Research Article

# Effect of Adding Bentonite and Charcoal to Reused Litter on the Productive Performance and Carcass Characteristics of Broilers

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**Abstract** | This study investigated the effects of bentonite and charcoal applied individually or in combination to reused broiler litter on growth performance, feed efficiency, mortality, and carcass traits. A total of 120 Ross 308 broilers were assigned to five treatments: reused litter without additives (T1), fresh litter without additives (T2), reused litter with bentonite (T3; 250 g/m$^2$), reused litter with charcoal (T4; 250 g/m$^2$), and reused litter with both bentonite and charcoal (T5; 250 g/m$^2$ each). Each group was divided into three replicates with eight birds per replicate (24 birds per treatment). Birds were reared on floor pens and managed under standard Ross 308 production guidelines. The results showed that, birds in T5 group exhibited the highest body weight, lowest feed conversion ratio, and reduced mortality ($P \leq 0.05$). Carcass yield and breast and thigh percentages were also significantly ($P \leq 0.05$) improved in T5 group as compared to other groups. These findings demonstrate the complementary effects of bentonite and charcoal and show that their combined use is a practical strategy for improving broiler performance when litter reuse is unavoidable.

**Keywords** | Broiler chickens, Reused litter, Litter amendments, Bentonite, Charcoal, Growth performance, Feed conversion ratio, Carcass traits

**Received** | November 08, 2025; **Accepted** | February 02, 2026; **Published** | April 13, 2026
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**Citation** | Saad HF, Al-Hummod SK (2026). Effect of adding bentonite and charcoal to reused litter on the productive performance and carcass characteristics of broilers. J. Anim. Health Prod. 14(2): 582-587.
**DOI** | https://dx.doi.org/10.17582/journal.jahp/2026/14.2.582.587
**ISSN (Online)** | 2308-2801



## INTRODUCTION

Broiler production relies heavily on maintaining an optimal indoor environment, as litter quality plays a central role in bird health, growth, and overall productivity. Reused litter often accumulates manure, residual feed, moisture, and harmful microorganisms, which contribute to elevated ammonia levels and a decline in air quality. These conditions negatively impact respiratory health, immune function, and growth performance in broilers (Whiting *et al*., 1991; Yasmeen *et al*., 2023). Therefore, improving the physicochemical properties of reused litter has become increasingly important in modern poultry management.

Several studies have explored the use of adsorbent materials such as bentonite and charcoal to improve litter quality by reducing moisture, binding toxins, and lowering microbial activity (Tang *et al*., 2023). Bentonite, a clay rich in montmorillonite, possesses a high absorption capacity and cation-exchange properties that help limit moisture accumulation and reduce microbial proliferation (Taylor-Pickard and Tucker, 2005). Additionally, previous research indicates that bentonite may enhance nutrient digestibility and reduce exposure to mycotoxins, thereby supporting improved growth performance (Saad and Raheem, 2025).

Charcoal (biochar) is another effective absorbent material known for its strong ability to bind ammonia, toxic metabolites, and undesirable gases. Its inclusion in poultry systems has been associated with improved air quality, enhanced respiratory comfort, and modulation of gut microbiota (Samanya and Yamauchi, 2002; Zhang

*et al*., 2013). Recent studies have also demonstrated that biochar can alter the litter microenvironment by reducing pathogenic bacterial load and stabilizing pH, thereby contributing to improved footpad health and better weight gain outcomes in broilers (Kazemi, 2025; Zaid *et al*., 2023).

However, although bentonite and charcoal have each been studied individually, limited information exists regarding their combined use in reused litter and whether such a combination may produce a synergistic effect greater than either material alone. This combined approach may offer dual benefits: bentonite functioning as a moisture and toxin binder and charcoal acting as a gaseous pollutant adsorbent, thereby addressing multiple litter-related challenges simultaneously.

Accordingly, assessing the combined influence of bentonite and charcoal on broiler performance and carcass characteristics is of both scientific and practical importance. Developing an effective dual-amendment strategy may offer poultry producers a cost-efficient and sustainable solution for improving litter quality, particularly in systems where litter reuse is necessary. Such improvements align with global efforts toward environmentally sustainable poultry production, reduced waste, and improved animal welfare outcomes (FAO, 2023). Therefore, current study was carried out to investigate the effects of bentonite and charcoal applied individually or in combination to reused broiler litter on growth performance, feed efficiency, mortality, and carcass characteristics.

## MATERIALS AND METHODS

### Animals and grouping

The experiment was conducted at the Animal Production Field, College of Agriculture, University of Basrah, from October 12 to November 15, 2024. A total of 120 one-day-old Ross 308 broiler chicks were randomly allocated to five treatments, each consisting of three replicates with eight birds per replicate (24 birds per treatment).

