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Impact of *Yucca* extract and basil oil supplementation on carcass characteristics, quality of meat, and the cecal microbiota in broiler chickens

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ABSTRACT

The current study investigated the effects of *Yucca* extract and basil oil as phytogenic supplements on broiler chickens' carcass traits, different return parameters of carcass, quality of meat and the cecal microbes. A total of 200 one day-old avian 48 broiler birds were divided into 5 treatments. The dietary treatments were control group fed basal diet only (CON), group fed basal diet +150 mg *Yucca* extract /kg ration (YE 150), group fed basal diet + 300 mg *Yucca* extract /kg ration (YE 300), group fed basal diet + 400 mg basil oil /kg ration (BO 400) and group fed basal diet + 800 mg basil oil/kg ration (BO 800). Our outcomes showed that differences weren't significant in carcass traits and different return parameters between different groups, while there were numerical increase in total return from carcass and breast meat % in all treated groups than control group. Dressing % for *Yucca* and BO 800 groups showed numerical increase than those of control & BO 400 groups. Tenderness, malondialdehyde (MDA), total antioxidant capacity (TAC), pH and color showed significant difference. MDA decreased in BO groups and TAC increased in YE 300 and BO groups compared to control group, pH decreased in YE 150 compared to other groups. Also, using YE and BO didn't affect total aerobic bacterial count, while had positive impact on *Lactobacillus* count. In conclusion, including YE and BO in the diet did not negatively impact carcass traits but enhanced meat quality and *Lactobacillus* count in broiler chickens.

Introduction

Broiler industry is the fastest growing and least expensive source of animal based protein for human consumption (Stiborova *et al*., 2020). Expansion of the chicken business in the last two decades corresponds with excessive use of antibiotics to increase profit and decrease production costs (Rafiq *et al*., 2022). As antimicrobial agents were added to chicken feed as additives to feed to enhance performance, protect birds from harmful bacteria, maintain the best chicken production (Sabir *et al*., 2023), strengthening the gut, improved the absorption of nutrients (Cox and Dalloul, 2015), decreased morbidity and mortality in birds (Zeng *et al*., 2015).

Developing countries banned using antibiotics in feed due to their bad effect on human and the high incidence of microbial resistance among human infections (Mohammadi Gheisar and Kim, 2018). Over usage of antimicrobial agents as a stimulant of growth in the production of chickens might result in drug toxicity and an increase in the number of microorganism resistant to antibiotics either in chickens or human (Carrique-Mas and Rushton, 2017). Consequently, demand for finding effective alternative to antibiotics for broiler production is increasing (Alam and Ferdaushi, 2018).

Nowadays, Feed additives with phytogenic properties have been used as growth stimulant substitutes for antibiotics as they have favorable effects on the growth and the immunity and decrease responses to stress (Mehdi *et al*., 2018). They consist of a wide range of naturally occurring compounds, including saponins, tannins, piperine, thymol, cineole, linalool, anethole, capsaicin, allicin, allyl isothiocyanate. Alkaloids, bitters, phenolics, polyphenols, terpenoids, flavonoids, glycosides and polypeptides, Research on these feed additives has been performed using extracts, essential oils and cold-pressed oils (Upadhaya and Kim, 2017). According to Alghirani *et al*. (2021) *Yucca schidigera* is one of the phytochemical feed additives that contain steroidal saponin, which can be used as a substitute for antibiotics because it has a favorable effect on production and health.

Moreover, essential oils are a category of beneficial feed additives that may significantly mitigate the harmful effects of antibiotic growth promoters (AGPs) in animal feed (Attia *et al*., 2017). The essential oils derived from *Lamiaceae* or *Labiatae* such as basil (*Ocimum basilicum*), sage (*Salvia officinalis*) and thyme (*Thymus vulgaris*), were used as phytogenic feed additives in the diets of chickens (Vlaicu *et al*., 2023).

The dietary inclusion of essential oils, either independently or in combination, has been demonstrated to improve performance and positively influence the gut flora (Kirsti *et al*., 2010; Khattak *et al*., 2014), Because essential oils have gastrointestinal stimulant, immune-modulating, antiviral, antifungal, antioxidant, hypolipidemic, and thermal stress reducing properties, their use in chicken feeding has been recognized (Ruff *et al*., 2021). The basil plant, has antimicrobial, antibacterial, anti-inflammatory, antipyretic effects, so the dietary supplements of it can improve broiler performance and blood parameters (Hb, PCV and RBCS) when the birds are exposed to stress (Swathi *et al*., 2012). Additionally, Cobb 500 chickens that fed 0.05% basil oil showed improvement in carcass traits, *Lactobacillus* count and significant improvement ($p < 0.05$) in meat quality (Vlaicu *et al*., 2023). Enhancing broiler performance resulting from addition of basil plant seening as promoting growth hormone production & emission (Al-Kelabi *et al*., 2019).

