feed. On the other hand, separation from raw materials often occurs due to transport and handling. This may impair the nutritional quality of the feed, especially individual insect feed intake, where absolute feed intake per individual is low (Jullien, 2016). Mash or hydrothermally processed diets, such as pellets or crumbles, are commonly used as broiler feeds. Although it is generally believed that pelleting has a positive effect on broiler growth performance, feed intake (FI), and feed conversion ratio (FCR) (Abdollahi *et al.*, 2013). Mash feed is less palatable to broilers compared with crumbles, thus reducing feed intake. For this reason, broiler chicks are usually fed crumble or pellets to stimulate feed intake. Research has shown that feeding broilers pellets or crumbles stimulates feed intake, resulting in higher body weight and improved feed conversion compared with mash diets (Amerah *et al.*, 2008; Chewning *et al.*, 2012). Pelleting is a step in feed processing in which the ingredients are agglomerated by mechanical action, in combination with moisture, pressure, and temperature, to form larger structures called pellets. Broiler diets are pelleted for different reasons, but particularly for promoting feed intake **(FI)** (Svihus *et al.*, 2004). In feed formulation, determining the dietary energy level is critical to optimize performance, carcass quality, productive efficiency, and profitability. Because broilers fed pelleted diets present higher FI and abdominal fat deposition than those fed mash at the same dietary energy level (Maiorka *et al.*, 2005). Crumble is also a type of feed prepared at the mill by pelleting the mixed ingredients and then crushing the pellet to a consistency coarser than mash. Recently, this form of feed is becoming popular in broiler production due to its convenience of feeding. The best feed conversion was obtained with the feeding of a high energy level with a high protein profile in crumble form, which is better than mash and pellet form for the production of the commercial broiler for the age duration of 21 to 56 days (Ommati *et al.*, 2013; Lv *et al.*, 2015). Feeding each form of feed has its advantages and disadvantages. The effectiveness, digestibility, and conversion efficiency of different forms of feed are also different. But limited research work has been performed to investigate the effect of feeding different forms of feed (hand-mixed, pellet, and crumble) on the productive performance of broilers in Bangladesh. Nowadays, consumers have additional concerns about antibiotic residues/resistance, and, more interestingly, consumers are demanding antibiotic-free safe foods (Islam *et al.,* 2024). Therefore, the present study is undertaken to compare the effect of physical forms of feed on the growth rate, feed efficiency, and other productive characteristics of sustainable antibiotic-free broilers.

2. Materials and methods

2.1 Experimental design, duration, and preparation of the feed

A total of 150 one-day-old Lohmann broiler straight-run chicks were allocated into three distinct feeding groups: hand-mixed mash (T_1), pellets (T_2), and crumble (T_3), containing five replications of ten chicks each in a Completely Randomized Design (CRD). The birds were reared for 34 days without antibiotics. Ready-made pellet feed was purchased from the local market (Quality Feed Ltd). Crumbles were made from it. Different types of required ingredients for hand-mixed ration formulation were purchased and collected from the local feed market of Rajshahi city. The hand-mixed feed contained the ingredients shown in Table 1.

2.2 Feeding, watering, and management of birds

Feeds were supplied to the chicks on clean, simple paper or newspaper at a three-hour interval for the first 3 days. After 3 days, the paper was removed, and the feeders and waterers were evenly distributed around the brooder. Feed was given *ad libitum* to chicks from one day old to 34 days of age. Chicks were given three different feeds, like pellets, hand-mixed mash, and crumble, according to their age and the design of the experiment. Round drinkers were used for the experimental birds. Fresh, clean, and cold drinking water was made available all the time during the experimental period. Some water-soluble vitamins were supplied to the birds with drinking water. All birds were exposed to continuous lighting of 23 hours and a one-hour dark period per day throughout the experimental period. The dark period was practiced to make the broilers familiar with the possible darkness due to an electricity failure. Supplementary light at night was provided by an electric bulb hanging at a height of 2.8 meters to provide necessary lighting. When the temperature became high (over 30°C), vitamin C and electrolytes were supplied with water. Housing temperature was recorded every 4 hours during the experimental period (6.00 AM, 10.00 AM, 2.00 PM, 6.00 PM, and 10.00 PM). The satisfactory level of relative humidity for broiler houses was 55-65%, but the observed relative humidity level was 60-70%, which was almost satisfactory.

