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Impact of Dietary Oregano Plant Extract Supplementation on Carcass Traits, Physical and Chemical Meat Quality of Broilers

Asmaa M.S. Salama[1*], Soad S.A. Belih[1], Nasser E.A. Khedr[2]

[1]Department of Animal Nutrition, Animal Health Research Institute, Tanta Branch, Agricultural Research Center (ARC), Egypt.

[2]Department of Nutrition and Clinical Nutrition, Faculty of Veterinary Medicine, Benha University, Egypt.

***Correspondence**
Corresponding author: Asmaa M.S. Salama
E-mail address: asmaa.salama52@gmail.com

Abstract

The aim of this experiment was to investigate the impacts of dietary supplementation of extracted oregano essential oils on the physical, chemical properties of meat and the carcass properties of broilers, 180 one day old chicks (Ross 308) arranged into3 dietary groups with 3 replicates (20 birds for each replicate). The experimental groups as follows: Group 1 (G1) control (basal diet), Group 2 (G2) included basal diet + 300 µl of oregano plant extract per kg of diet, Group 3 (G3) contained basal diet + 600 µl of oregano plant extract for kg of diet. The period of experiment was 35 days. Results revealed that the % of dressed weight as well as % weight of breast was significantly ($P < 0.05$) increased in groups which feeding with essential oil of oregano compared to a control diet. In contrast, there were no significant ($P > 0.05$) influences of essential oils of oregano on (heart, liver, kidney, spleen, pancreas, gizzard) relative weights and intestinal length. However, supplemented groups with oregano essential oils showed a significant decrease in % of pH, TVN and TBA, as well as a significant ($P < 0.05$) reductions in % of cooking loss, % of drip loss and shear force of the pectoral muscles when compared to the group feeding control diet. A higher significant increase in WHC was found in the group supplemented with 600 µl of OEO compared to the 300µl OEO and control group. OEO had non-significant influence on breast meat color (a, b, l) compared to the group feeding control diet. In conclusion, the supplementation of essential oils of oregano plant extract can improve carcass quality, physical and chemical meat quality of broiler chickens.

KEYWORDS
Oregano essential oils, Broilers, Carcass characteristics, Meat quality

INTRODUCTION

Following the prohibition on the growth-promoting use of antibiotics in recent years, Probiotics, organic chemicals, enzymes, and phytogenic compounds have all been touted as effective non-antibiotic options in many countries (De Silveira Deminicis *et al*., 2021; Ghasemian *et al*., 2021). The widespread emergence of resistant bacterial strains that might quickly evolve and transmit resistance to other strains of bacteria populations was the driving force behind this ban (Rahimi *et al*., 2012; Gholami-Ahangaran *et al*., 2021a).The popularity of herbal medicine has increased in recent years, largely because of its advantages over chemical medications, such as reduced or zero toxicity, availability in nature, and suitability as a feed additive (Gholami-Ahangaran *et al*., 2021b).

For humans, chicken flesh is regarded as a significant source of high-quality protein and other nutrients. Fresh chicken flesh, on the other hand, has a high water activity level, which favors the growth of germs (Katiyo *et al*., 2020). Fresh meat and poultry can get spoiled due to microorganisms, which results in nutrient loss and a loss of sensory qualities. Additionally, pathogenic bacteria (including *Salmonella*, *Campylobacter jejuni*, and *Listeria monocytogenes*) can result in numerous foodborne illnesses, placing a significant cost on global public health, the economy, and society. Currently, nitrites, nitrates, organic acids, and hydrogen peroxide are the most often employed chemical preservatives to enhance the microbiological safety and quality qualities of meat and meat products (Phillips, 2016). However, some artificial preservatives may have very negative impacts on people and have detrimental impacts on human health (Cardador and Gallego, 2018). Alternative, naturally based antibacterial compounds have so gained popularity in recent years.

Essential oils (EOs) are pure, aromatic, natural compounds that are taken from plants that may have health benefits, like herbs and spices. According to Antonioli *et al.* (2020), the majority of EOs is biodegradable and generally recognized as safe. Due to their remarkable potential for antibacterial and antioxidant activities, EOs have thus been increasingly used in food preservation as safe and environmentally acceptable alternatives to chemical preservatives in recent years. One of the most often utilized essential oils in the world is oregano essential oil (OEO), which is produced from *Origanum vulgare* L. (Shi *et al*., 2021).