Awad *et al*. (2021) revealed that *Yucca schidigera* is a common medicinal plant found in deserts, its extracted or powdered form is added to animal feed due to it improves growth rate, feeding efficiency and has antioxidant characteristics. The broiler chickens that received *Yucca schidigera* in drinking water showed a significant rise in the intestinal *Lactobacillus* count ($p < 0.001$), a higher dressing percentage, a higher carcass weight ($p>0.005$) (Rahman *et al*., 2023), an improvement in meat pH, drip loss % and cooking loss % (Benamirouche *et al*., 2020).

So, in this research, our motive is to detect the influence of the dietary addition of *Yucca* extract and basil oil at different levels on carcass traits, meat quality parameters (drip loss after 24 and 48 hours, cooking loss, tenderness, MDA, TAC, pH, and meat colour (a*, b*, L*, chroma, and hue angel) and the caecum microbiota (*Lactobacillus* and total aerobic bacterial count) in broiler chickens.

Materials and methods

The experiment was carried out in the Centre of Experimental Animal Research, Faculty of Veterinary Medicine, Benha University, Egypt. The experimental protocol was accepted under ethical number BUFVTM 16-04-23.

Yucca extract (saponin) was purchased from ABChem company (a company for pharmaceutical raw materials) and Basil oil derived from the Ocimum basillicum plant, purchased from Science Trade Company and extracted by applying a microwave extraction technique without a solvent according to Putri and Rahmawati (2020). The feeding plan was divided to 4 stage (Table 1).

Birds and diets

One day old 200 avian broiler birds were distributed into five uniform groups, each group contains 40 chicks and 4 replicates, and each replicate consists of 10 chicks. Birds were raised on deep litter (a floor covered with wood shaving material with 5 cm depth), and reared for five successive weeks.

The chicks were allowed unrestricted access to water and feed. They received a diet that was designed to satisfy their nutritional needs. The nutritional treatments were divided to 5 treatments as follows: control group fed basal diet only (CON), group fed basal diet +150 mg *Yucca* extract /kg ration (YE 150), group fed basal diet + 300 mg *Yucca* extract / kg ration (YE 300) (Su *et al*., 2016), group fed basal diet + 400 mg basil oil /kg ration (BO 400) (Riyazi *et al*., 2015) and group fed basal diet + 800 mg basil oil /kg ration (BO 800).

Evaluation of carcass traits

At the final of the trial (day 35), four birds from each group (one from each replicate) were chosen randomly and slaughtered. Before slaughter, the birds were fasted for 12 h with a continuous supply of water. The birds were weighted before and after slaughter, then weight of the internal organs (liver, heart, gizzard, intestine, abdominal fat, gizzard fat, spleen, thymus, bursa), breast with and without bone, thigh muscle and dressed carcass were recorded, and are stated as a percentage of live body weight related to their weight (Biesek *et al*., 2020). Dressing percentage was calculated according to Vlaicu *et al*. (2023) and Biesek *et al*. (2020).

Evaluation of the economic efficiency of the carcass

Returns from breast meat (without bone), thigh meat, liver & gizzard

Table 1. Components and chemical structure of the basal diet (kg).

Ingredients	Starter 0-8 days	Grower 9-18 days	Finisher1 19-28 days	Finisher 2 28-35 days
Yellow corn	551.25	573.4	588.73	622.2
Soya bean meal 46	326	296	276	217
Corn gluten meal	35	17	17	38
Vegetable oil	25	34	44	43
Di-calcium phosphate	20	12	15	16.5
Wheat bran	15	38	38	39
Limestone	10.15	12.35	7.5	7.8
L-Lysine	3.8	3.45	1.95	3.6
D-L methionine	3.25	3.2	2.3	2.55
Sodium chloride	3.2	2.35	2.62	2.3
Vit &min premix	3	3	3	3
L- threonine	1.65	1.25	0.4	0.95
Choline chloride	1.1	1	1	1.1
Sodium bicarbonate	1	2.35	1.9	2.4
Anti- coccidia	0.5	0.5	0.5	0.5
Anti-clostridia	0.1	0.1	0.1	0.1
Xtra PHY	0	0.05	0	0
Chemical composition				
Crude protein (%)	22	20.01	19.02	18
Metabolizable energy (kcal/kg)	2979.07	3.026.68	3103.05	3154.94
Linoleic acid (%)	2.29	2.68	3.09	3.1
Crude fat (%)	5.05	5.99	7.01	7.05
Lysine (%)	1.34	1.23	1.06	1.06
Methionine (%)	0.65	0.61	0.51	0.54
Methionine + cysteine (%)	1	0.93	0.82	0.84
Calcium (%)	0.95	0.84	0.72	0.76
Available phosphorus (%)	0.45	0.42	0.36	0.38
Chloride (%)	0.3	0.24	0.23	0.24
Sodium (%)	0.16	0.16	0.16	0.16
Choline (ppm)	1681.55	1561.15	1525.47	1481.44

and other parts were computed as stated by Salih *et al*. (2023), liver & gizzard, other parts, and finally total return from carcass were calculated according to Zahran *et al*. (2024). Then we calculate the relative return from each of the mentioned organs as the market price for kg of the organ multiplied by organ weight, then divided by live body weight.

