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Research Article

Performance of Caged Broilers and Uncaged Broilers Fed with Activated Bamboo Charcoal and Bentonite Clay Mineral as Feed Additives

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ABSTRACT

The issue of animal welfare and the usage of antibiotics resulted in the development of different rearing systems and the use of feed additives as antibiotic alternatives. Cage-free broiler production allows birds to express their normal behavior promoting better welfare of the animal. The study aimed to investigate the growth performance of broiler chickens reared in cages and uncaged with feed additives. A total of 180 COBB broilers were used and randomly distributed into 6 different treatments and replicates following a randomized complete block design. The birds were weighed prior to arrival, 1st week, 2nd week, 3rd week, 4th week, and 5th week to determine the growth performance parameters. Economic analysis was also measured after the end of the study. The data was analyzed using Proc Mixed of SAS v. 9.4, and group comparison was used to evaluate the differences between the control and experimental groups. The result showed significant differences in feed intake at 1st week ($p=0.0249$) compared to the birds reared in an uncaged system. Feed intake in subsequent weeks and other growth performance parameters showed no significant differences throughout the study. Birds fed with 0.5% activated bamboo charcoal and bentonite clay obtained a higher return on investment than in 1% inclusion. These results imply that uncaged birds have the same growth performance with caged birds and could express their natural behavior at the same time. The result also revealed that better performance and profitability can be achieved at 0.5% inclusion of feed additives in the diet.

Keywords: *Activated bamboo charcoal, Bentonite clay, Broiler, Caged, Feed additive, Uncaged*

Introduction

Raising of chickens outdoor was very common until around 1950's (Alvarado et al 2005). The increase demand of poultry meat and the increase of its production has resulted to the development of intensive rearing systems (Bogosavljevi-Boskovic et al 2012). This development in broiler production has resulted to the

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use of cage system. Broiler chickens can be reared in two system: cage system and floor system. The type of broiler raising is an important factor in considering the welfare of the animal. Birds can exhibit their normal behavior such as dustbathing and sunbathing when free range or outdoor raising is practiced (da Silva et al 2017). Also, birds that are reared in a free-range system showed decrease stress level conditions because there are no environmental constraints allowing better welfare of the animal (Santos et al 2005; da Silva et al 2017). According to some studies, birds that are raised in a floor system showed improve growth rate and final body weight in comparison with birds that are raised in cage system (Fouad et al 2008). Additionally, meat quality of birds reared in outdoor system are preferred by consumers because it has a better taste and highly nutritive compared to those meat coming from indoors (Horsted et al 2010). According to Duncan (2002), when the bird can adjust to or deal with the limitations of the housing and management situations to which it is subjected, the concept of good welfare is realized.

Bamboo can be processed as bamboo charcoal and can also be used as a feed additive. It was reported in the past that charcoal has been used to improve animal performance since 1940's (Totusek & Beeson 1953). Charcoal as one of non-feed additives could promote growth performance in broiler chickens because of its adsorptive properties (Majewska et al 2011) which acts on the gastrointestinal tract of the animal and adsorbed gases such as ammonia and hydrogen sulfide. Charcoal does not only work on adsorption of gases but also adsorb toxins produced by bacteria and fungi and can prevent the effects of mycotoxin present in feedstuffs (Majewska et al 2011; Paramasivam 2021). Meanwhile, clay has been used by wild animals to alleviate gastrointestinal problems and to promote internal healing. Clay product particularly bentonite clay is known for its physical and chemical features which is the cation exchange and its speed of adsorption.

The application of activated bamboo charcoal and bentonite clay as feed additive in poultry industry are quite known for their adsorptive capabilities which makes it helpful in reducing the harmful effects of microorganisms. There are several studies stated that the application of bamboo charcoal and bentonite clay as feed additive could improve the growth performance of broiler chickens. However appropriate or standard amount of feed additives that could improve the growth performance as well as help reduce the harmful effects of microorganisms are inconsistent. This study is conducted to determine the performance of cage-free broilers compared to caged birds and the amount of feed additives such as activated bamboo charcoal and bentonite clay mineral in improving the growth performance of the broiler chickens.

Methodology

Procurement of birds and treatments

One hundred eighty (180) broiler chicks were sourced out from a reliable source. Upon arrival, chicks were weighed to determine its initial weight. Electrolytes were given to the chicks upon arrival. Treatments such as bentonite clay and activated bamboo charcoal food grade were procured in a reliable source. These birds were assumed to have been vaccinated prior to arrival at the study site.

