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NATURAL ANTIOXIDANTS IMPACT ON CARCASS TRAITS, MEAT QUALITY AND ECONOMIC FEASIBILITY IN BROILER SUBJECTED TO HEAT STRESS

Sh. Dh. Mohammad* **S. Y. Al-Sardary**

College of Agriculture Engineering Sciences/ Salahaddin University

***Correspondence to:** Sh. Dh. Mohammad, Department of Animal Resource, College of Agriculture Engineering Sciences, Salahaddin University, Erbil, Iraq.
Email: Shireen.mohammad@su.edu.krd

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Abstract

This experiment aimed to investigate the effects of natural antioxidants in powders of beetroot (Br), grape pomace (Gp), and willow (W) added to the diet at two levels (1% and 0.5%) on carcass traits, meat quality, and economic feasibility of thermally-stressed (average 33°C) broilers. Six hundred thirty Ross-308 day-old chicks were reared. After 2 weeks of starter feeding, the treatments were applied with grower feed followed by finisher feed until marketing age (42 days). The treatments were as follows: T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). A Complete Random Design (CRD) was used with three replicates per treatment; thirty birds per replicate. The results of carcass traits showed that control birds deposited significantly more fat in their abdomen than treated groups. Breast meat quality results indicated that the control group lost significantly more water than the treated groups during cooking, and the T5 group was significantly juicier than the control. The deluxe meat produced from groups fed feed fortified with eco-antioxidants had significantly lower lipid content and higher moisture, protein, unsaturated fatty acids (except T2), polyunsaturated fatty acids (except T2), omega-3 (except T2 and T4), omega-6 (except T2, T3, and T5), vitamin A (except T2 and T6), and vitamin E (in

T7 and T4) than the control. Furthermore, the treated groups' meat contained significantly more antioxidants (GPx) and less MDA than the control. Economically, the benefit (output) obtained from treated groups was significantly higher than that of the control group. Thus, the dietary supplementation with eco-antioxidants decreased carcass abdominal fat, produced luxurious nutritionally superior meat for consumers, and improved economic benefit.

Keywords: Eco-friendly antioxidants, Cadaver, Breast trait, Benefit, Thermal-fatigue chicken.

تأثيرات مضادات الاكسدة الطبيعية على صفات الذبيحة، جودة اللحم والجدوى الاقتصادية في فروج اللحم المجهد حراريا

شيرين ظاهر محمد * سردار ياسين السرداري

كلية علوم الهندسة الزراعية، جامعة صلاح الدين

***المراسلة الى:** شيرين ظاهر محمد، قسم الثروة الحيوانية، كلية علوم الهندسة الزراعية، جامعة صلاح الدين، اربيل، العراق.

البريد الالكتروني: Shireen.mohammad@su.edu.krd

الخلاصة

هدفت هذه التجربة دراسة تأثير مضادات الاكسدة الطبيعية في مساحيق كل من جذر الشمندر (Br) وثفل العنب (Gp) والصفصاف (W) المضافة للعليقة بتركيزين 0.5 و1٪ على صفات الذبيحة وجودة اللحم والجدوى الاقتصادية لفروج اللحم المجهد حراريا (بمعدل 33م°). تم تربية 630 كتكوت روس 308 بعمر يوم واحد. بعد أسبوعين من التغذية البادئة، تم تطبيق المعاملات في علف النمو ثم علف الناهي وحتى عمر التسويق (42 يومًا). كانت المعاملات كالتالي: T1 السيطرة (C: عليقة اساسية خالية من الاضافات) T2عليقة أساسية +1% Br، T3عليقة أساسية +0.5% Br، T4عليقة أساسية +1% Gp، T5: عليقة أساسية +0.5% Gp، T6عليقة أساسية +1% W و T7 عليقة أساسية +0.5% W. طبق التصميم العشوائي الكامل بثلاث مكررات/معاملة، ثلاثين طائر/مكرر. أظهرت نتائج صفات الذبيحة أن طيور السيطرة رسبت دهون بطنية أكثر معنويا مقارنة بطيور المعاملات. بينت نتائج جودة لحم الصدر أن مجموعة السيطرة فقدت معنويا قدرًا اكبر من الماء مقارنة بباقي مجاميع المعاملات أثناء الطهي، وكانت المعاملة T5 أكثر عصارة من لحم طيور السيطرة. تم انتاج لحوم فاخرة من المعاملات التي تم تغذيتها بأعلاف مدعمة بمضادات الأكسدة الصديقة للبيئة من خلال محتوى دهني أقل بكثير، إلى جانب محتوى أعلى بكثير من نسب كل من الرطوبة، البروتين، الدهون غير المشبعة (USFA) والدهون الغير مشبعة المتعددة (PUSFA) عدا (T2)، الاوميغا 3 عدا (T2, T4)، الاوميغا 6 عدا (T2, T3, T5)، فيتامين أ في (T3,T4,T5,T7) وفيتامين هـ في (T4,T7). بالإضافة لاحتواء لحوم المعاملات على نسبة أعلى بكثير من مضادات الأكسدة (GPx) وأقل من MDA معنويا مقارنة بمجموعة السيطرة. اقتصاديا كانت الفائدة (الناتج) المتحصل عليها من مجموعات المعاملات أعلى بكثير من السيطرة. وبالتالي فإن مضادات الأكسدة الطبيعية المضافة غذائيا خفضت دهون البطن في الذبائح وانتجت لحوم فاخرة تغذويا للمستهلكين وحسنت من الناتج الاقتصادي لفروج اللحم المعرض للإجهاد الحراري.