2.3 Parameter studies

The data were collected until the end of the experimental period. The daily feed and water intake and the production performance in terms of body weight and body weight gain of the birds were recorded. The feed conversion ratio (FCR) was calculated as the proportion of cumulative feed intake to final body weight gain and survivability. Carcass characteristics were studied during the experimental period by randomly selecting three birds per replicate for sacrifice and analyzing the dressed weight, dressing percentage, thigh meat yield, breast meat yield, and gut microflora analysis of experimental birds. On day 34 of the experimental period, two broilers were randomly selected from each replication and were sacrificed. After slaughter, the intestinal content was collected immediately by swab. The samples were immediately mixed with distilled water and stored at -10°C. Samples were serially diluted from 10^{-1} to 10^{-7}. The E. coli count was performed in MacConkey agar after aerobic incubation at 37°C for 24 h. The numbers of colony-forming units (CFU) were expressed as Log^{10} CFU per gram. Microbiological analysis of intestinal content revealed the presence of several types of bacteria in different treatments. The survival of the birds from each treatment was recorded until the end of the experiment.

2.4 Statistical Analysis

The data obtained from this study were subjected to analysis by the one-way analysis of variance (ANOVA) technique in a completely randomized design (CRD). All data were presented as means ± standard deviation (SD). Analysis of variance (ANOVA) was conducted to evaluate the recorded data using KaleidaGraph (Synergy Software, Reading, PA, USA), and statistical analysis was performed by Fischer's LSD comparison test, in which any difference was considered statistically significant when the *p*-value was smaller than 0.01 or 0.05.

3. Results

3.1 Effect of physical forms of feeds on the production performance of broilers

The average water intake (ml), feed consumption (g), live weight (g), live weight gain (g), and FCR of experimental birds under three treatments are presented here in **Table 1.** Mean water consumed for the three groups was 8813.00 ± 40.15, 6758.00 ± 26.10, and 6485.33 ± 5.13 ml for T_1, T_2, and T_3, respectively. The effect of the physical forms of feed on the water intake of broilers at 34 days significantly ($p < 0.01$, $p < 0.05$) differed among the treatment groups. The highest water intake was observed in T1 (8813.00 ± 40.15 ml), whereas the lowest water intake was found in T3 (6485.33 ± 5.13 ml) among the dietary treatment groups. Further, the mean feed consumed for the three groups was 2999.93±10.85, 3008.47±7.31, and 2937.97±6.04 for T_1, T_2, and T_3, respectively. The present study revealed that the feed intake was significantly ($P < 0.01$, $P < 0.05$) varied among the treatment groups (**Table 1)**. At the end of the experiment, the highest feed intake was found in T_2 (3008.47±7.31), and the lowest feed intake (2937.97±6.04) was recorded in T_3 among the dietary treatment groups. The result revealed average live weight for T_1, T_2, and T_3 as 1776.46 ± 71.28, 2551.67 ± 78.43, and 2486.38 ± 46.30, respectively. The findings revealed a significant variation in live weight pattern from 8 to 34 days of age experimental birds under various treatments (**Fig. 1**). The statistical analysis indicated that the average live weights significantly ($p < 0.01$) differed from each other at the end of the experiment (**Table 1)**. The results indicated that the average body weight gain of the experimental birds under T_2 at 34 days of age was the highest (2239.54±76.78), followed by T_3 (2171.17±48.00), and the lowest body weight gain was recorded under T_1 (1440.79±76.28). The body weight gain of the T_2 and T_3 groups was significantly ($p < 0.01$) higher than that of the T_1 group. Further, there was a non-significant ($P>0.05$) difference observed between the T_2 and T_3 groups (**Table 1)**.

Furthermore, the results indicated that providing feed to the birds in pellet form had a very significant ($p< 0.01$) effect on the FCR of the experimental broilers. The superior FCR (1.34 ±0.04) in this study was exhibited in the pellet-feeding group (T_2). On the other hand, the worst FCR in this study was recorded for hand-mixed mash feeding (T_1) (2.09 ± 0.10). It was shown from the study that physical forms of supplied feed significantly ($p< 0.01$) influenced the obtained FCR of the experimental birds (**Table 1**). A highly significant ($p< 0.01$) difference in FCR was detected between T_1 and

T_2 or T_3, but a non-significant ($p > 0.05$) variation was revealed between T_2 and T_3.