OEO has potent antibacterial capabilities against a range of bacteria, fungi, and even viruses, along with its main bioactive components (such as carvacrol and thymol) (Leyva-Lopez *et al*., 2017; Li *et al*., 2022). OEO has so far been utilized successfully to extend the shelf life and improve storage stability of a variety of food goods. Because of its low fat content and significantly high proportions of polyunsaturated fatty acids, which have grown in importance over the past few years, chicken meat is a biologically very valuable food with a high protein content and favorable amino acid composition (López-Ferrer *et al*., 2001).

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Additionally, chicken meat is an essential part of the diets of children, the elderly, chronic patients, people with cardiovascular diseases, and convalescents due to its favorable saturated to unsaturated fatty acid composition and low content of total cholesterol (Milicevic *et al*., 2014). According to Petracci *et al*. (2013), this form of meat has a neutral taste, a decent texture, and a light color, making it more appropriate for processing than other types of meat. The above-mentioned characteristics give producers the ability to tailor the flavor and texture of meat to the demands of the market and the customer target demographics.

Phytobiotics have demonstrated efficacy following the ban on the use of antibiotics in animal nutrition. To enhance the nutritional, technical, and sensory aspects of chicken meat, they are successfully incorporated into the diet of grill chickens (Puvaca *et al*., 2016; Ismail *et al*., 2021). In addition, bioactive substances made from essential oils have characteristics that benefit not just the animals fed with them, but they may also have a minor indirect effect on meat consumers. Due to its phenolic components, particularly thymol and carvacrol, oregano essential oil possesses antioxidant qualities.

One explanation for how bioactive components from dietary essential oils can enhance the quality of meat is that both are volatile fatty acid precursors of the animal's muscle and fat components. By including natural antioxidants in poultry diets, applying these substances to the surface of the meat, or employing active packaging, meat quality can be improved. Retarding lipid oxidation and microbiological development are two advantages of natural antioxidants on meat properties (Velasco and Williams, 2011).

As a result, adding oregano essential oils to chicken feed may have a big impact on the chickens. Therefore, the goal of this research was to evaluate the effects of oregano extract's essential oils on the physical and chemical characteristics of chicken flesh as well as carcass properties.

MATERIALS AND METHODS

This experiment was conducted between 2/11/2021 and 7/12/2021 at Tanta Animal Health and Research Institute, Egypt, to study the influence of essential oils extract of dietary oregano on the carcass traits and physical and chemical meat quality of broilers.

Ethical approval

The animal husbandry and handling procedures during the experiments as directed by the Institutional of Animal Precaution Agency (NO BUFVTM 18-04-23) of the Faculty of Veterinary Medicine, Benha University.

Birds, Experimental design and feeding plan

A total of 180 healthy day-old broilers (Ross -308), with average body weight (42.77g). They were purchased from commercial hatcheries. Broilers were randomly divided into three dietary groups. Each group contained 60 chickens divided into three replicates of 20 chickens each.

Group 1 (G1): Broilers were fed on control diet.

Group 2 (G2): Broilers were fed on control diet + 300 µL of freshly prepared oregano essential oil extract for kg of diet.

Group 3 (G3): Broilers were fed on control diet + 600 µL of freshly prepared oregano essential oil extract for kg of diet.

The dietary formula was described in Table 1. The formula represents a basic diet supplemented with the applicable oregano plant extract (300 µl per kg diet) was added at the top of the diet (1 cm per 3 kg ration), when applicable oregano plant extract, was incorporated (600 µl per kg diet) at the top of diet (2 cm per 3 kg ration).

The floor of the room was divided to 9 equal partitions (2×1.3×0.5 m^2 for one); the floor was covered with fresh, clean shavings to form a 5 cm deep litter which is turned once a week. Each shelf was equipped with a feeder (manual plastic feeder for 8 kg of food) and a drinker (6 liters plastic cup). The chicks had enough food and water during the trial period.