كلمات مفتاحية: مضادات الاكسدة الصديقة للبيئة، ذبيحة، صفات لحم الصدر ، الفائدة، دجاج مجهد حراريا.

Introduction

In 2030, poultry is expected to make up 41% of all meat consumed globally. The rising popularity of chicken over other types of meat in recent decades can be traced back to cultural and economic shifts, as well as a general trend toward better eating (24). Heat stress (HS) is one of the major emerging environmental challenges for the poultry industry and thread food security, due to rising global demand for animal protein and rising temperatures caused by climate change. Because commercially raised birds are especially sensitive to high temperatures, this is considered a limiting factor in the meat supply to the population. Thus adopting production methods that mitigate the negative effects of HS on bird performance is critical and necessitates a comprehensive strategy (23).

Over the last decade, there has been a growing interest in the use of a wide range of feed additives as adding phytochemicals in mono-gastric diets has been evaluated as a natural alternative to the use of synthetic and antibiotic growth promoters (35 and 53). Among various forms “beetroot (Beta vulgaris), grape pomace and willow (Salix spp.)” possess numerous bioactive ingredients that are important natural sources of powerful antioxidants such as: triterpenes, sesquiterpenoids, carotenoids, coumarins, flavonoids, betalains and phenolic compounds (16); anthocyanins, flavanols, stilbenes, and phenolic acids (18); salicin, β-O-glucoside of saligenin, polyphenols, flavonoids and tannins (26), respectively. The mentioned bioactive compounds grant antioxidant, antimicrobial, and anti-inflammatory activity (32, 34 and 38). Also, phytochemicals represented an advantageous strategy to counteract the harmful effects of heat stress in poultry via combating heat stress, enhancing chicken performance, and reducing lipid peroxidation in poultry meat; this originates from the bioactive compounds ability in modulating metabolic processes which resulting health promotion (51). Besides may differentially affect the meat quality, and consequently, its market price (13).

Meat's physicochemical characteristics, such as pH, color, and water-holding capacity (i.e., drip loss and cooking loss) make up its technological quality. An important criterion of the meat’s technological quality is its color. Whereas its sensory profile is characterized by characteristics like its overall appearance, flavor, and texture. Meat acceptance can be gauged using a combination of technical and sensory characteristics, with the latter perhaps being more dependent the dietary approach (12). The health benefits to consumers make the higher unsaturation degree very desired. Yet, it might have an impact on the meat's oxidative stability, which would certainly cause it to lose some of its nutritional and sensorial value (31). When this occurs, it is essential to strategically use plant source antioxidant substances to effectively slow down the oxidation of lipids while enhancing the meat with additional useful nutrients (14).

The objective of this research was to detect how the bioactive (functional) ingredients in beetroot, grape pomace, and willow as natural antioxidants might affect the quality of breast meat as this is the most commonly main eaten part of the broiler. This research focused on the most crucial aspects of the technological and sensorial profile, such as nutritional and functional properties. Besides the effectiveness of the natural antioxidants on the economic efficiency obtained from broilers raised under heat stress.