3.2 Effects of physical forms of feeds on the meat yield characteristics of antibiotic-free broilers

The effect of physical forms of feed on the dressing percentage, breast, thigh, and drumstick meat yield of experimental birds is presented in **Table 2**. The results revealed the highest dressing percentage (70.76 ± 0.76) in T_3, whereas the lowest dressing percentage (68.45 ± 3.08) was in T_1. There was a nonsignificant ($P<0.05$) difference in average dressing percentage among the treatments. Furthermore, the highest breast meat yield (613.33 ± 54.31g) was obtained under T_3 (crumble), whereas the lowest breast meat yield (366.33 ± 17.01g) was recorded for birds in T_1 (mash). The differences in average breast meat yield were highly significant ($p < 0.01$, $p < 0.05$) between T_3 and T_1, as well as T_2 and T_1. On the other hand, a non-significant ($P<0.05$) difference was observed between T_2 and T_3 (Table 2). It was found that the highest thigh meat yield was in T_3 (269.33 ± 17.93 g) group, followed by T_2 (226.33 ± 10.02 g), and the lowest was in T_1 (162.33 ± 8.33 g) group. The effect of physical forms of feeds on thigh meat yield (g) was significantly ($p< 0.01$) different among the dietary treatment groups. The highest drumstick meat was obtained in T_3 (238.33 ± 7.51g), followed by T_2 (190.00 ± 46.52 g), whereas the lowest drumstick meat was recorded for birds in T_1 (150.00 ± 6.24g) (mash) group. It was revealed that different physical forms of supplied feeds significantly ($p < 0.05$) influenced the yield of drumstick meat (**Table 2**). The differences in average drumstick meat yield were significant ($p < 0.05$) between T_3 and T_1, as well as T_3 and T_2. On the other hand, a non-significant ($P<0.05$) difference was observed between T_1 and T_2.

3.3 Effect of physical forms of feeds on the survivability and* gut microflora status *of experimental broilers

The survivability of the experimental birds under different treatments was recorded from the beginning to the end of the experiment and was expressed in terms of percentages for each group. The recorded survivability from day 7 to 34 days of age of the experimental birds is demonstrated here in **Fig. 2.**

The results indicated that the percent survivability was the lowest under T_1 (93.33±5.25%). On the other hand, the highest survivability was recorded for T_3 (100%), followed by T_2 (96.67±5.71). It was noteworthy to mention that mean differences in survivability among the treatments were non-significant ($P < 0.05$). Furthermore, microbial analysis revealed that the hand-mixed mash feeding group (T_1) and pellet feeding group (T_2) contained *Staphylococcus,* whereas T_3 (crumble feeding) contained *Streptococcus* (**Fig. 3**).

4. Discussion

4.1 Effect of physical forms of feeds on the production performance of broilers

The obtained results of water intake in this study agreed with the findings of Fairchild and Ritz (2009), which indicated that drinking behavior is closely associated with feed intake, such that factors affecting feed consumption will indirectly influence water intake. Water intake can also be influenced by several other factors, such as age, sex, and environment. Due to this, daily water consumption makes an excellent litmus test for the overall health and condition of a flock. May *et al.* (2000) showed that broilers exposed to high air velocity during times of potential heat stress consumed less water and more feed, gained more weight, and had an improved feed: gain ratio. Numerous studies (Dozier *et al.,* 2002; Manning *et al.,* 2007) found that decreases in water consumption can be an indication of health problems or environmental issues. Inadequate consumption of water will result in decreased growth rates. Increased consumption is associated with higher feed conversions. However, in this current study, the highest water intake is detected in T_1 (hand-mixed mash) due to the heterogeneous particle sizes of the formulated diet.

Furthermore, the obtained feed intake results in this study agree with several previous findings, such as Mirghelenj and Golian (2009), who reported that feeding crumble-pelleted diets caused a significant increase in feed intake. The advantage of the crumble-pellet diets may result from an increase in appetite and diet density, a decrease in feed wastage, and alterations in ingredients. Jensen *et al.* (2000) reported that crumble-pellet feed increased feed intake by 5 to 8% during the starter and grower phases, respectively, compared with mash diets. Similar results were found by Jahan *et al.* (2006), who reported that birds had greater feed intake with crumble or pellets than with mash feeding. Preston *et al.* (2000) found that there was significantly lower performance of mash-fed chickens, which is supported by the present study. Similar results were found by Jahan *et al.* (2006), who reported that greater feed intake could occur with pellets rather than with mash. Zang *et al.* (2009) reported that there was a 7 to 10% higher feed intake in birds fed crumbles compared with those fed mash diets and attributed the higher feed intake to a reduction in selective feeding and increased nutrient digestibility of the crumbled diets. It was investigated the response of broiler chickens to a processed soy protein product when offered at different inclusion levels in the mash or crumbled pre-starter diets and observed that birds fed crumbles had a higher feed intake, which resulted in higher BW gain compared with those fed the mash diet at 24 D post-hatch. The increased feed intake was attributed to the larger sizes of crumbles compared with the mash diet, which reduced selective feeding.

The results of live weight are similar to the findings of Van Biljon (2005), Jahan *et al.,* (2006) and Zakeri *et al.,* (2013), who reported that broilers fed crumbled pellet diets had significantly heavier BW

Table 1. Effects of physical forms of feeds on the production performance of antibiotic-free broilers.