During the first two days of incubation, the chickens were received continuous light using compact incandescent lamps; the chickens were given a 23L: 1D light regime throughout the period to reduce chicken activity. The heater was installed in the room and the room temperature was adjusted according to the age of the chicks. The incubation temperature started at 35°C and decreased daily to a total of 2°C per week , a temperature of 24°C was reached at the end of the experiment (day 35).

Natural ventilation is sufficient to remove moisture, allow litter to dry, and remove carbon dioxide and ammonia emitted by birds from their droppings.

The Oregano plant essential oils and its composition

The freshly organized vital oils of oregano plant extract were purchased from Rival pharm Egypt enterprise (aqueous extraction of oregano plant extract) and analyzed by HPLC at meats evaluation center at the Faculty of Veterinary Medicine, Benha University, Egypt.

Carcass traits parameters

At the end of the trial, nine chickens from every dietary group were slaughtered according to Islamic method. Prior to slaughter, the birds were randomly selected and fasted for 12 hours, then weighed individually (estimated live weight). Birds allowed completing bleeding and be weighed.

Dressing Percentage

After the head was detached and the feathers were removed. Both legs were knuckled from the hock joint and internal organs were removed. The carcasses weighed were recorded (oven ready carcass) and percentage of dressing was assessed according to Biesek *et al*. (2020) and Wu *et al*. (2020).

Dressed carcass (oven-ready carcass) which refers to the body weight after removal of feathers, head, legs, and viscera (edible carcass yield).

Weight of Breast muscle and other organs

Breast meat, heart, gizzard, liver, spleen, pancreas and kidney are Weighing and recording as a percentage of live weight by using this formula according to Biesek *et al*. (2020) and Wu *et al*. (2020). The length and width of the intestine were also recorded.

Estimation of Meat Quality Parameters

Meat Sampling

Pectoralis major plus pectoralis minor muscles were removed from carcasses and frozen directly for 24 h at 4°C for further es timation of meat quality considerations, including water holding capacity (WHC) and cook loss, drip loss, color (a*,b*, L*) and shear

Table 1. Physical and chemical composition of starter, grower, and finisher rations (%) of the experimental groups.

	Dietary formula		
	Starter ration day (0:10)	Grower ration day (11:24)	Finisher ration day (25:35)
Ingredient	(%)	(%)	(%)
Yellow corn	51.69	54.96	58.32
Soybean meal (46)	35	32	31.6
Corn gluten meal	3.7	3.5	4.6
Wheat bran	2.5	3.4	1.7
Soyabean oil	2.4	1.9	1.23
Dicalcium phosphate	1.43	1.3	1.04
Limestone	1.37	1.24	0.3
l- lysine	0.38	0.3	0.3
DL –Methionine	0.36	0.3	0.27
Vit & min premix [1]	0.3	0.29	0.18
Sodium bicarbonate	0.28	0.24	0.16
Sodium chloride	0.23	0.1	0.09
L- Threonine	0.12	0.09	0.05
Choline chloride	0.1	0.05	0.05
Anti-mycotoxin	0.05	0.05	0.05
Anticoccedia	0.05	0.03	0.04
Niutrokeem extend [2]	0.03	0.01	0.02
Anticlosterdia	0.01	0.01	0.01
Anto oxidants	0.01	0.01	0.01
Phytase enzyme [3]	0.1	0.01	0.01
Analytical value			
ME (diet Kcal \ Kg)	3,010.76	3,115.04	3,207.57
CP%	23.03	21.52	19.52
Crude fat	4.9	6.04	7
Digestible fat of poultry	2.12	2.19	2.15
Linoleic acid	2.2	2.66	3.12
Crude fiber	2.42	2.33	2.33
Lysine	1.44	1.29	1.16
digested lysine	1.31	1.17	1.05
Methionine	0.71	0.63	0.58
digested Methionine	0.68	0.6	0.56
Methionine +cysteine	1.08	0.99	0.91
Methionine + digested cysteine	0.98	0.89	0.83
Threonine	0.96	0.88	0.78
digested Threonine	0.83	0.76	0.67
Tryptophan	0.26	0.24	0.23
Tryptophan digested	0.23	0.21	0.2
Calcium	0.96	0.88	0.8
Available phosphorus	0.48	0.44	0.4
Phytate	0.26	0.25	0.24
Chloride	0.24	0.23	0.23
Sodium	0.17	0.16	0.16
Potassium	0.9	0.84	0.83
Dietary electrolyte balance	227.75 me /kg	214.65 me /kg	212.55 me /kg
Choline	1,656.61 ppm	1,607.19 ppm	1,512.11 ppm
Pellet quality factor	3.25%	2.82%	2.39%
Press quality factor	5.63%	5.67%	5.71%