Materials and Methods

Experimental treatments: This experiment was achieved at the Poultry Research House at Girdarash Farm; Animal Resource Department; Agricultural Engineering Science College; Salahaddin University– Erbil/Iraq; from 19th/June/2021 to 1st /August/ 2021. A total of 630 day-old Ross-308 chicks were distributed and housed, randomly, into 21 floor pens with dimensions of 200 × 150 × 100 cm (length, width, and height, respectively). 30 birds/pen; a pen represents one replicate (rep.) of a treatment (treat.). The experiment lasted 6 weeks, and consisted of three feed phases (starter was from 0 to 14 days of age; grower was from 15th to 28th days of age; finisher was from 29th to 42nd days of age). Basal diet formulation and composition of the experiment are shown in Table 1.

Table 1: The formulation of basal diet used during the experiment.

Ingredients* (g/Kg)	Starter (0-14) days	Grower (15-28) days	Finisher (29-42) days
Soybean (46% Crude Protein)	325	300	235
Corn (8% Crude Protein)	300	320	370
Wheat (12% Crude Protein)	93	100	100
Wheat Flour	220	214	225
Di Calcium Phosphate	5	5	4
**Premix (2.5%)	25	25	25
Soybean oil	14	20	25
Lysine	0.5	0.3	0.25
Methionine	0.5	0.3	0.25
Choline chloride	0.4	0.4	0.4
Salt	0.5	0.5	0.5
Enzyme	0.5	0.5	0.5
Limestone	14.6	13	13.1
Anti-toxin	1	1	1
Total	1000	1000	1000
Analyzed chemical composition (%)			
Crude Protein	22	21	18.5
Ether Extract	3.1	4.4	5
Crude Fat	2.3	2.3	2.2
Starch	40.8	41.35	44.8
Ash	5.2	5.4	5
Metabolic Energy (Kcal/Kg)	2900	3000	3100
Calculated chemical composition (%)			
Avail. P for Poultry	0.160	0.157	0.136
Methionine	0.315	0.282	0.244

*Broiler feed formulation prepared according to NRC (39); **Premix (2.5 %) matrix values: crude protein 30,01%; crude fat 2,00%; crude fiber 0,79%; moisture 3,20%; crude ash 42,95%; calcium 5,06%; Phosphorus 5,26%; Phosphorus avail. (calc.) 11,14%; Sodium 5,30%; chloride 6,20%; M.E. Poultry (calc.) 5664.22 KCAL/KG; Lysine 8,19%; Methionine 9,52%; Meth + Cyst 9,62%; Tryptophan 0,12%; Threonine 3,05%; Isoleucine 0,42%; Valine 2,11%; Arginine 0,65%. Constitute of vitamin provided per kilogram of diet: vitamin A 400.000 IU; vitamin D3 100000 IU; vitamin E 3000 mg: vitamin B1 120 mg: vitamin B2 320 mg: vitamin B6 240 mg: vitamin B12 100000 µg: Biotin 12 mg; Folic acid 80 mg; Niacin 2400 mg; Vitamin K3 140 mg: choline chloride 23000 mg: choline 19954.80 mg: calcium D-Pantothenate 600 mg. Trace element provided per kilogram of diet: Fe 1800 mg; Cu 600 mg; Mn 2400 mg; Zn 2800 mg; iodine 80 mg: Se 16 mg.

The first 2 weeks of age the chicks were raised upon Ross broiler management program guide (42) means standard environmental factors with starter phase diet. As starting the grower phase at the 15th day of age thereby finisher feed at 29th day of age until marketing 42 d; the chicks divided according to the natural antioxidants supplemented on seven dietary treatments (3 rep./treat; 30 birds/rep.), as follow: T1: Control (C: fed Basal Diet BD without additives); T2 (1% Br): fed Basal diet +1% beetroot; T3 (0.5 % Br): fed Basal diet +0.5% beetroot; T4 (1% GP): fed Basal diet +1% grape pomace; T5 (0.5% GP): fed Basal diet +0.5% grape pomace; T6 (1% W): fed Basal diet +1% willow; T7 (0.5% W): fed Basal diet +0.5% willow. The birds were supplied with ad libitum feed and water during the overall rearing period. The broilers were raised under continuous heat stress as in-house temperature was 32-34◦C with average of 33 ◦C. An intermittent lighting program of 5D: 19L hours was applied.