Variable	Treatments (mean ± SD)			P value	Significance
	T_1	T_2	T_3		
Water intake (ml)	8813.00^{a} ± 40.15	6758.00^{b} ± 26.10	6485.33^{c} ± 5.13	<0.0001	**
Feed intake (g)	2999.93^{b}±10.85	3008.47^{a}±7.31	2937.97^{b}±6.04	<0.0001	**
Live wt. (g)	1776.46^{c} ± 71.28	2551.67^{a} ±78.43	2486.38^{b} ± 46.30	<0.0001	**
Live wt. gain (g)	1440.79^{b} ± 76.28	2239.54^{a} ±76.78	2171.17^{a} ±48.00	<0.0001	**
FCR	2.09^{a} ± 0.10	1.34^{b} ±0.04	1.35^{b} ± 0.03	<0.0001	**

** = significance at the 1% level ($p < 0.01$), and superscript different letters in means indicated significant differences, n = 50.

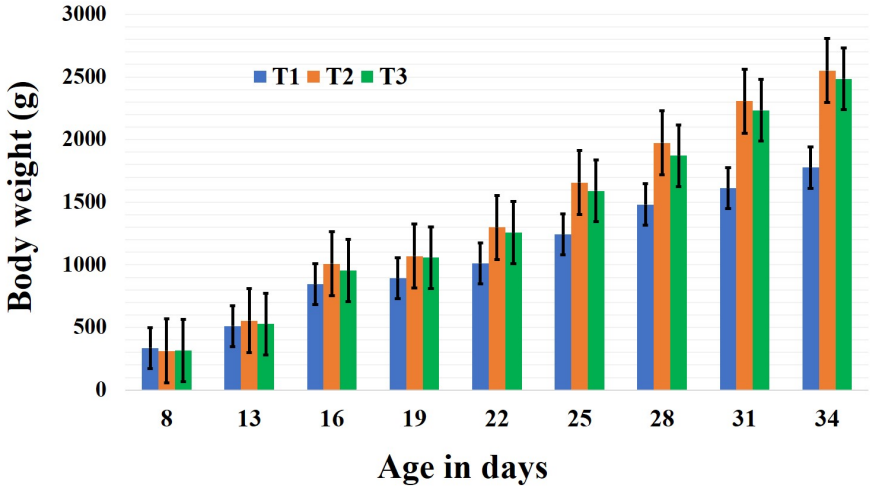


Figure 1. Variation in body weight of broilers under different treatments. Here, the vertical bar indicates the error, and n = 50.

Table 2. Effects of physical forms of feeds on meat yield characteristics of the experimental broilers.

Variable	**Treatments (mean ± SD)**			**P value**	**Significance**
	T_1	**T_2**	**T_3**		
Dressing %	68.45 ± 3.08	68.79 ± 1.83	70.76 ± 0.76	0.40987	NS
Breast meat wt. (g)	366.33^{c} ± 17.01	595.33^{b} ± 56.36	613.33^{a} ± 54.31	0.00104	**
Thigh meat wt. (g)	162.33^{c} ± 8.33	226.33^{b} ± 10.02	269.33^{a} ± 17.93	0.00015	**
Drumstick meat wt. (g)	150.00^{c} ± 6.24	190.00^{b} ±46.52	238.33^{a} ± 7.51	0.02147	*

** = significance at the 1% level ($p < 0.01$), * = significance at the 1% level ($p < 0.05$), and superscript different letters in means indicated significant differences, n = 50.

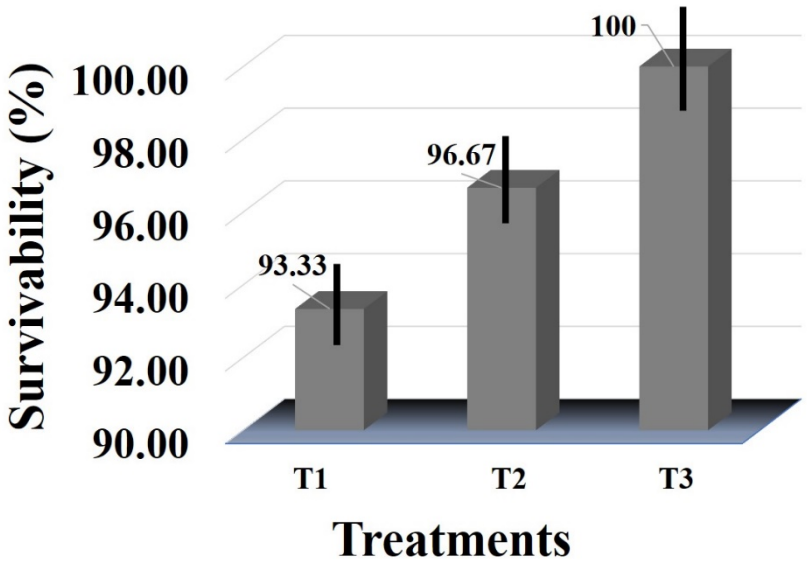


Figure 2. Effect of physical forms of feed on the survivability of the experimental birds.

