Changes of meat carcasses properties by using of added different methods of red beetroot powder in broiler

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Abstract:

The study consisted of a two-phase experiment. The first phase was conducted at the Al-Baz hatchery in the holy city of Karbala on October 30, 2025 (18 day of incubation). The second phase was conducted at the poultry farm belonging to the Agricultural Research and Experiment Station, College of Agriculture, Al-Muthanna University, from November 2, 2025, to December 7, 2025, for a duration of 35 days. Two hundred and seventy unsexed Ross 308 hybrid broiler chicks, one day old and weighing an average of 40 grams each, were used. The chicks were randomly distributed into six experimental treatments, with 45 chicks per treatment. Each treatment had three replicates (15 chicks/replicate). The experimental treatments were as follows: **T1:** Negative control treatment (no additives). **T2:** Positive control treatment (in ovo injection of distilled water at a concentration of 0.01 ml/L). **T3:** in ovo injection of aqueous extract of beetroot at a concentration of 0.01 ml/L. **T4:** Dose of powdered beetroot extract at a concentration of 0.25 ml/L. **T5:** Add of powdered beetroot to drinking water at a concentration of 2 ml/L. **T6:** Add of powdered beetroot to the feed at a concentration of 20 gm/kg. The results indicated a significant effect of all methods of adding red beetroot powder on all studied traits. A significant increase was observed in dressing ratio with and without giblet, the relative weight of giblet (heart, liver, and gizzard), and the relative weight of the main cuts (breast, thigh, and drumstick). Conversely, a significant decrease was observed in the relative weight of the secondary cuts (neck, wings, and back). The results also showed a significant increase in water-holding capacity, with a significant decrease in dripping loss, thawing loss, and cooking loss. The best results were obtained in T5.

Keywords: meat carcasses, different methods, beetroot, broiler.

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Introduction:

The poultry industry faces major challenges, including rising feed prices, the spread of certain infectious diseases such as avian influenza, and increasing requirements for animal welfare and health standards, which necessitates the development of more efficient and sustainable production systems [1, 2].

In light of the global trend towards using natural and functional ingredients in poultry feed, the need has arisen to search for plant sources rich in bioactive compounds capable of improving production performance and meat quality, and reducing oxidative stress without relying on artificial additives. Beetroot, in its various forms (red, sugar, and forage), considered a promising crop in this field, due to its richness in bioactive compounds and its versatility in feed use [3].

Red beetroot (*Beta vulgaris* L. var. rubra) is characterized by its betalain pigments, especially beta-cyanin, in addition to phenolic compounds and natural nitrates, which have shown a clear ability to reduce oxidative stress and improve the color and fat stability of meat when included in poultry diets [4, 5]. Recent studies have shown that the use of red beetroot extracts in broiler feed, led to a reduction in malondialdehyde (MDA) levels and improved antioxidant enzyme activity in muscle tissue, positively impacting shelf life and final product quality [6].

The effect of beetroot on carcass characteristics is linked to improved muscle blood flow and reduced oxidative stress in tissues. This may lead to increased dressing percentage and pectoral muscle growth [7]. Recent studies have shown that adding natural nitrate sources to poultry diets may improve breast relative weight, increase dressing percentage, and improve the relative weight of certain vital organs. This is associated with improved energy utilization efficiency and reduced losses due to oxidative stress [8].

This study aims to demonstrate the effect of using different methods of adding red beetroot powder on some carcass characteristics of Ross 308 broiler chickens.

Materials and Methods:

The study consisted of a two-phase experiment. The first phase was conducted at the Al-Baz hatchery in the holy city of Karbala on October 30, 2025. The second phase was conducted at the poultry farm belonging to the Agricultural Research and Experiment Station, College of Agriculture, Al-Muthanna University, from November 2, 2025, to December 7, 2025, for a duration of 35 days. The aim was to study the effect of adding beetroot powder in various ways on the weight, relative length, and some histological parameters of the intestines of broiler chickens. Two hundred and seventy unsexed Ross 308 hybrid broiler chicks, one day old and weighing an average of 40 grams each, were used. The chicks were randomly distributed into six experimental treatments, with 45 chicks per treatment. Each treatment had three replicates (15 chicks/replicate). The experimental treatments were as follows:

T1: Negative control treatment (no additives).