Measurement of meat quality of breast meat

Pectoralis major muscle from each group were taken to investigate drip loss, cooking loss, tenderness, malondialdehyde (MDA), total antioxidant capacity (TAC), pH and color (L*, a*, b*, chroma and hue angle).

pH and color

A calibrated pH meter was used to measure the pH, by penetrating an electrode at three different places in the broiler chicken's pectoralis major muscle according to Özbek *et al*. (2020).

For measuring the color, thirty grams of breast muscle were taken and subjected to a color flex spectrophotometer. On the basis of the whole color appearance, the meat samples' lightness (L*), yellowness (b*), and redness (a*) were assessed using the color fluorescence spectrophotometer (Chung *et al*., 2020).

Drip loss

Meat samples used for drip loss calculation were measured separately, sealed in polythene bag, and kept at 4°C for 48 hours according to Petracci and Baéza, (2011). The samples were weighted after 24 hours (W24) and then weighted after 48 hours (W48) (after any obvious liquid buildup was removed using paper towels). The drip loss was determined according to Petracci and Baéza (2011).

Cooking loss

Samples for cooking loss were weighted then placed in firmly sealed food-safe containers and soaked for 20 minutes in water bath at 80°C as described by Lopez *et al*. (2011). After being extracted from the water bath, the samples were dried, chilled then weighted. The cooking loss was then computed according to Lopez *et al*. (2011)

Tenderness

For measurement of tenderness, the cooked meat samples were sliced and then evaluated using a texture analyzer according to Cavitt *et al*. (2004).

Malondialdehyde

Malondialdehyde (MDA) concentration is a measure of lipid peroxidation and was measured using HPLC analysis as described by Karatas *et al*. (2002).

Total antioxidant capacity

The measurement of total antioxidant capacity (TAC) was conducted by V 530 Jasco spectrophotometer according to Untea *et al*. (2018).

Evaluation of cecal microbiota

Immediately after slaughter, cecal contents were collected from three birds in each group for microbiological examination. *Lactobacillus* bacteria were cultured on Rogosa and Sharpe (MRS) agar (*Lactobacillus*) (Ashraf and Shah, 2011), while total aerobic bacteria cultured was on Plate Count Agar (PCA) (Islam *et al*., 2023).

Statistical analysis

SPSS, Version 26.0 (SPSS, 2019) was used to analyze the dataset. First, the Shapiro-Wilk test was performed to assess whether the datasets were normal. After that, a one-way ANOVA was carried out, and Tukey's test was utilized to assess significance. At a significance level of ($p < 0.05$). Mean and standard error were used to determine the variance in the data.

Results

Carcass characteristics

The impact of addition of YE (saponin) and basil oil to the diet on weight of dressed carcass, liver, heart, gizzard, intestine, abdominal fat, gizzard fat, spleen, thymus, bursa, breast and thigh, also its impact on their relative weight are demonstrated in Table 2 that showed insignificant changes ($p>0.05$) between different groups, while there were numerical increases in weight of dressed carcass, liver, breast meat and thigh meat in all treated groups compared to control group.

There were numerical increases in dressing weight percentage for YE 150, YE 300 and BO 800 groups (71.42, 70.31 and 70.86%, Respectively) compared to CON and BO 400 groups (69.59 and 68.19%, Respectively), liver weight percentage numerically increased in YE 300 and BO 400 groups (3.07 and 3.32%, Respectively) compared to CON,YE 150 and BO 800 groups (2.73, 2.59 and 2.56%, Respectively), breast meat without bone % numerically increased in all treated groups (24.17, 22.75, 21.96 and 24.52% for YE 150, YE 300, BO 400 and BO 800, Respectively) compared to control group (21.63%), thigh muscle weight percentage numerically increased in YE 300 group (27.80%) compared to other groups (26.90, 26.64, 26.86 and 26.23% for CON, YE 150, BO 400 and BO 800, Respectively). Abdominal fat weight percentage were lowest in YE 300 and BO 800 groups (0.74 and 0.64%, respectively) compared to CON, YE 150 and BO 400 groups (0.97, 1.08 and 1.02%, respectively).

Return parameters from carcass

In term of return from breast, thigh, liver, gizzard, other parts and total return of carcass showed a non-significant difference ($P>0.05$) and there were numerical increase in YE and basil oil groups as shown in Table 3, (Return from breast meat were 89.49, 80.12, 81.41 and 93.14 LE; return from thigh meat were 52.49, 52.12, 53.00 and 53.02 LE; total return from carcass were 171.94, 160.80, 164.35 and 176.40 LE for YE 150, YE 300, BO 400 and BO 800, Respectively). In term of return from breast meat per kg live weight and total return from carcass per kg live weight showed numerical increase in groups received YE 150, YE 300, BO 400 and BO 800 in their diet (return from breast meat per kg live weight were 41.33, 38.89, 37.55 and 41.93 LE; total return from carcass per kg live weight were 79.42, 78.06, 75.80 and 79.41 LE). Return from thigh meat per kg live weight increased in YE 300 (25.30 LE) compared to other groups.