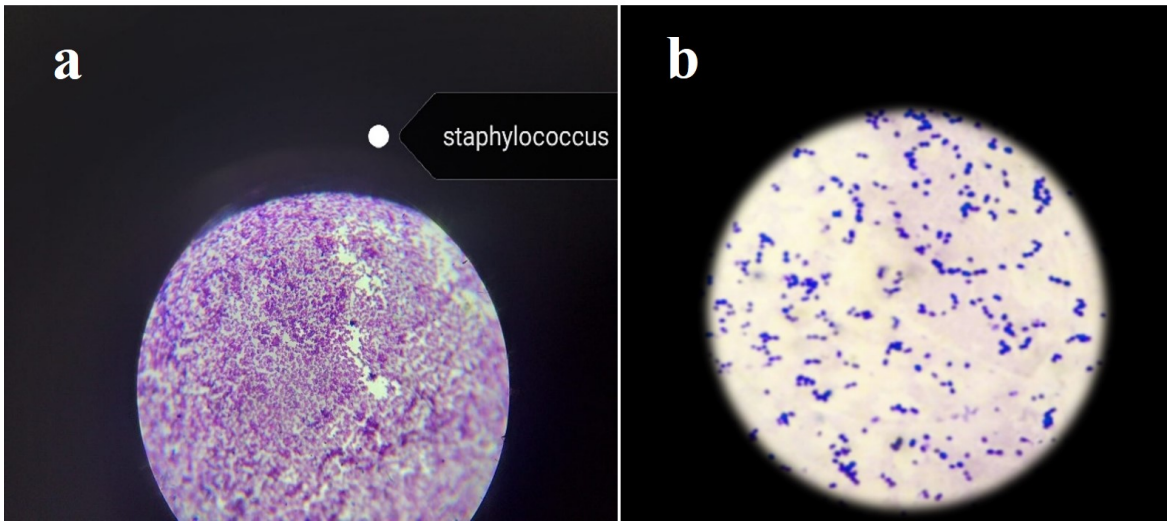


Figure 3. Microscopic image of bacteria obtained in the intestinal samples after microbial analysis. Here, *Staphylococcus* and *Streptococcus* are indicated by plates (a) and (b), respectively.

at 42 D because of increased feed intake when compared with birds fed all mash diet which is similar of the present study. Jafarnejad *et al.* (2010) found that broiler feeding crumble-pellets from 1 to 21 days of age improved body weight. Further, Preston *et al.*, (2000) and Munt *et al.* (1995) reported that significantly poorer performance of mash-fed birds. Jahan *et al.* (2006) found that statistically similar and higher body weight gain values were observed in pellet and crumble 5th to 8th weeks of age than mash group. These results agreed with the findings of the present study. Saleh *et al.* (2004) and Dozier *et al.* (2011) observed that broilers fed low-energy diets that lower WG and have worse feed per unit gain than those fed high-energy diets, which agrees with the present study.

Al-Nasrawi (2016) observed that FCR was significantly ($P<0.05$) lower in broiler-fed crumble and pellet diets than mash during the three periods (22-32 d, 33-42 d, and 1-42 d), which is supported by the present study. Amerah *et al.* (2007) reported that 8.9% improvement in FCR (1.52 and 1.67), whereas Chewning *et al.* (2012) reported that 8.4% improvement in FCR (1.85 vs. 2.02) when broilers were fed crumbles vs. mash diets, respectively. These results agreed with the findings of Rajini *et al.* (1998) and Mendes *et al.* (1995). They reported that pellets had a better feed efficiency than

mash. However, Howlider and Rose (1992) found that pelleting increases feed conversion by 5.9%.

4.2 Effects of physical forms of feeds on the meat yield characteristics of antibiotic-free broilers

Carcass weight results of the current study are in agreement with the findings of Habibi *et al. (2019),* who reported that chickens fed with pellets and crumble produced higher carcass weight compared with chickens fed only mash feeds.

Furthermore, the current result of breast meat yield agreed with the findings of Al-Nasrawi (2016), who found that the superiority of broilers fed on crumble and pellet diets was extended to breast meat yield was significantly higher than mash. Dozier *et al.* (2010) reported that higher breast meat yields in broilers fed pelleted diets relative to mash diets. These differences between studies may have occurred due to variations in the physical quality of diets because broilers fed high-quality pellets exhibit advantages in rate and efficiency of growth, which are supported by the present study. Shafiee *et al.* (2006) reported that the weight of the breast and thigh meat was significantly ($P<0.05$) heavier in broiler-fed pellet diets than in the broilers fed mash diets. These results were in agreement with the current study. Previous studies stated that feed form does not significantly affect broiler carcass and cut yield. Nabi *et al.* (2017) reported that the average carcass weight and dressing percentage of broilers fed different feed forms at the age of 4th week and 6th week were significantly higher in crumble-fed broilers ($P<0.01$) than mash-fed broilers in both parameters at the 4th week of age. Jensen (2000) indicated that the advantage of crumble and pellet may result from an increase in appetite and diet density and a decrease in feed waste. Maiorka *et al.* (2005) and Corzo *et al.* (2011) reported higher abdominal fat deposition in broilers fed pelleted diets relative to mash.