T2: Positive control treatment (in ovo injection of distilled water at a concentration of 0.01 ml/L).

T3: in ovo injection of aqueous extract of beetroot at a concentration of 0.01 ml/L.

T4: Dose of powdered beetroot extract at a concentration of 0.25 ml/L.

T5: Add of powdered beetroot to drinking water at a concentration of 2 ml/L.

T6: Add of powdered beetroot to the feed at a concentration of 20 gm/kg.

The newly hatched chicks were raised in four-tiered batteries, each tier measuring 1.5 x 1 m. Each tier housed 15 broiler chicks (one replicate per treatment per tier). The temperature was regulated using a mercury thermometer from day one until market age (35 days). Gas incubators and exhaust fans were used. Suitable conditions were provided for rearing Ross 308 broiler chicks. Feed and water were provided ad libitum. A continuous lighting system was used for 23 hours a day during the first three days of the chicks' lives. One hour of lighting was provided during this period to acclimate the chicks and prevent crowding. The number of lighting hours was gradually reduced according to the recommendations in the hybrid breed manual [9].

Plastic feed trays with a diameter of 38 cm were used during the first week, one tray per tier. These were then gradually replaced with long, suspended metal feeders, similar to those used in battery cage rearing systems. These feeders are raised to the level of the birds' backs as they age. Clean water was provided in inverted 5-liter plastic waterers until the end of the experiment. The birds were fed a starter diet for days 1-16, containing 21-22% crude protein and 3100 kcal/kg metabolizable energy. For days 16–35, they were fed a finisher diet containing 20–21% crude protein and 3150 kcal/kg metabolizable energy. This was based on the recommendations of the NRC [10].

The red beetroot (*Beta vulgaris* rubra) used in this study was obtained from local markets in Al-Muthanna Governorate. After cleaning it of all impurities, it was peeled and cut into small strips. Then, it was dried in a clean, well-ventilated room at a temperature of 40-45°C using oil heaters at 10% humidity for seven days. Afterward, the dried beetroot tablets were ground, using a Crest electric grinder (made in China). The

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powder was then placed in polyethylene bags and stored in a dry place. The dried beetroot powder was used at a concentration of 20 gm per kilogram of animal feed.

The aqueous extract of beetroot was prepared by mixing 20 gm of beetroot powder with 250 ml of distilled water. The mixture was then shaken for one hour. Afterward, the extract was filtered using Whatman No. 1 filter paper. The filtrate was concentrated at 50°C until it reached full concentration [11]. This concentrated extract was then added to the birds' drinking water at a rate of 2 ml of the concentrated red beetroot extract per liter of water.

Results and Discussion:

Table (1) shows the presence of significant differences (P≤0.05) between the different treatments in carcass weight. T5 recorded the highest carcass weight, reaching approximately 1096.52 gm. This was followed by T6 (1079.70 gm). In contrast, the negative control treatment (T1) recorded the lowest carcass weight, this was followed by the positive control treatment (T2), which reached 878.14 and 987.08 gm, respectively, with a significant difference between them.

Regarding the dressing ratio without giblet, the results showed significant differences (P≤0.05) between the different treatments. A significant increase in T5, compared to the other treatments, reaching 64.88%. This was followed by T6, which reached 64.44%, with a significant difference between them. Meanwhile, the negative control treatment, recorded the lowest mean (63.86%).

The results of the relative heart weight analysis showed significant differences (P≤0.05) between the different treatments. T5 recorded the highest relative heart weight at 0.32%, this was followed by T6 (0.32 %), with a significant difference between the two treatments. This was in comparison with the negative control treatment, which yielded the lowest value at 0.30 %, a significant difference compared to all treatments.