Quality of meat

Quality of meat indices are showed in table 4 revealed that adding YE (saponin) and basil oil at various levels in chickens feed resulted in insignificant effect on percentage of drip loss either at 24 or 48 h, and cooking loss. While Razor blade force (N) related to tenderness" showed significant decrease ($p<0.001$) in birds that fed 400 mg and 800 mg basil oil and significant increase ($p<0.001$) in birds that fed 150 mg YE (11.49), while these that fed 300 mg YE showed non-significant difference compared to control group. Broilers fed different levels of basil oil showed significant ($P<0.01$) reduction in MDA value (21.84 and 19.93 for BO 400 and BO 800, respectively) compared to control group and groups fed YE (25.91, 28.81 and 23.88 for CON, YE 150 and YE 300, respectively. Regarding TAC, broiler fed 300 mg YE (saponin), 400 and 800 mg basil oil was raised ($p<0.05$)

(13.42, 14.02 and 15.02 for YE 300, BO 400 and BO 800, respectively) comparing with CON (11.62). The lowest pH was recorded in YE 150 group (9.75) comparing with that of BO 800 group which showing significant highest value (13.72). There was no significant change (p>0.05) in the lightness of the breast meat across the treatment groups. Redness value showed significant increase in YE 300, BO 400 and BO 800 (12.14, 12.04 and 12.31, respectively) compared to CON and YE 150 groups (10.47 and 10.65, respectively). Yellowness value revealed significant variation (p<0.05) between groups, as yellowness value in BO 800 group (11.25) was lower than in YE 300 (12.25). Chroma level was highest in YE 300, BO 400 and BO 800 groups (17.27, 16.67 and 16.68, respectively) than control group (15.71). Hue angle increased on BO 400 and BO 800 groups (46.26 and 47.55, respectively) than other groups (41.83, 41.50 and 44.73 for CON, YE 150 and YE 300, respectively).

Table 2. Effect of supplementation of *Yucca* extract or basil oil on carcass traits.

Parameters	CON	YE 150	YE 300	BO 400	BO 800	P value
Live weight (g)	1910±111.21	2165±152.56	2060±99.33	2168.33±176.22	2221.25±105.62	NS
Dressing weight(g)	1329.15±95.77	1546.14±108.08	1448.45±70.56	1478.68±119.72	1574.02±83.91	NS
Liver weight (g)	52.16±3.45	56.14±6.08	63.33±8.55	72.01±9.64	56.89±2.87	NS
Heart weight (g)	9.60±0.47	9.95±1.39	9.77±0.85	10.74±0.58	10.39±1.54	NS
Gizzard weight (g)	40.05±3.7	46.56±3.68	41.89±3.55	41.03±1.7	48.18±4.76	NS
Intestine weight (g)	118.78±6.49	122.34±11.23	118.30±9.94	132.60±18.45	129.37±12.71	NS
Abdominal fat weight (g)	18.51±5.96	23.31±4.38	15.17±2.88	22.01±1.48	14.27±5.71	NS
Gizzard fat weight (g)	20.42±4.81	11.78±3.69	11.94±1.84	13.56±4.01	14.98±3.08	NS
Spleen weight (g)	2.84±0.33	3.65±0.6	2.81±0.35	3.07±0.23	3.41±0.32	NS
Thymus weight (g)	9.22±1.1	8.20±1.88	8.99±0.71	8.88±0.51	8.62±0.19	NS
Bursa weight (g)	1.70±0.13	1.91±0.34	1.67±0.26	1.91±0.58	1.35±0.21	NS
Breast meat with bone weight (g)	489.09±35.8	598.27±50.07	543.70±29.62	544.92±37.99	619.92±47.19	NS
Breast meat without bone weight (g)	413.05±27.71	523.35±47.69	468.56±35.35	476.08±41.33	544.65±47.03	NS
Thigh muscle weight (g)	513.80±34.28	576.77±36.63	572.73±34.87	582.43±54.28	582.60±23.66	NS
Dressing (%)	69.59±1.14	71.42±0.12	70.31±0.23	68.19±0.22	70.86±1.26	NS
Relative internal organ weight (%)						
Liver	2.73±0.18	2.59±0.11	3.07±0.36	3.32±0.23	2.56±0.08	NS
Heart	0.50±0.02	0.46±0.03	0.47±0.04	0.50±0.03	0.47±0.07	NS
Gizzard	2.10±0.14	2.15±0.05	2.03±0.12	1.89±0.14	2.17±0.17	NS
Intestine	6.22±0.27	5.65±0.15	5.74±0.31	6.12±0.46	5.82±0.45	NS
Abdominal fat	0.97±0.34	1.08±0.15	0.74±0.12	1.02±0.1	0.64±0.29	NS
Gizzard fat	1.07±0.28	0.54±0.14	0.58±0.07	0.63±0.16	0.67±0.12	NS
Spleen	0.15±0.02	0.17±0.02	0.14±0.02	0.14±0.01	0.15±0.01	NS
Thymus	0.48±0.06	0.38±0.06	0.44±0.05	0.41±0.01	0.39±0.02	NS
Bursa	0.09±0.01	0.09±0.01	0.08±0.01	0.09±0.02	0.06±0.01	NS
Breast meat with bone	25.61±0.4	27.63±1.02	26.39±0.26	25.13±0.55	27.91±1.36	NS
Breast meat without bone	21.63±0.6	24.17±1.59	22.75±0.75	21.96±0.22	24.52±1.6	NS
Thigh muscle	26.90±0.27	26.64±0.51	27.80±0.62	26.86±0.94	26.23±0.2	NS

