**Original Research** 

Journal of Advanced Veterinary Research (2023) Volume 13, Issue 7, 1386-1393

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

Asmaa M.S. Salama<sup>1\*</sup>, Soad S.A. Belih<sup>1</sup>, Nasser E.A. Khedr<sup>2</sup>

<sup>1</sup>Department of Animal Nutrition, Animal Health Research Institute, Tanta Branch, Agricultural Research Center (ARC), Egypt.

<sup>2</sup>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 into 3 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).

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made. ISSN: 2090-6277/2090-6269/ © 2011-2023 Journal of Advanced Veterinary Research. All rights reserved.

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 +  $300 \mu$ L of freshly prepared oregano essential oil extract for kg of diet.

Group 3 (G3): Broilers were fed on control diet + 600  $\mu L$  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 orega-

no plant extract (300  $\mu$ l 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  $\mu$ l 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  $(2 \times 1.3 \times 0.5 \text{ m}^2 \text{ for one})$ ; 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.

InstructureInstructur			Dietary formula	
Inproduct(%)(%)(%)Yellow com51.6954.9658.32Yellow com51.6954.9658.32Com gluto mol3.73.544.6Yellow com3.73.544.6What ham2.53.431.7Soylacan all2.41.91.23Dicalcinnythophate1.431.31.04Limeshone0.380.30.27Vi & min promix '0.30.290.18Solam khordek0.280.240.06Solam khordek0.230.110.09L'Theonaire0.120.090.05Chilic chlorik0.010.010.01L'Inconaire0.050.050.05Antispectoria0.010.010.01Antispectoria0.010.010.01Antispectoria0.010.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.100.010.01Antispectoria0.2		Starter ration day (0:10)	Grower ration day (11:24)	Finisher ration day (25:35)
Yellow com51.6954.9658.32Soybean meal (46)353231.6Com platen meal3.73.54.6Waar bran2.53.41.7Soybean oil2.41.91.23Dirakterin phosphate1.431.31.04Linnetone1.971.240.3Dirakterin phosphate0.380.30.3Dirakterin phosphate0.260.30.1Vik min permenk0.260.10.16Sodium induorink0.230.10.16Sodium induorink0.120.050.05Choire chloride0.050.050.05Antroycoxtin0.050.030.04Antroycoxtin0.010.010.01Antroycoxtin0.010.010.01Antroycoxtin0.010.010.01Antroycoxtin0.110.010.01Antroycoxtin0.010.010.01Antroycoxtin0.010.010.01Physice cargue 3'0.110.010.01Antroycoxtin0.023.115.047.7Digetable for fronthy2.122.192.15Code fit4.90.647.7Digetable for fronthy0.240.330.81Androit Vibren0.710.630.56Grade fibrer0.840.660.88Androit Vibren0.730.620.24Code fibrer0.840.850.62 <td>Ingredient</td> <td>(%)</td> <td>(%)</td> <td>(%)</td>	Ingredient	(%)	(%)	(%)
Soyben medi (46)353231.6Con gluen medi (46)3.73.54.4Con gluen medi (47)2.41.91.23Soyben oli2.41.91.23Soyben oli2.41.91.24Unaction plosphola1.371.240.3Linaction (47)0.30.271.01Unaction (47)0.30.290.18Soldum hichbonda0.230.10.09Loritorian0.120.090.05Colline chloride0.10.050.05Anticocectian0.050.050.05Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01Anticocectian0.010.010.01	Yellow corn	51.69	54.96	58.32