4.3 Effect of physical forms of feeds on the survivability and* gut microflora status *of experimental broilers

The current finding of survivability is supported by Nabi *et al.* (2017), who reported that mortality during the trial was insignificant only five out of the 150 birds dying, and the mortality was not linked to any definite treatment. Furthermore, Brickett *et al.* (2007) reported that feeding mash decreased mortality (3.8%) compared with feeding pelleted feed. The data on survivability percent did not differ significantly. Only two birds from the mash group and 2 birds from the pellet group died due to vitamin E deficiency. Results suggest that the physical form of feed had no or little effect on health. Ommati *et al.* (2013) reported no differences in mortality rate. They observed that mortality was the highest in pellets fed broilers with 12.7%, while the mash-fed birds group had 9%. The inconsistency of reports on the effect of feed forms on mortality may be due to the difference in the duration of feeding. The broiler feed forms had a significant ($P<0.05$) difference in ascites and skeletal disorders, however, there were no differences ($P>0.05$) between feed forms on sudden death incidences. The incidence of ascites and skeletal disorders was significantly higher in broilers fed a pelleted diet than in birds fed a mash diet. A similar trend in results was observed for sudden death syndrome (SDS), where a higher incidence was observed in birds offered a diet in the form of pellets. Biljon (2006) concurred with the findings of the study on incidences of ascites and skeletal disorders, which reported significantly higher mortality mainly caused by ascites (2.11%) and SDS (1.39%) in crumble-pellet treatment than in all mash diets. Skeletal disorders incidences were higher in the ground crumble-pellet treatment group than in the group fed a mash diet. Hasani *et al.* (2018) confirmed that feeding pellets to broilers leads to fast growth rates that, in turn, result in high incidences of ascites and SDS.

Olayemi *et al.* (2017) reported that the gut microflora is involved in a wide array of physiological, nutritional, and immunological events, which can directly or indirectly affect the health and productivity of commercial flocks. Ingested feed and extension, nutrients play a significant role in the development and functionality of the GIT. Diet composition (ingredients, nutrients, and additives) can influence the development and function of the digestive system, including the immune system and the microbiota (Borda-Molina *et al*., 2018). Finally, the overall findings revealed that pellet form is the best feeding approach, and by using hand-mixed mash feed, antibiotic-free green broiler production is quite possible commercially here in Bangladesh. These findings may suggest and encourage the farmers to antibiotic-free green broiler production by using hand-mixed mash feed, which may contribute to meeting the national demand for safe meat as well as develop the national economy of Bangladesh.

5. Conclusion

This study evaluated the effects of different physical forms of feed—hand-mixed mash (T_1), pellet (T_2), and crumble (T_3)—on the growth performance, carcass characteristics, and microbial profile of broiler chickens raised without antibiotics. The findings demonstrated that broilers fed pelleted diets (T_2) exhibited significantly higher body weight, weight gain, and improved feed conversion ratio (FCR) compared to those fed mash diets (T_1). In conclusion, pelleted feed (T_2) demonstrated superior growth performance and economic returns in antibiotic-free broiler production. However, hand-mixed mash feed (T_1) still achieved acceptable performance metrics, suggesting its viability for antibiotic-free, green broiler production in Bangladesh. These findings support the adoption of pelleted or crumble feeds to enhance productivity while also validating the feasibility of using hand-mixed mash feed for sustainable, antibiotic-free broiler farming.

Author contributions

MSI supervised the research and conceptualized the theme of the manuscript. AAA conducted the research. JR, MSA, and MMH prepared the shed and the images of the manuscript. AHH and AAA wrote the original manuscript. SSJ and MSI edited and reviewed the manuscript. All authors reviewed, revised, and approved the final draft for publication.

Acknowledgment

The authors were grateful to their department.

Competing financial interests

The authors have no conflict of interest.

References

Abdollahi, M. R., Ravindran, V., & Svihus, B. (2013). Influence of grain type and feed form on performance, apparent metabolizable energy, and ileal digestibility of nitrogen, starch, fat, calcium and phosphorus in broiler starters. Animal Feed Science and Technology, 186(1–2), 193–203.

Al-Nasrawi, M. A. M. (2016). The impact of different dietary forms (mash, crumble, and pellets) on some growth traits and carcass characteristics of broilers. Journal of Animal Health and Production, 4(2), 31–36.

Amerah, A. M., Ravindran, V., Lentle, R. G., & Thomas, D. G. (2008). Influence of feed particle size on the performance, energy utilization, digestive tract development and digesta parameters of broiler starters fed wheat-and corn-based diets. Poultry Science, 87(11), 2320–2328.