Research Design

A total of 180 broilers were used and was randomly distributed into 6 different treatments following randomized complete block design. Blocking was based on the location of the range area of the broilers. Five (5) broilers were distributed per treatment per block.

Data Collection and Analysis

Voluntary feed intake, body weight, average daily gain, was collected at weekly interval. Data on broiler performance efficiency factor was obtained at the end of the study. The growth performance data was analyzed using SAS v.9.4 program using randomized complete block design. Group comparison was used to evaluate the differences between the control group vs the experimental groups.

Results and Discussions

Voluntary Feed Intake

The voluntary feed intake (VFI) of birds is shown in Table 1. Based on the result, birds in

cages (T_1) had significantly higher VFI compared to the birds raised in uncaged system (T_2, T_3, T_4, T_5, T_6) during the first week (p=0.0249). It showed that caged system (T_1) broilers had higher (p=0.0186) VFI at 139.13g compared to those uncaged (T_2, T_3, T_4, T_5, T_6) broilers with 118.72g. Within uncaged broilers, higher VFI (137.17g) was obtained from T_2 (uncaged without feed additive) than those with either ABC or BCM. Moreover, no differences were noted when activated bamboo charcoal & bentonite clay when compared to each other. In succeeding weeks, there were no significant differences were observed in the VFI of birds across all treatments in 2nd week (p=0.0736), 3rd week (p=0.3858), 4th week (p=0.4028), and 5th week (p=0.5407).

Table 1. Voluntary feed intake (VFI, grams) of broiler chicken reared in caged and uncaged system with activated bamboo charcoal and bentonite clay mineral as feed additive

DAY	TREATMENTS						SEM	p- value
	1	2	3	4	5	6		
7	139.13	137.17	118.23	113.27	116.13	105.80	9.85	0.0249
14	450.93	437.47	425.53	397.20	368.67	392.97	29.64	0.0736
21	975.73	954.57	930.47	881.73	871.23	898.03	56.56	0.3858
28	1687.57	1710.20	1669.53	1607.03	1548.80	1577.03	86.57	0.4028
35	2690.17	2841.03	2761.87	2747.97	2616.27	2660.17	115.04	0.5407
Total	5943.53	6080.43	5905.63	5474.20	5521.10	5634.00	287.13	0.4219

1 – Caged
2 – Uncaged (Control)
3 – 0.5% ABC
4 – 1% ABC
5 – 0.5% BCM
6 – 1% BCM

Table 1a. Group comparison at day 7 of the voluntary feed intake (VFI) of broiler chicken reared in caged and uncaged with activated bamboo charcoal and bentonite clay mineral as feed additive

ITEMS	CONTRAST		p-value
	MEAN 1	MEAN2	
C1	139.13	118.72	0.0186
C2	137.17	113.27	0.0099
C3	115.75	110.97	0.5360
C4	109.07	117.18	0.3252

Contrast 1 = Caged (T_1) vs Uncaged (T_2, T_3, T_4, T_5, T_6)
Contrast 2 = Uncaged (T_2) vs Uncaged treated (T_3, T_4, T_5, T_6)
Contrast 3 = Activated bamboo charcoal vs Bentonite clay mineral
Contrast 4 = ABC 1% and BCM 1% vs ABC 0.5% and BCM 0.5%

Broiler chicks in the early ages cannot regulate their own body temperature hence, artificial heat should be provided for the birds to be in their normal comfort zone. VFI is affected if there are sudden changes in the temperature in the environment. In the present study, birds in the cages are limited in their movement but was given a sufficient space. On the other hand, the broiler chicks raised in the uncaged system were given a wider space. The increase in VFI in caged birds (T_1) in comparison to the birds in uncaged system can be attributed to the temperature and elevation of the cage in the first week. Also, caged birds were given a limited space which helped in maintaining the required temperature needed by the chicks during brooding stage. However, according to Şimşek et al, (2014), this effect on the VFI of broiler chickens was due to their reduced in activity, thus decreasing the VFI of the birds in the

caged. The differences found in the present study may be due to the space constraint in the caged birds since they were given a little space in the first week in compared to the uncaged birds.

As per observation, the apparent higher VFI among birds in caged system was because there was no adjustment period involved in birds on the feed additive in the first week compared to uncaged birds. Similar findings were reported by Alhamed and Kharoufa, (2022) where no significant differences were observed in the following weeks which proves that birds had already adjusted or accustomed in the feed additive introduced in the diet.