Birds were reared on floor pens and managed under standard Ross 308 production guidelines including proper temperature, lighting, ventilation, feeding, and drinking. Each pen measured 2 × 2 meters (4 $m^2$), with a stocking density of 10 birds/$m^2$. The treatments were arranged as follows: T1 – used litter without additives (control), T2 – fresh litter without additives, T3 – used litter + 250 g/$m^2$ bentonite, T4 – used litter + 250 g/$m^2$ charcoal, T5 – used litter + 250 g/$m^2$ bentonite + 250 g/$m^2$ charcoal

The charcoal used in the study was derived from citrus wood, ground, and sieved to ensure uniform particle size. Bentonite was a fine montmorillonite-rich clay powder. Both materials were weighed, placed in mesh bags to minimize dust dispersion, and evenly distributed across the litter surface to ensure proper mixing.

Environmental conditions were precisely controlled: temperature started at 33°C during week 1 and was gradually reduced by 2–3°C per week until reaching 24°C by week 5; relative humidity ranged between 55–65%; ventilation operated at 1.5–2.0 $m^3$/min using a cross-flow system.

### Study parameters

Birds were weighed individually on days 1, 7, 14, 21, 28, and 35 to calculate weekly live body weight. Feed intake per replicate was calculated weekly by subtracting the refusals from the feed offered. The feed conversion ratio (FCR) was calculated correctly using the formula: FCR = feed intake (g) / body weight gain (g). Mortality was recorded daily and expressed as: Mortality (%) = (number of dead birds / total birds placed) × 100.

At day 35, three birds from each replicate were randomly selected and slaughtered following halal and hygienic guidelines. Carcasses were chilled at 4°C for 24 hours, after which cold carcass weight was recorded. Breast and thigh muscles were excised and weighed to determine their relative yield. Dressing percentage was calculated as: Dressing (%) = (cold carcass weight / live weight before slaughter) × 100.

### Statistical analysis

Statistical analysis was performed using one-way ANOVA within a completely randomized design (CRD) in SPSS (Version 2016; IBM Corp., 2017). Model assumptions of normality and homogeneity of variances were verified using Shapiro–Wilk and Levene's tests (Shapiro and Wilk, 1965; Levene, 1960). When ANOVA showed significant differences ($P \leq 0.05$), means were compared using Fisher's LSD test (Fisher, 1935). The statistical procedures followed the guidelines described by Field (2018).

## RESULTS AND DISCUSSION

### Effect of addition of bentonite and charcoal to reused litter on average body weight of broiler chickens

Table 1 shows a significant difference in the mean body weight between the experimental groups ($P < 0.05$). Finally, the reclaimed litter amended with bentonite and charcoal (treatment T5) showed the highest mean body weight compared to the control (treatment T1; reclaimed litter without amendments). This improvement is likely due to the better litter quality resulting from the moisture- and gas-adsorbing properties of bentonite and charcoal.

By reducing ammonia accumulation, these additives likely decreased heat and respiratory stress, thereby promoting excellent growth performance.

**Table 1:** Effect of adding bentonite and charcoal to reused litter on weekly average body weight (g) of broiler chickens from 1 to 5 weeks of age (mean ± SE).

| Treatment | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 |
|---|---|---|---|---|---|
| T1 | 150.76 ± 5.02c | 400.84 ± 10.02c | 850.98 ± 1.05c | 1300.10 ± 20.63c | 1700.19 ± 2.52c |
| T2 | 155.87 ± 5.02bc | 410.76 ± 12.50bc | 870.54 ± 1.41bc | 1320.05± 18.03bc | 1750.88 ± 2.56bc |
| T3 | 160.98 ± 6.04b | 420.23 ± 10.01b | 890.43 ± 1.85b | 1350.17 ± 20.94b | 1800.91 ± 2.02b |
| T4 | 162.45 ± 5.54b | 425.65 ± 11.19b | 900.56 ± 1.25b | 1370.44 ± 19.51b | 1820.00 ± 2.08b |
| T5 | 170.66 ± 6.07a | 440.22 ± 12.18a | 920.00 ± 1.69a | 1400.92 ± 20.01a | 1900.72 ± 2.53a |

Means within the same column followed by different superscript letters (a, b, c) differ significantly at P ≤ 0.05. T1: Reused litter without additives (control); T2: Fresh litter without additives; T3: Reused litter + bentonite (250 g/m$^2$); T4: Reused litter + charcoal (250 g/m$^2$); T5: Reused litter + bentonite (250 g/m$^2$) + charcoal (250 g/m$^2$).