Vitamin and Mineral mix consisted of: Each 2 kg contained: Vitamin A, 12000000 IU, vitamin. D3, 3500000 IU, vitamin. E, 30000 mg, vitamin K3, 3000 mg, Vitamin B1. 1000 mg, Vitamin B2, 5000 mg, Vitaminb6. 2500 mg, vitamins. B12. 20mg, biotin. 100mg, Pantothenic acid .10000mg, Niacin. 35000mg, Folic acid, 1000mg, Manganese, 620000mg, Zinc, 75000mg, Iron. 440000mg, copper. 50000 mg, Ethoxyquin 1300 mg, blend of vitamins and minerals, manufactured by a GRI-VET 10th, Ramadana2, Egypt. Nutrikem Extend 2: energy- releasing enzyme manufactured by kemin (Belgium). Phytase 3: (Avemix, P5000) is given as a feed additive in broilers by a dose of 0.10 g per Kg.

force.

Physical examination

The left pectoral muscle of each broiler was used to measure water holding capacity (WHC), cooking loss (CL), and drip loss (DL). The rectus muscle from the breast of every broiler was accustomed to measure color and shear force; samples were analyzed in Faculty of Veterinary Medicine, and Food Analysis Center at Benha University.

Instrumental color determination

The technique recommended by Hijazeen *et al*. (2016) for color measurement of test samples was used. Chicken color of meat samples were measured on the surface using a Hunter Lab colorimeter (D25-INC4750-Hunter Associate Lab, Reston, VA, USA). Colorimeters were calibrated using an optical sensor that was normalized to a standard of white (average daylight) at the start of each measurement. Colors were described as (CIE), L*(brightness), a*(redness) and b* (yellowness) standards. Regions a selection of color measurement not contain any obvious imperfections which alert consistent color evaluations.

Determination of water holding capacity (WHC)

WHC was measured by low speed centrifugation (Honikel and Hamm, 1994) with some modifications. Briefly, 5 g of whole meat samples were centrifuged at 10,000 x g and 5°C for 10 min in a 15 ml Falcon tube filled with glass beads, and then the meat was removed directly with forceps and dried with filter paper and reweighed. Change in WHC described as a percentage of the variance in weight of meat before and after centrifugation.

Determination of drip loss percentage

The analysis of drip losses was done according to the method adopted by Demirok *et al*. (2013). Percentage of drip loss was designed as the variance between the first chicken weight measured at the facility besides the second weight measured post-mortem at 1, 2, and 3 days during refrigerated storage at 4°C.

Determination of cooking loss percentage

Moisture content and cooking loss were settled corresponding to the method of Association of Official Analytical Chemists "AOAC" (2005). The matter of moisture of chicken meat (25 g) was evaluated as the weight percentage lost at constant weight after cooking in the water bath at 100°C for 60 min.

Determination of Shear Force (SF)

The estimated shear force (kg f/cm3) with an Instron universal testing machine (model 2519-105, USA). Six tests were performed for each sample. The crosshead speed of the shear system was set at 200 mm/min according to Bourne (1978).

Chemical examination

Determination of pH corresponding to Pearson (2006)

In a blender, an average of 10 g of a chicken sample was mixed with 10 ml of neutralized distilled water. The homogenate was incubated at room temperature for 10 min with continuous shaking. The pH was determined using an electric pH meter (Bye version 6020, USA). The pH meter was calibrated using the buffer response for the precisely considered pH (basic pH 7.0, acidic pH 4.0). Therefore, the pH electrode was washed by neutral water instead and then introduced into the homogenate after adjusting the temperature correction device.