The results for relative liver weight indicate a significant difference (P≤0.05) in all treatments. T5 recorded the highest liver weight (1.34 %), T6 followed closely with 1.33 %, showing a significant difference between the two. In contrast, the negative control treatment yielded the lowest value at 1.31 %.

The results of the relative gizzard weight analysis showed a significant difference (P≤0.05) in some treatments. T5 recorded the highest value at 1.23 %, this was followed by T6 (1.21 %). However, no significant difference was found between T6 and T4. The negative control treatment (T1) recorded the lowest weight at 1.17 %.

Regarding dressing ratio with giblet, a significant difference (P≤0.05) was

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observed in some treatments. The results showed a significant advantage for T5 (67.79%). In contrast, T6 and T4 did not show a significant difference. Meanwhile, the negative control treatment T1 recorded the lowest value at 66.64 %.

Table (1) Effect of using beetroot powder on dressing ratio with and without giblet (%) of broiler carcasses ± standard error.

Treatments	Carcass weight (gm)	Relative weigh of heart (%)	Relative weigh of liver (%)	Relative weigh of gizzard (%)	Dressing ratio without giblet (%)	Dressing ratio with giblet (%)
T1	±878.14 1.12 f	±0.30 0.00 f	±1.31 0.00 f	±1.17 0.00 e	±63.86 0.06 e	66.64± 0.06 e
T2	±987.08 0.63 e	±0.30 0.00 e	±1.32 0.00 e	±1.18 0.00 d	±64.07 0.01 d	±66.87 0.01 d
T3	±987.79 1.57 d	±0.31 0.00 d	±1.32 0.00 d	±1.20 0.00 c	±64.21 0.00 c	±67.05 0.00 c
T4	±1010.84 0.08 c	±0.32 0.00 c	±1.33 0.00 c	±1.22 0.00 d	±64.39 0.00 b	±67.25 0.00 b
T5	±1096.52 2.87 a	±0.33 0.00 a	±1.34 0.00 a	±1.23 0.00 a	±64.88 0.00 a	±67.79 0.00 a
T6	±1079.70 1.08 b	±0.32 0.00 b	±1.33 0.00 b	±1.21 0.00 b	±64.44 0.00 b	±67.30 0.00 b
Sig.	*	*	*	*	*	*

Table (1) shows that treatment number five significantly outperformed the control group and the other treatments in terms of dressing ratio and relative weight of giblet. However, no significant increase was observed in the percentage of uneaten offal. This improvement may be attributed to the addition of beetroot powder, which is a rich source of bioactive compounds such as betalains, phenolic compounds, and flavonoids. These compounds possess high antioxidant activity. They reduce oxidative stress and improve the efficiency of metabolic processes within the bird's body,

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contributing to improved nutrient utilization and enhanced protein deposition in muscle tissue, and consequently, a higher dressing ratio [8].

Furthermore, the natural nitrates in beets may contribute to improved blood circulation and increased oxygen and nutrient delivery to various tissues. This promotes muscle tissue growth and the development of vital organs such as the liver, heart, and gizzard. This leads to an increased percentage of edible offal, while no similar effect occurs in the inedible parts. This positively impacts carcass characteristics [4].

In addition, beetroot contains many important nutrients, such as vitamins, minerals, and digestible carbohydrates, which contribute to improved growth efficiency and productive performance in birds, leading to an increase in edible parts compared to uneaten parts. The significant superiority of the fifth treatment in dressing percentage and edible offal, with no increase in uneaten offal, can be explained, by the ability of the bioactive compounds in beetroot to improve the physiological state of birds, enhance muscle growth processes, and increase nutrient utilization efficiency compared to the control treatment [12].