Less energy is required for homeostatic regulation since the microenvironment is more stable, resulting in lower humidity and a lower concentration of ammonia. The saved energy can then be put towards somatic growth and weight gain (Tang, 2023). In addition, the toxin-binding and microbiota-modulating effects of charcoal can enhance gut function and improve nutrient absorption, which is another way it promotes growth.

These results are in agreement with Saad and Raheem (2025), who tested different rates of bentonite application (150, 250, 350, and 450 g/m$^2$) in the litter of Ross 308 broilers. Their findings indicated a highly significant improvement ($P < 0.05$) in body weight, weight gain, and both weekly and cumulative feed intake in all bentonite-treated groups compared to the control group in the fifth week. In addition, birds fed 250 and 350 g/m$^2$ bentonite had significantly improved feed conversion efficiency compared to birds on untreated litter.

Treatments T2 (fresh litter), T3 (bentonite), and T4 (charcoal) showed intermediate values between T1 and T5, suggesting that either litter replacement or the individual supplementation of bentonite or charcoal exerts a positive effect compared with used litter without additives. Nevertheless, the combined application of bentonite and charcoal (T5) resulted in the most pronounced improvement, thereby supporting the hypothesis of a synergistic interaction between the two materials when applied together. Recent studies also support this synergistic benefit. For example, Adebayo *et al.* (2021) reported that combining clay-based adsorbents with biochar significantly enhanced broiler weight gain by improving litter aeration and decreasing ammonia concentration. Such findings strengthen the interpretation that dual amendments provide superior environmental modification compared to single additives.

## Effect of adding bentonite and charcoal to the used litter on weekly feed intake of broiler chickens

As shown in Table 2, birds in treatment T5 consumed less feed than those in the control (T1), yet had higher body weights, indicating a better feed conversion. Given the improvement in the rearing environment resulting from the reduction in litter moisture and ammonia levels in this study, achieved through the addition of bentonite and charcoal, respectively, this effect may be attributed to reduced stress and improved feed utilization. Similar findings were reported by Abdel-Mageed etal. (2023), who concluded that poor litter quality was associated with reduced feed intake.

**Table 2:** Effect of adding bentonite and charcoal to reused litter on weekly feed intake (g/bird/week) of broiler chickens from 1 to 5 weeks of age (mean ± SE).

| Treatment | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 |
|---|---|---|---|---|---|
| T1 | 180.07 ± 0.52a | 600.12 ± 1.01a | 1050.0± 1.51a | 1550.0 ± 2.02a | 1908.98± 2.65a |
| T2 | 175.54 ± 0.44ab | 590.41± 1.21ab | 1030.0 ± 1.52ab | 1530.0 ± 2.01ab | 1880.76± 2.50ab |
| T3 | 170.74 ± 0.65bc | 580.32± 1.03bc | 1020.0 ± 1.21bc | 1510.2 ± 2.01bc | 1850.56 ± 2.00bc |
| T4 | 168.98 ± 0.53bc | 570.61 ± 1.01bc | 1000.0 ± 0.12bc | 1490.5± 1.81bc | 1830.57 ± 2.50bc |
| T5 | 165.05 ±0.56c | 560.44 ± 1.12c | 980.0 ± 0.21c | 1470.1± 2.01c | 1800.72 ± 2.51c |

Means within the same column followed by different superscript letters (a, b, c) differ significantly at P ≤ 0.05. T1: Reused litter without additives (control); T2: Fresh litter without additives; T3: Reused litter + bentonite (250 g/m$^2$); T4: Reused litter + charcoal (250 g/m$^2$); T5: Reused litter + bentonite (250 g/m$^2$) + charcoal (250 g/m$^2$).

The synergistic effect of the two additives could also be attributed to their distinct physiological activities: bentonite, combined with mycotoxins in the digesta, facilitates slower digesta passage, thereby improving nutrient absorption, and biochar reduces the microbial and toxic load in the gut, thereby enhancing digestive efficiency (Zhang *et al.*, 2013). More recent evidence suggests similar outcomes. According to Oliveira *et al.* (2022), broilers reared on litter

amended with biochar showed significantly lower feed intake and improved feed efficiency, mainly due to reduced oxidative stress and improved microbiome composition. This further supports the findings of the current study.