Average Daily Gain and Body Weight of Chickens

Table 2 shows the average daily gain (ADG) of broiler chickens reared in caged and uncaged system with ABC and BCM as feed additive. The results showed that the ADG of broiler chicken reared in caged and uncaged system did not vary across treatments from 1st week (p=0.2277), 2nd week (p=0.5275), 3rd week (p=0.5801), 4th week (p=0.1388), and 5th week (p=0.2490). Similarly, in terms of body weight (BW), no differences were observed in all treatments from 1st week (p=0.2206), 2nd week (p=0.4500), 3rd week (p=0.5150), 4th week (= .3146), and 5th week (p=0.5925) as shown in Table 2 & 3.

Table 2. Average Daily Gain (ADG, grams) of broiler chicken reared in caged and uncaged with activated bamboo charcoal and bentonite clay mineral as feed additive

DAY	TREATMENTS						SEM	p- value
	1	2	3	4	5	6		
7	16.98	16.92	16.50	16.84	14.79	15.71	0.98	0.2277
14	30.84	31.45	31.38	27.99	27.28	28.23	2.60	0.5275
21	56.69	52.08	53.12	52.85	49.34	50.36	3.46	0.5801
28	49.45	58.29	55.17	59.17	49.50	59.57	4.70	0.1388
35	72.09	72.03	76.27	72.62	71.48	68.46	4.90	0.2490

1 – Caged 3 – 0.5% ABC 5 – 0.5% BCM
2 – Uncaged (Control) 4 – 1% ABC 6 – 1% BCM

Table 3. Body weight (BW, grams) of broiler chicken reared in caged and uncaged with activated bamboo charcoal and bentonite clay mineral as feed additive

DAY	TREATMENTS						SEM	p- value
	1	2	3	4	5	6		
7	159.90	158.30	154.17	157.03	142.97	149.47	7.17	0.2206
14	375.80	378.47	373.87	352.93	333.93	347.13	24.44	0.4500
21	772.67	743.00	745.67	722.83	679.30	699.67	45.55	0.5150
28	1115.53	1151.00	1131.83	1137.00	1025.83	1075.47	55.68	0.3146
35	1602.30	1655.17	1663.50	1645.33	1526.17	1589.07	70.03	0.5925

1 – Caged 3 – 0.5% ABC 5 – 0.5% BCM
2 – Uncaged (Control) 4 – 1% ABC 6 – 1% BCM

Hypes et al, (1994) stated that ADG of birds reared in cage system was comparatively lower than the birds reared in the uncaged system. However, the study of Khulel, (2018) claimed otherwise that broilers reared in caged system obtained a greater BW gain throughout the grow. Compared to broilers raised in the floor, some studies reported that using ABC and BCM in poultry diet had improved the animal performance. Its adsorptive and binding capabilities will help alleviate in gastrointestinal problems (Williams et al, 2004), promote animal health and growth (Slamova et al, 2011), and alleviate the effects of toxin because of the presence of micropores that enables detoxification of mycotoxin (Chkuaselli et al, 2016). The addition of

feed additives in the diet was the result of equal growth rates observed in the study. Using data on VFI which showed result across treatments from 2nd week until 5th week, it can be inferred that the effect of feed additive had apparent improvement in BW in uncaged broilers, especially with activated charcoal. The comparable growth rate was the result of improved digestion and absorption of nutrients which was supported by the feed additive in utilization of nutrients in the digestive system (Alhamed and Kharoufa, 2022). At the same time, uncaged birds were able to express their natural behavior such as dustbathing and freedom from restriction of cages and still achieved comparable growth than the caged birds. This behavior manifests better welfare for birds kept in uncaged system.

Feed Conversion Ratio

Feed conversion ratio (FCR) is the measure of how efficient the bird can convert feeds into WG. Table 4 shows that the FCR of birds given a commercial feed in caged and uncaged birds results did not show any significant differences across treatments from 1st week (p=0.0546), 2nd week (p=0.9118), 3rd week (p=0.7305), 4th (p=0.2497), and 5th (p=0.7938). Overall, FCR also did not show any significant difference (p=0.5245) among treatments.