Furthermore, beetroot has positive effects on improving digestive health and regulating metabolic processes, particularly fat metabolism. It also possesses antioxidant and lipid peroxidation inhibitory properties. These combined physiological effects may contribute to enhancing the efficiency of fat metabolism and reducing its accumulation in the body, which positively impacts carcass characteristics and improves its composition [13].

Table (2) shows the effect of adding beetroot powder on the relative breast weight. Significant differences ($P \leq 0.05$) were observed between the experimental treatments. T5 recorded the highest relative breast weight, at approximately 28.11%, compared to the other treatments. T4 and T6 followed, showing no significant differences between them. Meanwhile, the negative control treatment, recorded the lowest value, at approximately 27.79%.

The results also showed significant differences ($P \leq 0.05$) in relative weight of thigh between the experimental treatments. T5 recorded the highest percentage at approximately 17.28% compared to the other treatments. T4 and T6 followed, showing no significant differences between them. Meanwhile, the negative control treatment (T1) recorded the lowest percentage at 17.03%.

Significant differences ($P \leq 0.05$) were observed in the relative weight of drumstick between all the experimental treatments. T5

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recording the highest relative weight of approximately 12.81%, while the negative control treatment, T1, recorded the lowest value of 12.68%.

Regarding the relative weight of the secondary cuts, the results in Table (2) showed significant differences (P≤0.05) between all the experimental treatments on relative weight of neck, with the negative control treatment T1 recording the highest value of approximately 6.30%, while T5 recorded the lowest value of approximately 5.97%.

As for the relative weight of the wings, significant differences (P≤0.05) were observed between some of the experimental treatments. The negative control treatment T1 recorded the highest value of approximately 22.92%, while the values gradually decreased in the other treatments, with T5 recording the lowest value of approximately 22.63%. T4, T5, and T6 did not record significant differences between them, respectively.

Regarding the relative weight of the back, significant differences (P≤0.05) were observed between some of the experimental treatments, with the negative control treatment T1 recording the highest value of approximately 13.27%, while T5 recorded the lowest value of approximately 13.09%. In contrast, T4 and T5 did not record significant differences between them.

Table (2) Effect of using beetroot powder on Main and Secondary cuts (%) of broiler carcasses ± standard error.

Treatments	Main cuts Breast (%)	Thigh (%)	Drumstick (%)	Secondary cuts Neck (%)	Wings (%)	Back (%)
T1	±27.79 0.01 e	±17.03 0.00 e	±12.68 0.00 f	±6.30 0.00 a	±13.27 0.01 a	±22.92 0.02 a
T2	±27.89 0.00 d	±17.10 0.00 d	±12.71 0.00 e	±6.28 0.00 b	±13.24 0.00 b	±22.77 0.00 b
T3	±27.94 0.00 c	±17.12 0.00 c	±12.73 0.00 d	±6.25 0.00 c	±13.20 0.00 c	±22.73 0.00 c
T4	±28.04 0.00 b	±17.21 0.00 b	±12.76 0.00 c	±6.17 0.00 d	±13.15 0.00 d	±22.65 0.00 d
T5	±28.11 0.00 a	±17.28 0.00 a	±12.81 0.00 a	0.00±5.97 e	±13.09 0.00 d	±22.63 0.00 d
T6	±28.04 0.00 b	±17.21 0.00 b	±12.77 0.00 b	±6.08 0.00 f	±13.15 0.00 e	±22.65 0.00 d
Sig.	*	*	*	*	*	*

The results in the table indicate a significant advantage for T5 in the proportions and weights of the main cuts of broiler chicken, including breast, thigh, and drumstick, as well as secondary cuts such as wings, neck and back, compared to the control and the other treatments. This improvement is attributed to the addition of beetroot powder, which is a rich source of bioactive compounds such as betalains, phenolic compounds, and flavonoids, known for their high antioxidant capacity. These compounds contribute to reducing oxidative stress and improving the efficiency of metabolic processes, thus enhancing nutrient utilization and increasing protein deposition in muscle tissue. This is reflected positively in the growth of the breast and leg muscles, which constitute the largest portion of carcass meat [8].