CON (control group fed basal diet only), YE 150 (fed basal diet +150 mg *Yucca* extract /kg ration), and YE 300 (fed basal diet+ 300 mg *Yucca* extract /kg ration), BO 400 (fed basal diet + 400 mg basil oil /kg ration and BO 800 (fed basal diet + 800 mg basil oil/ kg ration). NS: non-significant difference.

Table 3. Effect of supplementation of *Yucca* extract or basil oil on the different return parameters of the carcass (LE).

Parameters	CON	YE 150	YE 300	BO 400	BO 800	P value
Return from breast meat	70.63±4.74	89.49±8.15	80.12±6.04	81.41±7.07	93.14±8.04	NS
Return from thigh meat	46.76±3.12	52.49±3.33	52.12±3.17	53.00±4.94	53.02±2.15	NS
Return from liver and gizzard	9.68±0.73	10.78±1.02	11.05±0.95	11.87±1	11.03±0.76	NS
Return from parts	17.30±1.53	19.18±2.02	17.51±0.37	18.07±1.67	19.21±1.12	NS
Total return from carcass	144.37±9.77	171.94±12.25	160.80±9.67	164.35±13.83	176.40±10.78	NS
Different return / kg live body weight						
Return from breast meat per kg live body weight	36.98±1.03	41.33±2.73	38.89±1.29	37.55±0.38	41.93±2.73	NS
Return from thigh meat per kg live body weight	24.48^a±0.24	24.24^a±0.46	25.30^a±0.56	24.44^a±0.85	23.87±0.18	NS
Return from liver and gizzard per kg live body weight	5.07^a±0.31	4.98^a±0.15	5.36^a±0.32	5.47^a±0.14	4.97±0.24	NS
Return from parts per kg live body weight	9.06^a±0.28	8.86^a±0.48	8.50^a±0.38	8.33^a±0.59	8.65±0.28	NS
Total return from carcass per kg live body weight	75.59^a±1.47	79.42^a±1.97	78.06^a±1.02	75.80^a±0.5	79.41±2.51	NS

CON (control group fed basal diet only), YE 150 (fed basal diet +150 mg *Yucca* extract /kg ration), and YE 300 (fed basal diet+ 300 mg *Yucca* extract /kg ration), BO 400 (fed basal diet + 400 mg basil oil /kg ration and BO 800 (fed basal diet + 800 mg basil oil/ kg ration). In each row, different superscript letter means significant (P<0.05). NS: non-significant difference.

Table 4. Effect of supplementation of *Yucca* extract or basil oil on breast meat quality.

Parameters	CON	YE 150	YE 300	BO 400	BO 800	P value
Drip loss after 24 h	7.28±1.56	5.82±1.15	8.62±1.44	7.21±0.7	6.52±1.82	NS
Drip loss after 48 h	9.59±1.89	7.38±1.36	11.92±1.5	9.26±0.51	8.56±2.19	NS
Cooking loss%	29.75±1.06	28.57±1.46	25.39±4.51	30.22±2.39	20.80±1.12	NS
Razor blade force (N)	$11.01^{ab}\pm0.43$	$11.49^{a}\pm0.53$	$9.53^{bc}\pm0.46$	$9.09^{c}\pm0.19$	$8.49^{c}\pm0.35$	<0.001
Razor blade energy (N*mm)	$132.59^{ab}\pm5.18$	$138.15^{a}\pm6.46$	$114.67^{bc}\pm5.6$	$109.13^{c}\pm2.28$	$101.73^{c}\pm4.09$	<0.001
Malondialdehyde (MDA)	$25.91^{ab}\pm1.35$	$28.81^{a}\pm1.48$	$23.88^{abc}\pm1.93$	$21.84^{bc}\pm0.68$	$19.93^{c}\pm1.05$	<0.05
Total antioxidant capacity (TAC)	$11.62^{b}\pm0.54$	$10.87^{b}\pm0.89$	$13.42^{ab}\pm1.01$	$14.02^{ab}\pm0.4$	$15.02^{a}\pm1.04$	<0.05
pH	$10.25^{b}\pm0.73$	$9.75^{b}\pm0.91$	$12.01^{ab}\pm0.84$	$12.42^{ab}\pm0.49$	$13.72^{a}\pm0.8$	<0.05
Lightness (L)	56.92±0.99	57.82±1.3	58.27±1.3	57.24±1.53	56.56±1.05	NS
Redness (A)	$10.47^{b}\pm0.11$	$10.65^{b}\pm0.17$	$12.14^{a}\pm0.28$	$12.04^{a}\pm0.32$	$12.31^{a}\pm0.2$	<0.001
Yellowness (B)	$11.70^{ab}\pm0.16$	$12.04^{ab}\pm0.22$	$12.25^{a}\pm0.31$	$11.52^{ab}\pm0.21$	$11.25^{b}\pm0.1$	<0.05
Chroma	$15.71^{c}\pm0.18$	$16.08^{bc}\pm0.15$	$17.27^{a}\pm0.21$	$16.67^{ab}\pm0.3$	$16.68^{ab}\pm0.16$	<0.001
Hue angel	$41.83^{b}\pm0.23$	$41.50^{b}\pm0.83$	$44.73^{ab}\pm1.21$	$46.26^{a}\pm0.76$	$47.55^{a}\pm0.54$	<0.001