Antioxidant property of beetroot, grape pomace and willow: Table 2 illustrates the amount of phenol compounds measured according the Folin-Cipcaltue colorimetric assay and Gallic acid (19). The amount of total flavonoid; total flavonol were determined according Aluminum chloride colorimetric assay (19). The antioxidant activity was recorded as percentage compared to the constant yellow color of beta carotene (50). The antioxidant property of the plant’s powder was conducted at laboratories of Urmia University; Faculty of Veterinary Medicine.

Table 2: The polyphenolic (mg/g), poly flavonoid (mg/g), flavenols (mg/g) and the antioxidant activity (%) of the supplemented natural antioxidants.

	Beetroot	Grape pomace	Willow
Phenol (mg/g)	285.82	281.64	274.09
Flavonoid (mg/g)	145.67	131.56	127.70
Flavenol (mg/g)	95.44	92.30	88.82
Antioxidant activity (%)	74.63	70.80	68.63

Carcass Traits: At the 42nd day of the experiment, two birds per replicate (6 birds/treatment) were randomly selected, fasting for 8 hours, and weighed immediately before slaughtering as live body weight then sacrificed, eviscerated, and reweighted as carcass weight thereafter the carcass was cut into main parts (breast+ thigh) and secondary parts (wings+ back+ neck).The percentage of each part, giblets (heart+ liver+ gizzard) and abdominal fat was calculated by dividing the weight of the part by the carcass weight of the bird multiplied by 100.The dressing percentage was determined using the following equation: Dressing percentage (%) = (Carcass Weight (g)/Live Body Weight (g)) × 100.

Meat Quality Parameters: After 24 hrs. postmortem breast was divided into two parts; the first portion (left part) was labeled, vacuum packaged, and stored at -20 ºC for subsequent determination of Physicochemical properties, nutritive value, sensory traits, the content of antioxidant (GPx), lipid oxidation (MDA) state and technological quality (color). In contrast, the second portion (right pectoralis major muscle) was vacuum packed and directly stored at 4 ºC chillers for 24hrs then reweighted to estimate drip loss percentage and thereafter stored at -20 ºC for panel test.

Physicochemical properties included: breast muscle PH of each left filet was measured and evaluated at 24-h after slaughtering for pH using a spear tip pH probe with automatic temperature compensation (PSH-W series 2013, China). Samples were collected by inserting the pH probe near the wing joint area of each filet and allowed to equilibrate until a reading was maintained for 3s (28). The water holding capacity of the breast samples were evaluated by measuring drip and cooking losses following the procedure by (43).

Nutritive Value involved:

A. Proximate analysis: Proximate composition of the breast meat was determined following the procedures of AOAC (8, 9 and 10).
B. Fatty acid profile: The samples were stored in -20°C until gas chromatography analysis (GC). Fatty acid profile was detected according to the method of Muzolf-Panek and Kaczmarek (37).
C. Determination of Water and Fat -Soluble Vitamins of muscleall sample preparations were performed by the method of Sami et al. (46). Next, twenty microliters of the prepared samples were injected into the HPLC system.

Panel test was evaluated according to (36).

Antioxidant content (glutathione peroxidase Gpx): The muscle glutathione peroxidase was measured using commercial kit (Padgin Teb, Iran), based on kit instruction and using spectrophotometer (StatFax, USA).

Lipid Oxidation state (MDA): Measurements were done according to the method of (3), so one gram of muscle samples homogenized in four ml 0.15 M KCl + 0.1 mM BHT. Then 200 µL of the homogenized were mixed with TBARS solution (Thiobarbituric Acid Reactive Substances) and then heated in a water bath at 95 °C for 60 min until a pink color developed. After cooling, 1 mL distilled water and 3 mL n-butyl alcohol were added to the extracts and homogenized. The mixture was centrifuged at 5000 rpm for 10 min. The absorbance of the supernatant was read against an appropriate blank at 532 nm using a spectrophotometer (Beckman, Domont, France). The TBARS value was calculated from a standard curve of 1,1,3,3-tetraethoxypropane and expressed as nmol malondialdehyde (MDA)/mg of muscle.