Table 4. Feed conversion ratio (FCR) of broiler chicken reared in caged and uncaged with activated bamboo charcoal and bentonite clay mineral as feed additive

DAY	TREATMENTS						SEM	p- value
	1	2	3	4	5	6		
7	1.26	1.27	1.13	1.06	1.28	1.09	0.06	0.0546
14	1.42	1.36	1.36	1.33	1.33	1.36	0.06	0.9118
21	1.39	1.40	1.36	1.32	1.41	1.42	0.05	0.7305
28	1.70	1.58	1.57	1.51	1.62	1.58	0.05	0.2497
35	1.92	1.76	1.77	1.72	1.76	1.77	0.04	0.7938
Overall	1.79	1.85	1.78	1.80	1.86	1.87	0.04	0.5245
1 – Caged			3 – 0.5% ABC				5 – 0.5% BCM	
2 – Uncaged (Control)			4 – 1% ABC				6 – 1% BCM	

The present study shows that there were no significant differences in FCR values 1st week (p=0.0546), 2nd week (p=0.9118), 3rd week (p=0.7305), 4th week (p=0.2497), 5th week (p=0.7938), and overall FCR (p=0.5245) of the animals raised in caged and uncaged system given with activated bamboo charcoal and bentonite clay as feed additive. With no significant differences found between caged birds and uncaged birds it is safe to assume that the same FCR values can be achieved by raising broiler chickens regardless of the rearing system. This result disagrees with Şimşek et al, (2014) where birds reared in the uncaged system had better FCR values compared to the birds that were raised in the cage system. Cage birds in this study were given a limited space resulting to a decrease in activity during later stages and this affected the VFI and ADG of the birds especially at the later stages. This is also in accordance with Santos et al, (2014) and Sogunle et al, (2008) wherein broilers raised in litter floors had lower FCR values compared to the caged birds. However, the study was conducted in a tunnel ventilated farms where environment can be controlled. The present study was conducted in a conventional setting wherein the temperature, humidity and other requirements needed for broiler's optimal growth is dependent on the climate of the area. Also, in the first week of the growth cycle of birds, there was a decrease in VFI and ADG affecting the BW and FCR of the birds. Nevertheless, raising broiler chickens in uncaged environment could have similar FCR values with the birds raised in caged environment. By raising broiler in chicken in uncaged setting, birds can express their natural behavior, hence promoting better welfare of the birds.

Percent Livability

Table 5 shows the percent livability of birds reared in caged and uncaged system with inclusion of ABC and BCM feed additive in the diet. Based on the results, it showed no significant differences across treatments throughout the 35 days of feeding trial. However, there was a tendency (p=0.0647). that those in uncaged system had higher livability compared to caged system.

Table 5. Percent livability (%) of broiler chicken reared in caged and uncaged with activated bamboo charcoal and bentonite clay mineral as feed additive

DAY	TREATMENTS						SEM	p- value
	T1	T2	T3	T4	T5	T6		
1 - 35	90.00	100.00	90.67	100.00	100.00	96.67	2.56	0.0647
1 – Caged			3 – 0.5% ABC				5 – 0.5% BCM	
2 – Uncaged (Control)			4 – 1% ABC				6 – 1% BCM	

The treatments had no remarkable effect on the % livability of birds during this study. Mortalities were recorded among treatments, but higher tendency of mortalities were observed in caged birds. This finding was similar to that of Majewska et al (1999), where mortality was higher on the birds which were not given bamboo charcoal as feed additive. The higher mortality of the birds reared in the cages may be due to the limited space and rapid growth of broiler chickens and expected increase in body temperature. The mortality was observed during the 4th week of age. At this age, birds require at least around 27°C in the area to minimize the heat produced by the birds' body. There are different factors affecting the livability of the birds; environmental factor is one of the major factors that affects the growth of the birds as well as the livability of the animal. The increase in temperature and the lack of prevailing winds also became a factor in the mortality of the birds. Sudden increase in temperature may cause heat stress on the animal and it is considered a problem in poultry industry especially in broiler production. During the 3rd to 4th week of rearing the broiler, heat stress related problem was observed because of the increase body heat of the animal. Due to the increase in temperature in the area, panting and birds have suffered seizure in some blocks in the experimental site. Since caged birds was given limited space, there was a higher tendency of mortality as per record. Livability of the birds can be also affected by diseases which is also a major factor affecting the poultry industry. One of the purposes of the feed additive inclusion in the diet was to minimize the mortality in case there was an outbreak of disease. It was reported that these feed additives can alleviate the effects of bacteria and toxin on the animal performance because of its adsorptive and binding capabilities (Diaz et al 2003; Bueno et al 2005; Chkuaseli et al 2016).