Begum, S., Mostofa, M., Alam, A. K. M. R., Tanjim, M., Ali, A. A. M., Islam, M. N., & Das, S. (2010). Prevalence of ascariasis and comparative efficacy of pineapple leaves extract with patent drug piperazine against ascariasis of poultry at five villages under Mymensingh district. International Journal of Biological Research, 1, 41–44.

Behnke, K. C., & Beyer, R. S. (2002). Effect of feed processing on broiler performance. VIII International Seminar on Poultry Production and Pathology. Santiago, Chile.

Biljon, N. J. van. (2006). The effect of feed processing and feed texture on body weight, feed conversion and mortality in male broilers (Master's dissertation, University of Pretoria).

Borda-Molina, D., Jana, S., & Camarinha-Silva, A. (2018). Current perspective of the chicken gastrointestinal tract and its microbiome. Computational and Structural Biotechnology Journal, 16, 131–139.

Brickett, K. E., Dahiya, J. P., Classen, H. L., & Gomis, S. (2007). Influence of dietary nutrient density, feed form, and lighting on growth and meat yield of broiler chickens. Poultry Science, 86, 2172–2181.

Chewning, C. J., Stark, C. R., & Brake, J. (2012). Effects of particle size and feed form on broiler performance. Journal of Applied Poultry Research, 21, 830–837.

Corzo, A., Mejia, L., & Loar II, R. E. (2011). Effect of pellet quality on various broiler production parameters. Journal of Applied Poultry Research, 20, 68–74.

Dozier, W. A., Behnke, K. C., Gehring, C. K., & Brantton, L. (2010). Effects of feed form on growth performance and processing yields of broiler chickens during a 42-day production period. Pakistan Journal of Pharmaceutical Sciences, 2019–2026.

Dozier, W. A., Gehring, C. K., Corzo, A., & Olanrewaju, H. A. (2011). Apparent metabolizable energy needs of male and female broilers from 36 to 47 days of age. Poultry Science, 90, 804–814.

Fairchild, B. D., & Ritz, C. W. (2009). Poultry drinking water primer. http://extension.uga.edu/publications/detail.cfm

Hasani, A., Bouyeh, M., Rahati, M., Seidavi, A., Makovicky, P., Laudadio, V., & Tufarelli, V. (2018). Which is the best alternative for ascites syndrome prevention in broiler chickens? Effect of feed form and rearing temperature conditions. Journal of Applied Animal Research, 46(1), 392–396.

Howlider, M. A. R., & Rose, S. P. (1992). The response of growing male and female broiler chickens kept at different temperatures to dietary energy concentration and feed form. Animal Feed Science and Technology, 39, 71–78.

Islam, Z., Raihan, J., Ali, S., Hussein, A. H., Hasan, M., Hakim, A., Talukdar, L., Jahan, S. S., Khan, A., & Islam, S. (2024). The efficacy of prebiotic supplementation in mitigating heat stress and improving the survival of antibiotic-free broilers' production in hot climates. Poultry Science and Management, 1(1), 3. https://doi.org/10.1186/s44364-024-00003-w

Jafarnejad, S., Farkhoy, M., Sadegh, M., & Bahonar, A. R. (2010). Effect of Crumble-Pellet and Mash Diets with Different Levels of Dietary Protein and Energy on the Performance of Broilers at the End of the Third Week. Vet. Med. Int. 2010, Article ID 328123.

Jahan, M. S., Asaduzzaman, M., & Sarkar, A. K. (2006). Performance of broiler fed on mash, pellet and crumble. International Journal of Poultry Science, 5(3), 265-270.

Jensen, L. S., Merrill, L. H., Reddy, C. V., & McGinnis, J. (1962). Observations on eating patterns and rate of food passage of birds fed pelleted and unpelleted diets. Poultry Science, 41, 1414–1419.

Jensen, L. S. (2000). Influence of pelleting on the nutritional needs of poultry. Asian-Australasian Journal of Animal Sciences, 13, 35–46.

Jullien, R. L., Cortes Ortiz, J. A., Ruiz, A. T., Morales-Ramos, J. A., Thomas, M., Rojas, M. G., Tomberlin, J. K., Yi, L., Han, R., & Giroud, L. (2016). Insect mass production technologies. In A. T. Dossey, J. A. Morales-Ramos, & M. G. Rojas (Eds.), Insects as sustainable food ingredients (pp. 153–201). Academic Press.

Lv, M., Yan, L., Wang, Z., An, S., Wu, M., & Lv, Z. (2015). Effects of feed form and feed particle size on growth performance, carcass characteristics and digestive tract development of broilers. Animal Nutrition, 36(3). https://doi.org/10.1016/j.aninu.2015.06.001

Maiorka, A., Dahlke, F., Penz, A. M., & Kessler, A. M. (2005). Diets formulated on total or digestible amino acid basis with different energy levels and physical form on broiler performance. Brazilian Journal of Poultry Science, 7, 47-50.