Technological Quality (Color): Samples were removed from the -20 °C freezer and subjected to overnight thawing at 4 °C. They were removed from the packaging and the meat color was allowed to bloom in the air for 30 minutes before the color measurement took place (1). Meat color measurement was conducted using a Color Flex spectrophotometer (Precision colorimeter 3nh NR20XE, China) to assess the meat's color. The calibration of the device against black and white reference tiles took place prior to use. Each sample's L* (lightness), a* (redness), b* (yellowness), c* (chroma), and h* (hue angle) values were measured on the dorsal surface of each breast sample in triplicate on each sample at 24 hours after slaughtering at three locations (6).

Economic Traits: Economic Cost Calculations: The total cost of birds reared from 1 day to 42 days was calculated depends on the total expenses (chicks, feed, other variable costs involved: vaccine and electric) are called input or total variable costs (TVC). The costs were as follow:

A chick cost= 700 ID	Other variable costs = 333.35*630= 210000 ID
Cost of 1 tone starter feed =560000 ID	1 Kg dry beetroot=1000 ID
Cost of 1 tone grower feed =532000 ID	1 Kg dry grape pomace= 0 ID
Cost of 1 tone finisher feed =518000 ID	1 Kg dry willow= 500 ID

Calculating Economic benefit: The price one kilo of live bird was sold at marketing about 3000 ID. The economic benefit (B) depends on live bird price of groups which is called output.

Calculating Economic Feasibility: The economic return: It can be calculated by subtracting the TVC from the sale price of one bird to produce a net profit. As in the following equation:

The economic return of one live bird = Benefit of alive bird – TVC of one bird (36).

The benefit: cost ratio (B:C R) calculated upon the formula below:

B:CR = Benefit / Total Variable Cost (TVC).

Statistical Analysis: Completely Randomized Design (CRD) were applied, the collected data were analyzed by using SAS program (47). Duncan's multiple range (21) used for comparison between means among the treatments, to determine the impacts of treatments used on the studied parameters.

Results and Discussion

Mostly carcass traits results, show that there were no significant differences among all treated groups as they compared to each other and to control except the percentage of the edible parts in T7 was the lowest significantly than control and other treated groups excluding T6. On the other hand, the abdominal fat proportion was significantly higher in the control group than in all other groups fed natural antioxidants (Table 3). The results of dressing % and giblets % of beetroot groups were agree with (48) in the results of dressing and giblets percentage. Our results of beetroot agree with (33) reported significant reduction of fat pad in mice fed a diet supplemented with 8% of red beet leaf as an antioxidant source. Other side (48) resulted that that the abdominal fat percentage was similar to control in broilers fed beetroot in both levels 0.5 and 1%.

Table 3: Impact of natural antioxidants on carcass traits at marketing age (42 days) of broilers reared under heat stress.

Tret. / Trait	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
Live body weight (g)	2490.0	2640.0	2573.3	2496.7	2566. 7	2453.3	2506.7	45.9
Dressing (%)	75.20	74.81	74.66	74.73	74.27	73.83	74.63	0.21
Main parts (%)	65.13	65.21	65.47	65.06	64.58	65.52	65.39	0.21
Secondary parts (%)	34.87	34.79	34.53	34.94	35.42	34.48	34.61	0.21
Giblets %	5.27ab	5.10ab	5.12ab	5.46a	5.10ab	4.96bc	4.59c	0.06
Abdominal fat (%)	3.100a	2.112b	2.071b	2.300b	2.480b	1.594c	2.515b	0.085

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c within rows with different superscripts meant differ significantly at (P≤ 0.05). The same superscripts among the treatments mean insignificant.

Antioxidants are effective on broilers' health and welfare but they also contribute to meat yield and quality parameters improvement mostly for stressed broilers (44). The results of physicochemical properties showed that PH and the percentage of drip loss in all treated groups insignificantly differed than Control group. Our results of PH and dripping loss percentage of both T2 and T3 groups disagreed with (48) who reported an increase in PH of chilled breast meat and consequently a decrease in drip loss obtained of birds fed diet supplemented with beetroot in 0.5 and 1%. But cook loss percentage was significantly higher in the control group than all other treated groups except T6 which differed numerically than control Table 4.