CON (control group fed basal diet only), YE 150 (fed basal diet +150 mg *Yucca* extract /kg ration), and YE 300 (fed basal diet+ 300 mg *Yucca* extract /kg ration), BO 400 (fed basal diet + 400 mg basil oil /kg ration and BO 800 (fed basal diet + 800 mg basil oil/ kg ration). In each row, different superscript letter means significant (P<0.05). NS: non-significant difference.

Cecal microbiota

As demonstrated in Figures 1 & 2, dietary inclusion of YE (saponin) and basil oil to broiler didn't have significant impact on total aerobic bacterial count (TAB), while the birds that fed 300 mg YE/ kg ration and 800 mg basil oil / kg ration showed improvement in *Lactobacillus* count (log 7.52 and 7.65 for YE 300 and BO 800, respectively) compared to control group (log 3.67).

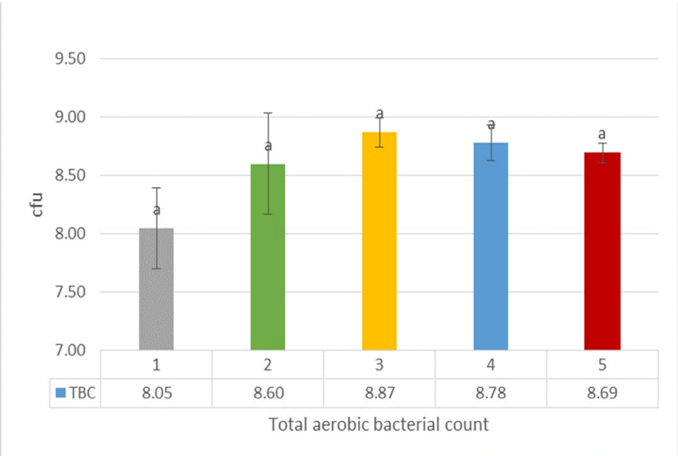

Figure 1. Effect of supplementation of *Yucca* extract or basil oil on total aerobic bacterial count.

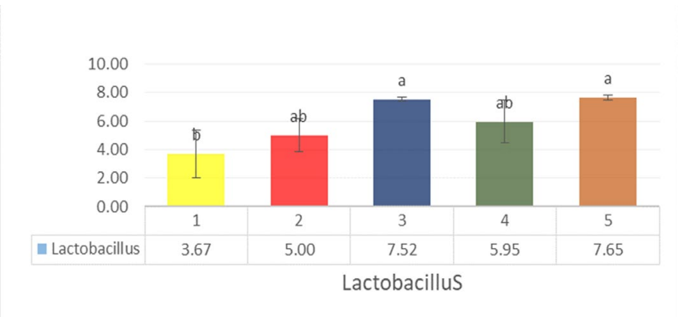

Figure 2. Effect of supplementation of *Yucca* extract or basil oil on *Lactobacillus* count.

Discussion

Concerning the impact of the dietary inclusion of YE (saponin) and basil oil on carcass traits of broiler chickens, our results showed that there were not significant changes in dressing %, internal organs weight, and carcass return between different groups. These outcomes agreed with Riyazi *et al.* (2015) who said that there was a non-significant difference on carcass output and relative weight of the gizzard, thigh, liver, heart, and breast when 200 ppm of basil oil were added to Arian chickens' diet. Gurbuz and Ismael (2016) found that Ross 308 chickens that received 0.5, 1 and 1.5% basil leaves in their diet showed a non-significant difference (p>0.05) in abdominal fat and carcass yield. Supplementation of broiler birds with 3 g/kg basil seed in their diet did not affect carcass traits and organ weight (Abbas, 2010). Also, Rahman *et al.* (2023) recorded that dietary addition of 0.5, 1.0 and 1.5 ml *Yucca schidigera* /liter drinking water of broiler birds resulted in insignificant rise in carcass weight and dressing %. Conversely, El-naggar and El-Tahawy (2018) cleared that addition of 0.5 and 1g/kg of sweet basil oil to diet of cobb 500 chickens led to significant increase (p<0.05) in total edible parts and dressing percentage. Abdominal fat weight and bursa of fabricius weight significantly increased (P < 0.05), also there were decrease in gizzard weight when broiler chickens were fed 100 mg/kg of caprylic acid and 100 mg/kg YE (Begum *et al.*, 2015). Alghirani *et al.* (2021) revealed that dietary addition of 25, 50, 75 and 100 mg/kg *Yucca schidigera* to the diet of Ross 308 chickens resulted in significant change in the live weight, slaughtering weight, feathering weight, breast weight and dressing %.