### Effect of adding bentonite and charcoal to the used litter on the weekly feed conversion ratio of broiler chickens

The feed conversion ratio (FCR) was lower ($P < 0.05$) in treatment T5 than in the control (T1), particularly in the fourth and fifth weeks, as shown in Table 3. This is an enhancement that can be used to illustrate the fact that birds have a better capacity for gaining weight using the same amount of food or less, meaning they are more efficient in terms of nutrient utilization. T2, T3, and T4 also demonstrated lower FCR values compared to T1, but not as significantly as T5, indicating that either litter replacement or the individual addition of bentonite or charcoal is effective in enhancing the rearing conditions. Nevertheless, both the use of bentonite and charcoal had the most significant impact, probably due to the complementary effects of the two on moisture, toxin adsorption, and gut health improvement. Reduced FCR is directly related to increased productivity and decreased cost, and it is a primary economic goal in the poultry industry (Cho *et al*., 2021; Taylor-Pickard and Tucker, 2005).

**Table 3:** Effect of adding bentonite and charcoal to reused litter on weekly feed conversion ratio (FCR) of broiler chickens from 1 to 5 weeks of age (mean ± SE).

| Treatment | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 |
|---|---|---|---|---|---|
| T1 | 1.20 ± 0.02a | 1.50 ± 0.03a | 1.60 ± 0.03a | 1.75 ± 0.04a | 1.90 ± 0.05a |
| T2 | 1.15 ± 0.02ab | 1.45 ± 0.03ab | 1.58 ± 0.03ab | 1.70 ± 0.04ab | 1.85 ± 0.04ab |
| T3 | 1.13 ± 0.02ab | 1.43 ± 0.02ab | 1.55 ± 0.03ab | 1.68 ± 0.03b | 1.83 ± 0.04b |
| T4 | 1.12 ± 0.02ab | 1.42 ± 0.02ab | 1.54 ± 0.03b | 1.66 ± 0.03b | 1.82 ± 0.03b |
| T5 | 1.10 ± 0.01b | 1.40 ± 0.02b | 1.52 ± 0.03b | 1.65 ± 0.03b | 1.80 ± 0.03b |

Means within the same column followed by different superscript letters (a, b) differ significantly at $P \leq 0.05$. T1: Reused litter without additives (control); T2: Fresh litter without additives; T3: Reused litter + bentonite (250 g/m$^2$); T4: Reused litter + charcoal (250 g/m$^2$); T5: Reused litter + bentonite (250 g/m$^2$) + charcoal (250 g/m$^2$).

Wang *et al*. (2020) demonstrated that biochar improves nitrogen retention and lowers the metabolic cost of detoxification, which directly enhances FCR. This supports the mechanism proposed for the improved performance of T5 birds.

### Effect of adding bentonite and charcoal to the used litter on the overall mortality rate of broiler chickens

The total mortality rate was lower ($P < 0.05$) in treatment T5 (2.8%) compared to the control (5.5%), as shown in Table 4. This enhancement represents the ability of bentonite and charcoal to improve the quality of litter as an indicator of decreased stress, respiratory, and digestive illnesses. This is because mortality is reduced due to the adsorption of toxins and pathogens, which enhances the overall survival and health of the flock (El-Deek *et al*., 2023).

**Table 4:** Effect of adding bentonite and charcoal to reused litter on total mortality (%) of broiler chickens during the experimental period (mean ± SE).

| Treatment | Total mortality ratios |
|---|---|
| T1 | 5.5 ± 0.54a |
| T2 | 5.5 ± 0.39a |
| T3 | 3.6 ± 0.32b |
| T4 | 3.3 ± 0.63b |
| T5 | 3.8 ± 0.28b |

Means within the same column followed by different superscript letters (a, b) differ significantly at $P \leq 0.05$. T1: Reused litter without additives (control); T2: Fresh litter without additives; T3: Reused litter + bentonite (250 g/m$^2$); T4: Reused litter + charcoal (250 g/m$^2$); T5: Reused litter + bentonite (250 g/m$^2$) + charcoal (250 g/m$^2$).

Although a specific mortality was experienced in all treatments, the variation in mortality rates highlights the impact of litter quality and environmental factors. These results are consistent with other pieces of literature that state absorbent powders, such as bentonite and charcoal, inhibit the growth of harmful bacteria and prevent the rate of death (Zhao *et al*., 2022). Recent work by Abubakar *et al*. (2019) demonstrated that broilers raised on biochar-amended litter exhibited improved immune status and reduced mortality under heat stress, indicating that the benefits observed in T5 are consistent with global findings.