Determination of total volatile nitrogen (TVN) (ES: 63-9/ 2006)

In the clean distillation flask, 10 g of chicken meat sample was added to 300 ml of distilled water and mixed well by inserting the polytron probe. Then the antifoam and 2 g of mag oxide were added. 25 mL of 2% boric acid and a little drop of indicator were added to a 500 mL collection bottle. The collection bottle was installed so that the receiver tube was submerged in the solution of boric acid. Distillation flask was boiled for 10 minutes, continued for 25 minutes, and then distilled for 25 minutes. TVN was titrated in boric acid with H2So4 N 0.1 (ES, 2006a).
TVN / l00g = (mls H_2So_4 N 0.1 of sample – ml H_2So_4 N 0.1 of blank) x 14

Determination of Thiobarbituric Acid (TBA) (ES: 63-10/2006)

The test depends on determination of malonaldehyde (MDA) as a product of lipid peroxidation. Briefly, 50 ml of distilled water were mixed with 10 grams of prepared meat samples and transferred to a distillation flask, and then antifoaming agent and 50 ml of diluted hydrochloric acid were added to flask. The distillation flask was heated for distillation of 50 ml of diluted hydrochloric within10 minutes from the beginning of boiling. Accordingly, 5 ml of distilled solution was put in a tube with cover, and then 5 ml of prepared thiobarbituric acid was added, the tube was covered and put on water bath and boiled for 35 minutes, then cooled by water for 10 minutes. By using Spectrophotometer (UNICAM969AA Spectronic, USA), the absorbance of sample was measured under wavelength 538 n m^3 (ES, 2006b).
TBA value= Absorbance of samplex7.8 (malonaldehyde (mg)/Kg).

Statistical analysis

The attained data in the experiment were analyzed by the SPSS software, using a one-way analysis of variance (ANOVA). The results for every group were expressed as mean ± SEM. Variances between means were tested for implication using Duncan's distance test ($P<0.05$) level differences were considered statistically significant.

RESULTS

Results presented in Table 3 showed that the relative weight of dressed carcass was significantly ($P < 0.05$) increased in Group 3 compared to G2 and G1 at day 35, also oregano essential oils supplemented diets (G3 and G2) showed a significant increase in breast weight compared to G1. Also, results showed that dietary supplementation of oregano essential oils had no significant effect ($p > 0.05$) on relative weights of heart, liver, spleen, kidney, bursa and intestinal length and diameter.

Physical meat quality of broiler chickens

As shown in Table 4, data revealed that breast color after 24 h post mortem showed no significant ($P > 0.05$) difference in (L*) , (a*) and ,(b*) values of meat color among the experimental dietary groups at 35 days of age. In the current study, results

showed that there was significant decrease ($p < 0.05$) in drip loss in diet (G3 and G2) compared to G1, also our results showed a significant increase ($p < 0.05$) in WHC in OEO supplemented groups for G 3and G 2compared to G 1. Also, results showed a significant decrease ($p < 0.05$) in cooking loss and shear force in G3 followed by G2 then finally G 1.

Table 2. Chemical and physical analysis of oregano plant extract.

Parameters	Findings
Sensory Examination	
Color	Slight yellow
Odor	Fair fresh odor
Aspect	Clear
Abnormalities	Nothing
Physicochemical Examination	
Solubility	Soluble in Ethyl alcohol
Optical rotation	-2°
Refractive index	1503
Carvacol (%)	61.4
Thymol (%)	2.7
α-terpineol (%)	1.9
Linalool (%)	4.1

Chemical meat quality of broiler chickens

Data presented in Table 5 revealed that groups supplemented with OEO for G 3and G 2 showed a significant decrease in pH, TBA and TVN compared to G1.

DISCUSSION

Results in Table 3 showed that at day 35, the relative dressed carcass weight indicated a significant increase in G 3 compared to diet G2 and diet G1. Oregano essential oils supplemented groups also revealed a significant increase in the weight of breast compared to group fed control diet and these results could be correlated to increased live weight in the OEOS supplemented groups. Our consequences are also approved with those of Bahakaim *et al.* (2020) who reported that groups supplemented with essential oil of oregano had a significant increase in relative carcass, breast weight compared to the control group. Khattak *et al.* (2014) also reported an increase in the weights of carcass, breast, and breast meat following Eos oregano supplementation. These consequences recommend that nutritional OEO supplementation can improve carcass characteristics of broiler chickens. Conversely, Kirkpinar *et al.* (2014) who revealed that nutritional supplementation with essential oil of oregano had no influence on carcass yield, carcass parts and relative breast weight. Also, our

Table 3. Represented the effects of dietary supplementation of oregano essential oils on carcass traits of broilers.