Table 4: Impact of natural antioxidants on physical meat quality at marketing age (42 days) of broilers reared under heat stress.

Tret. / Trait	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
***PH**	5.50ab	5.45ab	5.56ab	5.72a	5.66ab	5.42b	5.48ab	0.04
****DL%**	0.69	0.64	0.61	0.68	0.67	0.65	0.66	0.03
*****CL %**	3.62a	2.88b	2.77b	3.05b	3.00b	3.13ab	2.97b	0.07

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, within rows with different superscripts meant differ significantly at (P≤ 0.05). The same superscripts among the treatments mean insignificant. * PH (24 hrs after slughtering); **DL %: drip loss%; ***CL%: cook loss%.

Meat of good quality is characterized by lower drip loss, this may have been due to the fact that phytobiotics promote protein biosynthesis and improve the level of protein in the body (20 and 45); which it approved by the results of protein content in breast muscle in Table 5. The results of chemical contents showed that the control group contained the least significant in both moisture and protein percentages than all other treated groups. On the other hand, control group had significantly the highest content of lipids% of all treated groups. However, ash % was significantly higher in T7 group than control and other treated groups, although there were non-significant differences among treatments with control for ash % content (Table 5).

Table 5: Impact of natural antioxidants on breast meat's chemical composition at marketing age (42 days) of broilers reared under heat stress.

Tret. / Trait	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
Moisture (%)	75.543e	76.186d	76.471c	76.114d	76.443c	76.729b	77.129a	0.073
Protein (%)	19.586d	20.399b	20.857a	20.400b	20.286bc	20.500a	20.100c	0.062
Lipids (%)	3.586a	2.130bc	1.486d	2.271b	1.879cd	1.500d	1.643d	0.108
Ash (%)	1.286ab	1.286ab	1.186bc	1.214bc	1.393a	1.271b	1.129c	0.018

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c within rows with different superscripts meant differ significantly at (P≤ 0.01). The same superscripts among the treatments mean insignificant.

The results of fatty acids illustrate that natural antioxidants added feed groups omitting T2 increased both USFA and PUSFA in breast meat significantly than control. Additionally, N3 was superior significantly in T7, T6, T5 and T3 than control as well as each of T7, T6 and T4 were significantly wealthier in N6 level as they compared to control (Table 6). Polyunsaturated fatty acids (PUFA) n-3 and n-6 are essential fatty acids for both human and animal diets. Enriching the broiler diets of PUFA n-3 is an effective method of increasing the content of essential fatty acids in meat (44). In addition, the high ambient temperatures contribute to a series of breast meat quality and fatty acids composition disturbances (41, 49 and 55) resulting in a lower acceptance by consumers. However, the effects of heat stress on fatty acid compositions in the breast meat of broiler chickens have received little attention. It was reported that the contents of linoleic acid (C18:2n-6), linolenic acid (C18:3n-3), and eicosapentaenoic acid (C20:5n-3), as well as the PUFAs-to-SFAs ratios, are decreased under heat stress (57). Recently, it was found that the SFA levels increased, but the PUFA contents decreased in heat-stressed male ducks (29).

Table 6: Impact of natural antioxidants on fatty acid profile (mg/100 g) of breast meat at marketing age (42 days) of broilers reared under heat stress.

	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
USFA	1677.9f	1679.9f	1699.4d	1688.7e	1724.9b	1712.3c	1759.9a	3.9
PUSFA	1675.1f	1677.1f	1696.4d	1685.9e	1721.8b	1709.3c	1756.4a	3.9
N3	139.19d	138.94d	143.09c	139.36d	145.31b	146.00b	152.36a	0.69
N6	9.20d	9.44bcd	9.26cd	9.70b	9.33cd	9.51bc	10.54a	0.07

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c within rows with different superscripts meant differ significantly at (P≤ 0.01). The same superscripts among the treatments mean insignificant.

The supplemented natural antioxidants in T7, T5, T4 and T3 enriched breast meat by vitamin A significantly than control, also vitamin E prospered significantly in T7 and T4 groups breast meat as control. While results of vitamins D, B12 and C were numerically higher in breast meat of treated groups than control (Table 7). Vitamin E may improve the anti-oxidative activity of broilers by raised antioxidant enzyme activity (54).