There are several variables that affect meat quality, the consumer is primarily interested with the meat's taste, flavor, color, and softness (Ashour *et al.*, 2020). According to the effect of YE (saponin) and basil oil on meat quality we found that they didn't have effect on percentage of drip loss either at 24 or 48 h and cooking loss. This result match with Benamirouche *et al.* (2020) who cleared that supplementation of Cobb 500 chickens with 1 liter per 1000 liters of drinking water *Yucca schidigera* resulted in a non-significant difference in drip and cooking losses of breast muscle.

Tenderness is a measure of the rigidity or flexibility of hard or soft meat, since consumers demand tenderness, measuring tenderness is an ideal technique to measure consumer satisfaction with eating meat products (Zdanowska-Sasiadek *et al.*, 2019). Our result revealed that addition of basil oil by 400 and 800 mg\kg of ration or *Yucca schidigera* by 300 mg/kg of ration in diet resulting in decrease tenderness significantly (p<0.001), while addition *Yucca schidigera* by 150 mg/kg of ration in diet resulted in non-significant effect in tenderness than control group. These findings agreed with Alghirani *et al.* (2021) who reported that Ross 308 chickens fed *Yucca schidigera* in their diet until 100 mg/kg of ration shown non-significant changes (p>0.05) in their level of tenderness. On the other hand, Vlaicu *et al.* (2021) revealed that tenderness significantly increased in Cobb 500 chickens that supplemented with diet containing 5% Alfa Alfa and 1% basil as compared with control group and that variation most likely was caused by the muscles' varying total collagen contents, which can affect the meat's hardness and texture.

Regarding MDA and TAC, Essential oils have antioxidant properties by enhancing antioxidant enzymes and removing free radicals (Abd El-Hack *et al.*, 2022), consequently, essential oils are able to alter body's antioxidant defense system's equilibrium, which lowers lipid peroxidation (Thuekeaw, 2022). MDA is an indicator for lipid peroxidation (Mohammadi *et al.*, 2019). Our results showed that broilers fed different level of basil oil recorded significant decrease in MDA and those fed 300 mg YE in their diet recorded non-significant decrease in MDA comparing with control group. This decrease in MDA level may be due to the capability of *Y. schidigera* to remove secondary reactive radicals or inhibit the production of superoxide and hydrogen peroxide (Enginar *et al.*, 2006). This outcome disagreed with Saleh *et al.* (2018) who revealed that avian 48 chickens which supplemented with 0.5, 1 and 1.5 kg/ ton herbal mixture including *Yucca* resulted in significant decrease in meat MDA. Concerning TAC, broilers fed 300 mg YE, 400 and 800 mg basil oil in their diet showed significant increase in TAC. Steroid-derived saponins in *Y. schidigera* exhibit antioxidant properties that help to stop, retard, and preserve cells from degrading (Alghirani *et al.*, 2021) and essential oil derived from basil showed antioxidant properties in broiler meat (Raza *et al.*, 2022), this is a good thing since antioxidant capacity obtained from the phenol hydroxy group combine to peroxy radicals during the first stage of oxidation of lipid and delays production of hydroxyl peroxide (Untea *et al.*, 2022). These findings agreed with Vlaicu *et al.* (2023) who said that there was a significant increase in hue angle and antioxidant capacity of Cobb 500 chickens that take 0.05% basil oil in their diet confront to control group. Additionally, antioxidants level in broiler chickens' meat that were received 250 mg of YE/ kg was higher than control group (Galli *et al.*, 2020). Sun *et al.* (2017) cleared that arbor acres chickens that fed 200 and 300 mg/kg *Yucca schidigera* extract showed improvement in antioxidant capacity of liver. Also, addition of 5% Alfa Alfa and 1% basil to diet of Cobb 500 chickens resulted in increase in TAC of meat of the breast (Vlaicu *et al.*, 2021).

PH is one of the most important alterations that takes place during rigor mortis, which directly affects the features of meat, including its juicy, tender, color, and durability (Mir *et al.*, 2017). Also, color of meat may be used to estimate its pH. Meat has low pH when it's very light and high when it's very dark (Qaid *et al.*, 2022). The inhibition of microbe growth and deterioration may be caused by decrease pH in meat of bird that contain herbs (Alexandre *et al.*, 2022). In addition, meat pH is an essential indicator of quality, a high pH in the meat from broiler breasts allows it to retain more water than a low pH, which makes the meat softer (Barbut, 1993). Our results cleared that the significant highest pH level recorded in group received basil oil by 800mg/kg ration, while lowest level recorded by group receive *Yucca schidigera* by150mg\kg of ration. pH level in YE groups showed non-significant difference comparing with control group. These findings match with Begum *et al.* (2015) who cleared that Ross 308 chickens that were fed the 100 mg/kg caprylic acid + 100 mg/kg YE showed a non-significant effect on meat pH. Conversely, Alghirani *et al.* (2021) reported that pH of breast muscle of Ross 308 chickens that fed 25, 50, 75 and 100 mg/kg *Yucca schidigera* significantly increased ($p < 0.05$). Benamirouche *et al.* (2020) cleared that supplementation of Cobb 500 chickens with 1 liter per 1000 liters of drinking water *Yucca schidigera* led to significant rise in pH in contrast to control group.