In addition, beetroot contains natural nitrates, which are converted inside the body into nitric oxide, a compound that contributes to the dilation of blood vessels and improves blood flow to muscle tissues, thereby increasing the efficiency of oxygen and nutrient delivery and stimulating muscle growth and development, and thus increasing the weight and proportion of primary and secondary cuts in the carcass [4].

Beetroot also contains essential nutrients, such as digestible carbohydrates, vitamins, and minerals like potassium, magnesium, and iron, which support physiological processes and stimulate the activity of enzymes responsible for protein synthesis, thus contributing to improved productive performance and increased muscle tissue growth in birds [12].

Many studies have confirmed that adding beetroot powder or extract to poultry diets leads to improved carcass characteristics and weights of different cuts, as a result of increased growth efficiency, improved metabolism, and reduced oxidative stress in body tissues, which is reflected positively on the growth of breast, thigh, and other cut muscles [14]. Accordingly, the superiority of the fifth treatment in the ratios and weights of main and secondary cuts can be explained by the ability of the bioactive compounds in beetroot to enhance the physiological health of birds and stimulate muscle-building processes compared to the negative control treatment.

Table (3) shows the effect of adding beetroot powder on water-holding capacity (WHC) and dripping loss in broiler chickens. The table shows significant differences ($P \leq 0.05$) in all treatments. WHC was highest in T5, reaching 34.61, 30.86, and 31.55 respectively in breast, thigh meat, and drumstick meat, with significant differences between all treatments. In contrast, the negative control treatment recorded the lowest values, reaching 33.45, 29.97, and 31.05

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respectively. Regarding the dripping loss, significant differences ($p \leq 0.05$) were observed. The negative control treatment recorded the highest values for breast, thigh, and drumstick meat, reaching (6.12, 3.37, and 3.06) respectively. Conversely, T5 recorded the lowest values, reaching (5.32, 2.56, and 2.38) respectively, with a significant difference compared to all other treatments.

Table (3) Effect of using beetroot powder on water-holding capacity (WHC) and dripping loss (%) of broiler carcasses ± standard error.

Treatments	Water-holding capacity			Dripping loss		
	Breast (%)	Thigh (%)	Drumstick (%)	Breast (%)	Thigh (%)	Drumstick (%)
T1	±33.45 0.00 f	±29.97 0.00 f	±31.05 0.00 f	±6.12 0.00 a	±3.37 0.00 a	±3.06 0.00 a
T2	±33.89 0.00 e	±30.26 0.00 e	±31.21 0.00 e	±5.97 0.00 b	±3.18 0.00 b	±2.92 0.00 b
T3	±34.08 0.00 d	±30.47 0.00 d	±31.39 0.00 d	±5.83 0.00 c	±2.96 0.00 c	±2.79 0.00 c
T4	±34.39 0.00 c	±30.61 0.00 c	±31.55 0.00 c	±5.58 0.00 d	±2.81 0.00 d	±2.61 0.00 d
T5	±34.61 0.00 a	±30.86 0.00 a	±31.80 0.00 a	±5.32 0.00 f	±2.56 0.00 f	±2.38 0.00 f
T6	±34.41 0.00 b	±30.66 0.00 b	±31.59 0.00 b	±5.51 0.00 e	±2.79 0.00 e	±2.59 0.00 e
Sig.	*	*	*	*	*	*

Table (4) shows the effect of adding beetroot powder on cooking loss and thawing loss. Significant differences ($P \leq 0.05$) were found between the treatments. The negative control treatment recorded the highest values on cooking loss, at breast, thigh, and drumstick meat (37.83, 29.37, and 26.55%, respectively), with a significant difference compared to all other treatments. In contrast, T5 recorded the lowest values (36.12, 28.05, and 24.93). T6 followed, with values of (36.49, 28.42, and 25.45, respectively), showing a significant difference between the two treatments. Thawing lLoss showed significant differences between some

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treatments. The negative control treatment recorded the highest values in breast, thigh, and drumstick meat (6.73, 4.96, and 4.26, respectively). T5 recorded the lowest values in breast meat and drumstick meat (5.92 and 3.11, respectively). At thigh meat, T6 recorded the lowest value at 4.16. No significant difference was observed among T3, T4 and T5 treatments.