Table 7: Impact of natural antioxidants on vitamins content in breast meat at marketing age (42 days) of broilers reared under heat stress.

Tret. / Trait	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
Vitamin A(IU/100g)	30.63d	31.66cd	33.58abc	33.24abc	34.26ab	32.34bcd	34.65a	0.27
Vitamin E (mg/100g)	0.26c	0.30bc	0.29bc	0.40ab	0.33abc	0.34abc	0.44a	0.01
Vitamin D (IU/100g)	2.32	2.33	2.37	2.45	2.40	2.41	2.51	0.04
Vitamin B12 (microgram/100 g)	0.500	0.510	0.520	0.520	0.510	0.510	0.530	0.002
Vitamin C (mg/100g)	8.84	8.98	8.88	9.07	8.89	8.75	8.97	0.07

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c within rows with different superscripts meant differ significantly at ($P \leq 0.01$). The same superscripts among the treatments mean insignificant.

The results of antioxidant content in breast meat exemplified in Gpx level, it was noted that all treated groups breast meat possessed significantly higher Gpx than control (Table 8). As reported that dietary supplementation with phytochemicals improved antioxidant status (11).

The results of oxidation state represented in MDA value which was the highest significantly in control group than other treated groups except T2 group was different slightly (Table 8). MDA results is supported by the results of Gpx; Vitamin A; E in Table 8 and Table 7, respectively.

Heat stress has been observed to decrease endogenous enzymatic (superoxide dismutase, SOD; catalase, CAT) and non-enzymatic antioxidant (glutathione, GSH) levels and increase lipid and protein oxidation markers in liver tissue and meat (22). Polyphenols increase muscle antioxidant capacity and activity as glutathione peroxidase activity to improve meat quality from heat stress as struggling the oxidation state in meat (27). Our results of Gp treatments agree with (52). Generally, the higher MDA of meat has been previously showed to be positively from oxidative damage which decreased the meat quality (25). Therefore, the inclusion of natural antioxidants in broiler diets is to improve their oxidative stability and consequently the meat quality of broiler (15). Because compounds with antioxidant activity have both in vivo and post-mortem beneficial actions against oxidative stress and oxidative rancidity in meat production and food industry, respectively (56). Also the MDA of meat can be decreased by alpha-tocopherol in broilers because Vit- E has impact on lipid peroxidation of poultry meat, consequently, MDA was decreased in the muscles (54).

Table 8: Impact of natural antioxidants on breast meat oxidation and antioxidant state at marketing age (42 days) of broilers reared under heat stress.

Tret. / Parameters	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	MSE
MDA (nmol/mg)	92.77a	91.49a	85.54c	75.99d	87.29b	76.03d	65.90e	1.33
Glutathione peroxidase (U/g hb)	3.35g	3.54f	3.73d	3.94b	3.63e	3.84c	4.13a	0.04

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c, d, e within rows with different superscripts meant differ significantly at (P≤ 0.01). The same superscripts among the treatments mean insignificant.

The results regarding the eating quality (panel test) parameters are shown in Table 9. It should be highlighted that there were no significant differences reflected in sensory texture attributes, like tenderness and juiciness or flavor and general acceptance of the meat of both treated and control groups except the juiciness in T3 group was significantly higher than control group. Texture is probably the most important quality factor associated with consumer satisfaction in the eating quality of poultry. The texture and degree of firmness of the meat are a function of the amount of water held intramuscularly. Water tightly bound to the muscular proteins has a swelling effect on muscle proteins, occupying the spaces between myofibrils and giving the meat a firmer structure (7). While conversion into meat, the rate and extent of the chemical and physical changes occurring in the muscle also determine its tenderness when cooked (39). Our results of Gp (0.5%) agree with (52).

Table 9: Impact of natural antioxidants on panel test at marketing age (42 days) of broilers reared under heat stress.

	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
Tenderness	3.40ab	3.70ab	3.85a	3.60ab	3.50ab	3.15b	3.45ab	0.08
Juiciness	3.25b	3.40ab	3.70ab	3.30b	3.95a	3.15b	3.55ab	0.07
Flavor	3.30	3.80	3.75	3.65	3.40	3.60	3.25	0.07
Acceptance	3.55ab	3.65ab	3.75a	3.35ab	3.75a	3.20b	3.35ab	0.07

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c within rows with different superscripts meant differ significantly at (P≤ 0.05). The same superscripts among the treatments mean insignificant.