Items	Groups			P value
	Group 1	Group 2	Group 3	
Live body weight (g)	1987.22±72.81^{b}	2015.55±78.38^{b}	2238.33±62.03a	0.04
Weight after bleeding (g)	1883.88±74.22^{a}	1905.00±85.86^{a}	2050.00±69.62^{a}	0.27
Dressed carcass %	69.85±1.75^{b}	70.92±1.78^{b}	75.68±.79^{a}	0.03
Breast weight %	23.35±1.28^{b}	28.45±0.88^{a}	28.86±0.54^{a}	0.00
Gizzard weight (proventriculus) %	3.06±0.16^{a}	3.38±0.11^{a}	3.02±0.10^{a}	0.12
Heart weight %	0.46±0.02^{a}	0.45±0.04^{a}	0.46±0.01^{a}	0.96
Liver weight %	2.07±0.10^{a}	2.08±0.11^{a}	1.85±0.06^{a}	0.16
Kidney weight %	0.66±0.05^{a}	0.47±0.06^{a}	0.51±0.02^{a}	0.37
Spleen weight %	0.10±0.004^{a}	0.10±0.004^{a}	0.10±0.005^{a}	0.82
Pancreas %	0.24±0.007^{a}	0.30±0.07^{a}	0.21±0.004^{a}	0.29
Intestinal length (cm)	166.88±5.63^{a}	171.44±5.79^{a}	168.88±3.95^{a}	0.83
Duodenum diameter(cm)	1.83±0.08^{a}	1.55±0.10^{a}	1.56±0.08^{a}	0.65
Jejunum diameter (cm)	1.90±0.07^{a}	1.42±0.12^{a}	1.48±0.05^{a}	0.11
Ileum diameter(cm)	1.64±0.11^{a}	1.08±0.08^{a}	1.18±0.10^{a}	0.11

Different labels in the same row have different means and standard errors at ($P < 0.05$).

Table 4. Represented the effects of dietary supplementation of oregano essential oils on physical meat quality of broilers.

Items	Groups			P value
	Group 1	Group 2	Group 3	
Color measurements				
Color L	61.48±0.25^{a}	61.12±0.24^{a}	61.24±0.27^{a}	0.25
Color a	7.46±0.06^{a}	7.41±0.18^{a}	7.37±0.05^{a}	0.59
Color b	18.43±0.06^{a}	18.56±0.06^{a}	18.60±0.05^{a}	0.18
Drip loss 1 day (%)	1.08±0.02^{a}	0.96±0.03^{b}	0.87±0.02^{c}	0.00
Drip loss 2 day (%)	1.32±0.03^{a}	1.17±0.04^{b}	1.10±0.04^{b}	0.00
Drip loss 3 day (%)	1.44±0.03^{a}	1.30±0.04^{b}	1.23±0.03^{b}	0.00
WHC (%)	6.66±0.08^{c}	7.82±0.13^{b}	8.35±0.13^{a}	0.00
Shear force (kg)	15.90±0.07^{a}	10.41±0.09^{b}	9.65±0.08^{c}	0.00
Cooking loss (%)	22.41±0.21^{a}	21.58±0.19^{b}	20.94±0.17^{c}	0.00

Different labels in the same row have different means and standard errors at ($P < 0.05$).

Table 5. Represented the effects of dietary supplementation of oregano essential oils on chemical meat quality of broilers.

Items	Groups			P value
	Group 1	Group 2	Group 3	
pH	5.78±0.014[a]	5.70±0.019[b]	5.66±0.013[b]	0.00
TVN mg%	5.22±0.25[a]	3.61±0.13[b]	3.01±0.19[c]	0.00
TBA mg/kg	0.25±0.02[a]	0.16±0.01[b]	0.12±0.01[b]	0.00

Different labels in the same row have different means and standard errors at ($P < 0.05$).