Broiler Production Efficiency Factor

The broiler performance efficiency factor (BPEF) is a measure used to determine the broiler production performance and how efficient the grow cycle is. A value of 100 or higher is considered desirable and efficient. It considers the different growth parameters such as liveweight, mortality, FCR, and age at harvest (Maxwell et al, 2018; Murugan & Ragavan, 2017). Table 6 shows the BPEF of the grow cycle and no significant differences were found across treatments (p = 0.6886).

Table 6. Broiler production efficiency factor (BPEF) of broiler chicken reared in caged and uncaged with activated bamboo charcoal and bentonite clay mineral as feed additive

DAY	TREATMENTS						SEM	p- value
	1	2	3	4	5	6		
BPEF	91.29	92.93	96.18	95.05	85.65	91.37	5.13	0.6886
1 – Caged			3 – 0.5% ABC				5 – 0.5% BCM	
2 – Uncaged (Control)			4 – 1% ABC				6 – 1% BCM	

Since BPEF considers production parameters such as saleable liveweight, livability, FCR, and age at harvest, sudden changes in each production parameters would affect the BPEF. The result shown in the Table 6 on BPEF values were not significant (p = 0.6886) among treatments which means that uncaged broilers had comparable performance to that of caged broilers. This result showed that BPEF values of birds reared in the caged and uncaged system was not affected even if it was raised in caged and uncaged environment. The welfare of the animals was better provided since the natural behavior of the animals were expressed more in uncaged broilers than those under caged system.

Economic Analysis

Table 7 shows the Return Above Feed Cost (RAFC), Gross Income (GI), and Return on Investment (ROI) of rearing broiler chickens in caged and uncaged setting with different inclusion of activated charcoal and bentonite clay as feed additive.

Table 7. Economic analysis of broiler chicken reared in caged and uncaged with activated bamboo charcoal and bentonite clay as feed additive

Parameters	TREATMENTS					
	1	2	3	4	5	6
RAFC	155.37	134.73	142.54	134.31	142.01	132.75
GI	304.49	289.90	295.00	286.16	289.18	282.40
ROI	32.87	38.15	45.31	38.33	45.88	37.61

1 – Caged 2 – Uncaged (Control) 3 – 0.5% Activated Bamboo Charcoal
4 – 1% Activated Bamboo Charcoal 5 – 0.5% Bentonite Clay 6 – 1% Bentonite Clay

Gross income and RAFC were higher in birds reared in cage system (304.49) and (155.37) than birds reared in floor. However, in terms of ROI, the birds reared in the uncaged system were more profitable in comparison with the birds reared in the caged birds which is in agreement with the study of Fouad et al, (2008). The birds reared under uncaged system were more profitable compared to caged birds because the materials in caged system were more costly. The higher ROI in uncaged setting might be attributed to the effectiveness of the feed additive's role in improvement in digestive process (De Moura et al, 2015) thus reducing the actual amount of feed consumed of the birds. For birds fed with different inclusions of feed additives in the diet (T_3, T_5 Vs T_4, T_6), 0.5% inclusions of feed additives (T_3, T_5) in the diet were more profitable than 1% inclusion of feed additives (T_4, T_6) in the diet. The higher values in the birds fed with 0.5% feed additive in the diet is in agreement with Tauqir & Nawaz, (2001) that used feed additive which improved the performance of the birds. Using it at low levels helps lower the cost of feed since it reduces the feed consumed of the birds while improving weight gain.

Conclusion

In conclusion, the result of this study shows that higher voluntary feed intake can be obtain by caged and uncaged birds without feed additives at first week. Throughout the study, it showed that comparable effects in growth performance parameters such as VFI, ADG, BW, FCR, BPEF, and percent livability could be achieved while considering the expression of natural behavior of the birds. These findings suggest that birds can be reared in uncaged setting and still achieve the same performance of the birds reared in the cages and exhibit their natural behavior while having the same growth speed. Moreover, the use of these feed additives especially on birds reared in uncaged environment wherein they are vulnerable to certain diseases, can be considered as an alternative to antibiotics because of its binding and adsorption capabilities which binds on toxin and bacteria.

Recommendations

According to some studies, feed additives such as activated bamboo charcoal and bentonite clay mineral better on poor quality feeds.

Further studies are recommended in comparing the effect of these two feed additives on the growth performance of the broiler chickens in poor quality feeds vs commercial feeds. Further studies are recommended on what percentage of inclusion of feed additive between poor quality feed and commercial feed. Since cage free is popular to consumer, the study did not include the meat quality aspect therefore further studies on cage free meat quality characteristics fed with activated bamboo charcoal and bentonite clay.

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