Breast meat color results are seen in Table 10 explains that all treated groups did not differ significantly with control in color parameters lightness (L), redness (a), yellowness (b), chroma (C) and hue (H). However, both control and T5 meat were significantly redder (a) than T6. At the same time, both control and T5 meat reflected significantly less yellowness (b) and hue (h) than T6. Meat color or visual appearance is one of the indicators of meat quality and certainly is one of the most important sensory attributes that influence consumers' acceptance of meat and meat products (4 and 54). The lowest a* value in the meat from the group fed with 1% willow powder could be the result of better bleeding because willow contains salicin that acts as the blood-thinner aspirin which has anti-thrombotic action (5). The significant effect of bleeding on meat color was shown by Hopkins et al. (30). Additionally, (17) showed significantly lower redness value of breast meat in normal meat in comparison to the wooden breast. They observed that normal meat was significantly less red than other faulty breast meat (wooden breast and white stripping). In conclusion, it could be stated that the 1% willow powder positively influences the quality of meat in terms of its color. Our results of Gp treatments disagree with (52).

Table 10: Impact of natural antioxidants on breast meat color at marketing age (42 days) of broilers reared under heat stress.

	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
L*	56.978	59.088	60.845	60.600	58.335	62.135	62.023	0.692
a*	9.407a	7.547ab	7.565ab	7.645ab	8.975a	6.290b	7.345ab	0.312
b*	8.727b	9.627ab	9.790ab	9.473ab	8.765b	10.417a	9.593ab	0.186
C*	13.212	12.167	12.403	12.283	12.680	11.677	12.160	0.204
H*	43.830b	50.457ab	52.285ab	51.568ab	45.523b	58.988a	52.477ab	1.325

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c within rows with different superscripts meant differ significantly at ($P \leq 0.01$). The same superscripts among the treatments mean insignificant. L* (lightness), a* (redness) b* (yellowness), C* (chroma) and H* (hue).

Feasibility traits results indicates that there were no significant differences in obtained Total Variable Costs (TVC=Input), return and B:C ratio between the studied treatments as compared to control. While the benefit (output) obtained from all treated groups were significantly higher than Control except T6 and T7 that were less and non- significantly differed than control, respectively (Table 11). Our results agree with (2) this impute to positive effects of beetroot on productive performance. These results also, indicated that the use of 0.5 and 1% dried beetroots, has higher profitable economical effect among all studied treatments in growing rabbits.

Table 11: Impact of natural antioxidants on feasibility at marketing age (42 days) of broilers reared under heat stress.

Treat. Trait/ Iraqi dinar	T1 (Control)	T2 (Br 1%)	T3 (Br 0.5%)	T4 (Gp 1%)	T5 (Gp 0.5%)	T6 (W 1%)	T7 (W 0.5%)	SEM
Total Variable Costs (TVC=Input)	2834.6	2920.7	2890.2	2873.2	2914.9	2862.9	2837.2	25.4
Benefit (B) (Output)	7548.8d	7957.7b	8402.3a	7735.9c	7876.5b	7339.4e	7486.1d	227.5
Return (B-TVC)	4714.1ab	5037.0ab	5512.1a	4862.7ab	4961.5ab	4476.4b	4648.8ab	222.7
Benefit : Cost ratio (B:C ratio)	2.66ab	2.73ab	2.90a	2.69ab	2.70ab	2.56b	2.64ab	0.08

T1: Control (basal diet BD); T2 (BD+1%Br); T3 (BD+0.5%Br); T4 (BD+1%Gp); T5 (BD+0.5%Gp); T6 (BD+1%W); T7 (BD+0.5%W). a, b, c within rows with different superscripts meant differ significantly at ($P \leq 0.05$). The same superscripts among the treatments mean insignificant.

Conclusions

It can be concluded that adding plant powder as a natural antioxidant into a broiler's diet improved the economic benefit due to improved performance, recovered welfare via decreased carcass abdominal fat; elevated antioxidant content that decreased the MDA, and produced luxurious nutritional meat for consumers.

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No Supplementary Materials.

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