Table (4) Effect of using beetroot powder on thawing and cooking loss (%) of broiler carcasses ± standard error.

Treatments	Thawing loss			Cooking loss		
	Breast (%)	Thigh (%)	Drumstick (%)	Breast (%)	Thigh (%)	Drumstick (%)
T1	±37.83 0.01 a	±29.37 0.01 a	±26.55 0.01 a	±6.73 0.00 a	±4.96 0.00 a	4.26 0.00± a
T2	±37.31 0.01 b	±28.96 0.01 b	±26.23 0.01 b	±6.59 0.00 b	±4.77 0.00 ab	±3.94 0.00 b
T3	±36.89 0.01 c	±28.70 0.01 c	±25.97 0.01 c	±6.41 0.00 c	±4.46 0.00 bc	±3.68 0.00 c
T4	±36.52 0.01 d	±28.44 0.00 d	±25.48 0.01 d	±6.29 0.00 d	±4.18 0.00 c	±3.46 0.00 d
T5	±36.12 0.01 f	±28.05 0.01 f	±24.93 0.01 f	±5.92 0.00 f	±4.55 0.33 abc	±3.11 0.00 f
T6	±36.49 0.01 e	±28.42 0.01 e	±25.45 0.01 e	±6.25 0.00 e	±4.16 0.00 c	±3.43 0.00 e
Sig.	*	*	*	*	*	*

The results indicate a significant improvement in the physical characteristics of broiler meat in all treatments that included the addition of beetroot powder compared to the control treatment. This improvement was reflected in increased water-holding capacity (WHC), decreased drip loss, cooking loss, and thawing loss. These results can be explained by the presence of active compounds in beetroot (Beta vulgaris), such as betalains and phenolic compounds, which possess antioxidant activity. These compounds reduce oxidative stress and protect proteins and lipids in

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muscle tissue from oxidation, thus preserving the structural integrity of muscle fibers and increasing their water-retention capacity [4].

Improved water-holding capacity (WHC) is directly related to the stability of muscle proteins (actin and myosin). Reduced oxidation helps maintain these proteins' ability to bind water, thus minimizing losses during storage and processing. This has been confirmed by recent studies showing that improved WHC is a key indicator of meat quality (Barbut, 2024). Furthermore, the reduction in drip loss in treatments supplemented with beetroot, attributed to bioactive compounds such as betalains and phenolic compounds, which possess antioxidant activity, consistent with the findings of Al-Waili [15].

Regarding the reduction in cooking loss, this is attributed to the fact that improved WHC leads to a decrease in protein-associated water loss during heating. Protein denaturation releases water, while plant compounds stabilize proteins and reduce thermal shrinkage [16]. Similarly, the reduction in thawing loss is linked to the role of beets in mitigating freeze-drying damage. The antioxidant compounds reduce free radical formation during freezing and maintain the integrity of cell membranes, thus minimizing fluid loss during thawing [17].

On the other hand, improved meat physical characteristics are closely linked to reduced oxidative stress (lower MDA and higher CAT and GSH). Reduced lipid peroxidation helps maintain the integrity of cell membranes and proteins, which positively impacts meat quality and water retention [18]. Furthermore, improved meat pH resulting from reduced oxidative stress leads to decreased muscle protein shrinkage after slaughter, thus increasing WHC and reducing water loss. A sharp drop in pH leads to increased water loss from meat [19]. Jin *et al.* [20] stated that beetroot is rich in natural active compounds, most notably betalains, which are important natural pigments. The presence of natural nitrites also contributes to improved overall meat physical characteristics.

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