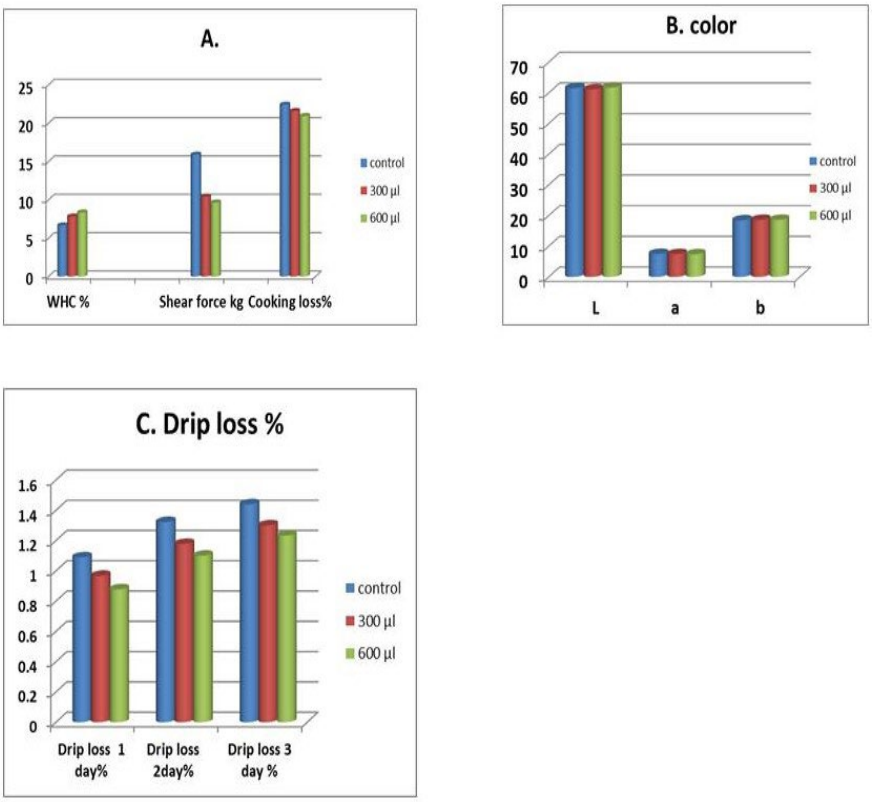

Fig.1. (A.B.C) Effect of oregano essential oils on physical meat quality of broilers.

results showed that dietary essential oil of oregano supplementation had non- significant influences on the relative weights of liver, heart, spleen, kidney, bursa, intestinal length and diameter, this could be attributed to the dose and form of EO used dietary composition and hygienic and environmental conditions. Similarly, Mustafa *et al*. (2021) who demonstrated that the weights of heart, spleen, gizzard, bursa fabricus and small intestine length and width of broiler chickens were not affected by diets containing aromatic plants.

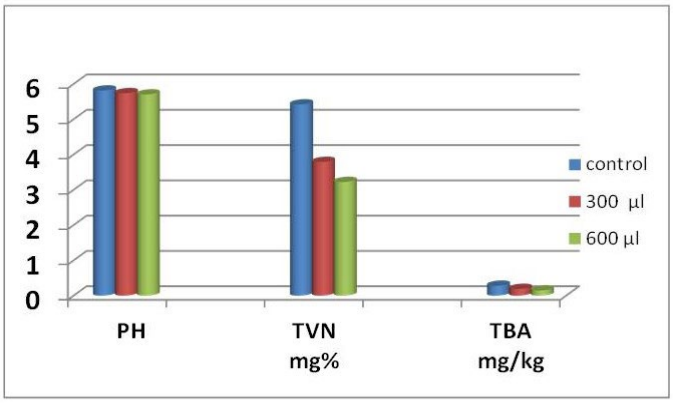

Fig. 2. Effect of oregano essential oils on chemical meat quality of broilers.