### Effect of adding bentonite and charcoal to the used litter on carcass traits of broiler chickens

As shown in Table 5, treatment T5 recorded the highest dressing percentage, with a significantly ($P < 0.05$) higher yield in the breast and thighs compared to the control (T1). This indicates that the joint supplemental addition of both bentonite and charcoal enhanced the utilization of nutrients, deposition of muscle, and reduced carcass loss. T2, T3, and T4 also exhibited an improvement compared to T1, albeit less significantly, which demonstrates that replacing litter or using either bentonite or charcoal alone is beneficial. Nevertheless, the joint supplementation

(T5) had the most dramatic effect, probably due to the complementary activity of bentonite in reducing mycotoxins and charcoal, as well as the reduction of litter moisture and improvement of the rearing environment. T2 (fresh litter) was superior to T1 (used litter without additives) due to its lower contamination and microbial loads; however, it was inferior to T3, T4, and T5, which had the advantage of the absorptive nature of the additives.

**Table 5:** Effect of adding bentonite and charcoal to reused litter on dressing percentage and major carcass traits (%) of broiler chickens at 35 days of age (mean ± SE).

| Treatment | Dressing percentage (%) | Breast yield (%) | Thigh yield (%) |
|---|---|---|---|
| T1 | 73.0 ± 0.50c | 21.5 ± 0.30c | 14.6 ± 0.25c |
| T2 | 74.1 ± 0.48bc | 21.8 ± 0.34bc | 14.8 ± 0.23bc |
| T3 | 74.8 ± 0.44bc | 22.3 ± 0.28bc | 15.0 ± 0.20bc |
| T4 | 75.4 ± 0.52ab | 23.0 ± 0.25ab | 15.1 ± 0.22ab |
| T5 | 76.2 ± 0.46a | 23.5 ± 0.32a | 15.3 ± 0.20a |

Means within the same column followed by different superscript letters (a, b, c) differ significantly at $P \leq 0.05$. T1: Reused litter without additives (control); T2: Fresh litter without additives; T3: Reused litter + bentonite (250 g/m$^2$); T4: Reused litter + charcoal (250 g/m$^2$); T5: Reused litter + bentonite (250 g/m$^2$) + charcoal (250 g/m$^2$).

These findings were consistent with the literature by Marzouq and Saad (2025), which showed that the analysis of carcasses revealed that the addition of charcoal improved the percentages of breast and thigh muscles, thereby enhancing the quality of the fresh meat.

Similar improvements were reported by El-Shafey et al. (2024), who found that dietary biochar supplementation enhanced carcass composition, particularly breast and thigh muscle percentages, leading to superior fresh meat quality. Furthermore, Kim *et al.* (2020) reported that litter amendments reducing ammonia and moisture significantly improved carcass yield and muscle deposition in broilers, supporting the outcomes observed in T5.

## CONCLUSIONS

The results of this study demonstrate that the application of bentonite and charcoal, either individually or in combination, produced measurable improvements in broiler performance when compared with untreated reused litter. Birds in T5 showed superior body weight, better feed conversion ratio, and lower mortality, while carcass traits such as dressing percentage, breast yield, and thigh yield were also enhanced. The findings indicate that combining bentonite and charcoal is the most effective among the tested treatments; however, the conclusions remain limited to growth performance and carcass characteristics only, as no environmental or microbial parameters were measured in this study.

## ACKNOWLEDGMENT

The authors express their appreciation to the College of Agriculture, University of Basrah, for providing facilities and logistical support during the conduct of this experiment. Special thanks are extended to the staff of the Poultry Research Unit for their assistance in animal care and data collection.

## NOVELTY STATEMENT

This study provides a novel comparative evaluation of bentonite and charcoal as litter amendments under reused litter conditions in broiler production. Unlike previous studies that investigated these materials separately or under fresh litter systems, the present work specifically examines their combined impact on productive performance and carcass characteristics under practical farm-like reused litter conditions. The study offers new insights into sustainable litter management strategies aimed at improving growth efficiency while maintaining carcass quality, thereby contributing to environmentally responsible poultry production systems.

## AUTHOR'S CONTRIBUTION

Huda Falih Saad: Conceptualization, experimental design, supervision, data analysis, statistical interpretation, manuscript writing and revision. Sabah Kadhum Al-hummod: Experimental implementation, data collection, laboratory analysis, and assistance in manuscript preparation. Both authors read and approved the final manuscript.

### Ethical approval

Ethical approval for the study was obtained from the Institutional Animal Care and Use Committee, University of Basrah (Approval No. BAU-APC-2024-17).

### Generative AI and AI-assisted technology statement

The authors confirm that generative AI tools were used solely for language editing and grammar refinement. All scientific content, experimental design, data analysis, and interpretation were performed independently by the authors. The authors take full responsibility for the integrity and originality of the manuscript

### Conflict of interest

The authors have declared no conflict of interest.

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