Manning, L., Chadd, S. A., & Baines, R. N. (2007). Key health and welfare indicators for broiler production. World's Poultry Science Journal, 63, 47–62.

May, J. D., Lott, B. D., & Simmons, J. D. (2000). The effect of air velocity on broiler performance and feed and water consumption. Poultry Science, 79, 1396–1400.

McKinney, L. J., & Teeter, R. G. (2004). Predicting effective caloric value of non-nutritive factors: I. Pellet quality and II. Prediction of consequential formulation dead zones. Poultry Science, 83, 1165–1174.

Mendes, A. A., Polity, E. S., Garcia, E. A., & Sartori, J. R. (1995). Effect of ground or pelleted diets on performance and carcass yield of broiler chickens. Veterinaria – Zootecnia, 7, 31–40.

Mirghelenj, S. A., & Golian, A. (2009). Effects of feed form on development of digestive tract, performance, and carcass traits of broiler chickens. Journal of Animal and Veterinary Advances, 8(10), 1911–1915.

Munt, R. H. C., Dingle, J. G., & Sumpa, M. G. (1995). Growth, carcass composition and profitability of meat chickens given pellets, mash or free-choice diet. British Poultry Science, 36, 277–284.

Nabi, F., Ismail Rind, M., Zulqarnain, Li, J., Shahzad, M., Ahmed, M., Kashif, Iqbal, M., & Rehman, M. U. (2017). Influence of different feed forms and particle size on efficiency of broiler production. Online Journal of Animal and Feed Research, 7(2), 24–28.

Olayemi, W. A., Akapo, O. A., Olorunsola, R. A., Oso, A. O., Bamgbose, A. M., & Mafimidiwo, A. O. (2017). Performance, carcass yield and gut microflora of broiler chickens offered Viola odorata leaf extract in drinking water. Journal of Scientific Research & Reports, 13(3), 1–8. https://doi.org/10.9734/JSRR/2017/31996

Ommati, M. M., Rezvani, M. R., Atashi, H., & Akhlaghi, A. (2013). Effect of physical form of diet and ambient temperature on performance and carcass attributes in broilers. Archiv für Geflügelkunde, 77, 247–253.

Preston, C. M., McCracken, R. J., & McAllister, A. (2000). Effect of diet form and enzyme supplementation on growth, efficiency and energy utilization of wheat-based diets for broilers. British Poultry Science, 41(3), 324-331.

Rahman, S., Begum, I. A., & Alam, M. J. (2014). Livestock in Bangladesh: Distribution, growth, performance, and potential. Livestock Research for Rural Development, 26(10).

Rajini, A. R., Kumararaj, R., Narahari, D., Ravindran, R., & Sundaresan, K. (1998). Influence of season, form of feed, dietary energy, age, and sex on carcass traits of broilers. Indian Journal of Poultry Science, 33, 346-348.

Rajini, A. R., Thanabalan, S., Narahari, D., Hyoung Ho, R. K., & Yuen Hoo, C. (1996). Effects of season, form of feed, and dietary energy levels on broiler performance. Indian Journal of Poultry Science, 33, 36-41.

Saleh, E., Watkins, S., Waldroup, A., & Waldroup, P. (2004). Effects of dietary nutrient density on performance and carcass quality of male broilers grown for further processing. International Journal of Poultry Science, 3, 1–10.

Shafiee, S. T., Dabiri, N., Agah, M. J., & Norollahi, H. (2006). Effect of pellet and mash diets associated with Biozyme enzyme on broilers performance. International Journal of Poultry Science, 5(5), 485-490.

Svihus, B., Kløvstad, K. H., Perez, V., Zimonja, O., Sahlstrom, S., Schuller, R. B., Jeksrud, W. K., & Prestløkken, E. (2004). Physical and nutritional effects of pelleting of broiler chicken diets made from wheat ground to different coarsenesses by the use of roller mill and hammer mill. Animal Feed Science and Technology, 117, 281–293.

Van Biljon, N. J. (2005). The effects of feed processing and feed texture on body weight, feed conversion, and mortality in male broilers. M.Med. Vet. Dissertation, University of Pretoria, South Africa.

Zakeri, A., Chehraghi, M. A., & Taghinejad-Roudbaneh, M. (2013). Effects of feed form on performance in broiler chickens. European Journal of Experimental Biology, 3, 66–70.

Zang, J. J., Piao, X. S., Huang, D. S., Wang, J. J., Ma, X., & Ma, Y. X. (2009). Effects of feed particle size and feed form on growth performance, nutrient metabolizability, and intestinal morphology in broiler chickens. Asian-Australasian Journal of Animal Sciences, 22(1), 107-112.