Meat color is an essential aspect that affects initial perceptions of consumers (Turcu *et al.*, 2021). The meat of fresh chicken should have bright red color, any change in color at first appearance by a customer denotes decline in quality and decreased nutritional content (Qaid *et al.*, 2022). Zdanowska-Sasiadek *et al.* (2013) found that customers dislike darker-colored meat that has a higher pH and a larger proportion of oxidized myoglobin.

From our study, we found that lightness of breast meat showed insignificant change ($p>0.05$) between different groups. Redness value showed significant increase in YE 300, BO 400 and BO 800 compared to con and YE 150 groups. Yellowness value showed significant difference ($p<0.05$) between various groups, as yellowness value in BO 800 group lower than in YE 300. Chroma level increased in birds received YE 300, BO 400 and BO 800 in their diet than control group. Hue angle increased in groups fed BO 400 and BO 800 in diet than other groups. These outcomes match with Alghirani *et al.* (2021) who indicated that there was insignificant change ($p>0.05$) in lightness when 25, 50, 75, and 100 mg/kg of *Yucca schidigera* were added to the diet of Ross 308 chickens. Begum *et al.* (2015) found that Ross 308 chickens that were fed the 100 mg/kg caprylic acid + 100 mg/kg YE showed non-significant increase in lightness (L) as compared with the control group. Conversely, Cobb 500 chickens that received diet containing 5 % Alfa Alfa and 1% basil showed significant decrease ($P<0.0371$) in redness contrasted to control group (Vlaicu *et al.*, 2021). Decrease of meat's redness may be due to changes in myoglobin, which makes up 80% of the total pigment in meat and is essential to its color (Mancini and Hunt, 2005).

Gut flora composition is one significant factor that influencing growth performance (Lan *et al.*, 2020). Also, the development of the immunity and the preservation of the gut barrier are both influenced by intestinal microbiota (Wang *et al.*, 2023). Gut microflora interacts with absorption of nutrient and the growth of the host's gastrointestinal tract, so it had a substantial effect on nutrition, health and growth performance (Riyazi *et al.*, 2015). In our research, dietary supplementation of *Yucca* extract didn't alter total aerobic bacterial count, while improve *Lactobacillus* count. This agreed with Rahman *et al.* (2023) who mentioned that addition of 0.5, 1 and 1.5 ml *Yucca schidigera* extract /litre drinking water significantly increased intestinal *Lactobacillus* count. Conversely, Ayoub *et al.* (2019) recorded that inclusion of 0.5ml *Yucca schidigera* extract / l litre drinking water of broiler chickens resulted in a significant reduction in total aerobic colony count and insignificant increase in lactic acid bacteria as compared with control group. Also, Wang and Kim (2011) reported that dietary addition of 30, 60 and 120 mg/kg YE to Hy-line brown laying hens did not affect *Lactobacillus* count. Broilers received 100 mg/kg Caprylic acid + 100 mg/kg YE showed a non-significant change in *Lactobacillus* count (Begum *et al.*, 2015). Also, our results revealed that dietary addition of basil oil didn't alter total aerobic bacterial count, while improve *Lactobacillus* count. These outcomes agreed with Islam *et al.* (2023) who said that dietary addition of basil extract to Cobb 500 chickens significantly increase *Lactobacillus* count and not significantly affect total aerobic bacterial count confront to the control group, while our results disagreed with Thuekeaw *et al.* (2022) who cleared that dietary addition of 500 ppm basil oil to Ross308 chickens didn't affect *Lactobacillus* count due to low percent of linalool and absence of eugenol and synergistic action between them. Engida *et al.* (2023) revealed that *Lactobacillus* count of Cobb 500 chickens that received 1% basil in their diet not significantly increased ($p>0.05$) as compared with control group. Vlaicu *et al.* (2023) cleared that Dietary addition of 0.05% basil oil to Cobb 500 chickens resulted in a significant decrease in *Lactobacillus* count.

Conclusion

According to our research, *Yucca* extract (saponin) and basil oil could be used in diets at different levels without effect on different return parameters from carcass, while improve meat quality as basil oil groups decrease MDA, YE 300 and basil oil groups increase TAC and pH decreased in YE 150. Also, there were improvement in *Lactobacillus* count in all treated groups, thus from the results we recommend poultry farmers to use *Yucca* extract (saponin) and basil oil as feed supplements in broiler ration due to increase in antioxidant properties of meat which preserve meat from deterioration and decrease in MDA and tenderness.

Conflict of interest

The authors have no conflict of interest to declare.

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