As exposed in Table 4, our data revealed no significant variance in the breast color (L*), (a*) and (b*) values between the treated groups of meat color at 24 hours post-mortem at age of 35 day and this result might be due to herbal plants may delay myoglobin and hemoglobin oxidation and preventing muscle protein denaturation in broiler meats. Our result was in accordance with Zaazaa *et al*. (2022) who found that dietary supplementation of thyme and oregano extracts had no significant differences between treatments in the color index (L*, a*, and b*). In consistent with Thashla *et al*. (2019) and Atay (2023) who's mentioned that color of breast meat was affected by diets containing aromatic and herbal plants.

In this study, the values shown that drip loss was considerably reduced in the supplemented groups with oregano essential oil compared to control diet also revealed a significant increase in WHC in OEO supplemented groups compared to control group. These findings could be due to OEOs have an effect in retention of water so decreased drip loss so increased shelf life of meat and the inverse relationship between WHC and DL. Our results contradicted with Chang-Song *et al*. (2017), who noticed no nutritional significant impact of oregano plant on drip loss and WHC.

Our results revealed that cooking losses were significantly decreased in the supplemented G3 followed by G 2 compared to G 1. The result of cooking loss was in accordance with Park *et al*. (2014) who found that dried powder of oregano reduces cook loss in chest muscle; these enhancements in boiling loss may be due to the antioxidant action of EOS. Contrary to our results, Chang-Song *et al*. (2017) who stated that there wasn't any dietary effect of oregano oil on breast cooking loss.

Our study showed that shear force was significantly reduced in diet G 3 followed by G 2 and finally G 1. Related results were described by Hong *et al*. (2012), who documented lower shear forces in OEO-fed chickens. This result possibly because of the antioxidant properties of polyphenols and flavonoids in OEO,

which slow down the oxidation of lipids and proteins. However, Chang-Song *et al*. (2017) set up no dietary effect of oregano oil on shear strength. Symeon *et al*. (2009) also found that dietary essential oil of oregano (100 or 250 mg/kg) did not change shear force.

In this study, the breast meat PH of broilers was decreased in G3 and G2 compared to G 1. Méndez-Zamora *et al*. (2015) found similar pH results in chicken breast meat at 300, 600 and 1200 mg MOO per kg. The chest pH changes obtained in this study can be clarified in a line with Roofchaee *et al*. (2011), where the strong antioxidant action of thymol existing in the vital oil of oregano is owing to the existence of phenolic OH groups, acting as hydrogen donors. Therefore, rising level of dietary levels of OEO or MOO increased the contribution of OH groups, which may decrease the pH detected in the chest meat. In contrast, Kirkpinar *et al*. (2014) and Chang-Song *et al*. (2017) noticed that the dietary supplementation on of oregano oils did not affect the pH of the breast muscle.

The obtained results showed that oregano essential oil was enough to reduce radical formation, decrease the lipid peroxidation, avoid the deterioration of meat and decrease deterioration reactions and extend the shelf life of the product. Our results for G 3 and G 2 showed a significant decrease in TBA and TVN compared to G 1. This result may be due to the fact that the action of oregano is primarily recognized to carvacrol and thymol, which make bacterial cell membranes permeable (Lambert *et al*. 2001) as well as counter with lipids and hydroxyl radicals, transform into stable products (Yanishlieva-Maslarova, 2001). Our results approved by (Velasco and Williams, 2011) who mentioned that meat quality can be improved by incorporating natural antioxidants into animal diets, adding these compounds onto the meat surface or using active packaging. Among the positive effects of natural antioxidants on meat characteristics are retarding lipid oxidation and microbial growth. Marcincak *et al*. (2008) also found that oregano essential oil supplementation of broiler foods was effective in slowing lipid oxidation compared to control diets.

Consistent with this, Oliveros *et al*. (2006) indicated that the supplementation of diet by oregano extract (100, 200 and 300 ppm) didn't had any significant effect on meat quality from start to finish. Kirkpinar *et al*. (2014) also mentioned that nutritional supplementation with essential oil of oregano had no effect on meat quality.

CONCLUSION

It could be concluded that the essential oil of oregano as a dietary supplement improve slaughter weight, relative weight of dressed carcass and breast weight in 300 µl and 600 µl diets/Kg, and reduce dripping loss, cooking-loss, and breast shear force, but increase breast WHC significantly. OEO supplementations also significantly reduce the pH, TVN, and TBA of breast meat, thereby OEOs improving the chicken meat oxidative stability.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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