Con place meal3.73.54.6Wheat beam2.53.41.7Styaken oil2.41.91.23Dicalcium phosphate1.431.31.04Limestore0.380.30.3Plytate0.380.30.3DL-Methionine0.630.290.18Sodium inscriptorate0.280.090.05Sodium inscriptorate0.280.090.05Choine chloride0.10.090.05Choine chloride0.10.090.05Choine chloride0.10.090.05Anti-raycotoxin0.050.030.01Nitrickern extend '0.010.010.01Anticoscetin0.010.010.01Phytee extracting0.010.010.01Phytee extracting0.010.010.01Phytee extracting3.00.763.115.043.207.57CPf23.032.1522.151.16Chale for do coulty2.122.163.12Chale for do coulty2.122.163.12Chale for do coulty2.122.663.12Chale for do coulty1.311.171.16Attendaritionine0.680.660.56Attendaritionine constant0.680.67Attendaritionine constant0.830.78Attendaritionine constant0.840.40Attendaritionine constant0.640.23Attendaritionine	Soybean meal (46)	35	32	31.6
Whene hum2.53.41.7Snyahan mil2.41.91.23Dicaldum phosphate1.431.31.04Limstone1.371.240.3I-lysine0.360.30.27Vi & min pramix'0.30.290.18Solum hichboarde0.230.10.09Lo Threenin0.120.090.05Colume hichboarde0.050.050.05Colume hichboarde0.050.050.05Colume hichboarde0.050.050.05Anticoxeefin0.050.010.01Anticoxeefin0.010.010.01Anticoxeefin0.010.010.01Anticoxeefin0.010.010.01Anticoxeefin0.010.010.01Anticoxeefin0.010.010.01Anto extains0.010.010.01Anto extains0.010.010.01Anto extains0.010.010.01Anto extains0.023.115.043.207.57Cifk2.202.151.521.52Code far4.96.647Digestel for ponitry2.122.192.15Uinobia exit0.810.630.58digestel fuencine0.640.640.56Methionine0.710.630.58digestel fuencine0.840.640.67Troenine0.840.640.67Troppo	Corn gluten meal	3.7	3.5	4.6
Soyahar al2.41.91.23Dicalcium phosphate1.431.31.04Linentore1.371.240.3L'spiac0.380.30.3Di-Melhoime0.360.30.27Vit & min premix 10.30.290.18Sodium biniche0.280.240.16Sodium biniche0.230.10.09L'Inconine0.120.090.05Anti-nycotoxin0.050.030.01Anti-nycotoxin0.050.030.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Phyte enzyme 12.022.032.02Code for2.122.142.15Linobicia cid2.232.152.15Linobicia cid0.240.230.16Antipolicium0.940.910.16Antipolicium0.960.880.83Antipolicium0.96	Wheat bran	2.5	3.4	1.7
Dealering phophate1.431.31.04Linestore1.371.240.31-Sysine0.380.30.3DL-Mchomine0.360.30.27Vis & min premix'0.30.240.16Sodium hichorhoate0.280.240.16Sodium hichorhoate0.230.10.09L-Threonine0.120.050.05Cholane chloride0.010.050.05Anti-nycotoxin0.050.050.05Anticoccedia0.030.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anticoccedia0.010.010.01Anto oxidants0.010.010.01Anto oxidants0.020.020.02C	Soyabean oil	2.4	1.9	1.23
Lineators1.371.240.3I yaine0.380.30.3U Selime Moinine0.360.30.27Yi & mi premix 10.30.290.18Sodium thienbonate0.280.240.16Sodium thienbonate0.230.10.09L-Treconine0.120.090.05Anti-mycotoxin0.050.050.05Anti-mycotoxin0.050.030.04Natriscecedia0.010.010.02Anticoscedia0.030.010.01Anticoscedia0.010.010.01Anticoscedia0.010.010.01Anticoscedia0.010.010.01Anticoscedia0.010.010.01Anticoscedia0.010.010.01Anticoscedia0.010.010.01More caryne 30.010.010.01Anticoscedia0.023.01.521.52Crude far2.032.152.15Crude far for outry2.122.192.15Uinokie acid2.22.663.12Crude far for outry1.441.053.01Upsitol biano0.710.630.58digested Neinnine0.980.890.83Methonine + digested cysteine0.980.89Methonine + digested cysteine0.980.81Methonine + digested cysteine0.240.23Colorine0.240.230.24 <td>Dicalcium phosphate</td> <td>1.43</td> <td>1.3</td> <td>1.04</td>	Dicalcium phosphate	1.43	1.3	1.04
i-yain0.380.30.3DiMethionine0.360.300.27Vik arin premix <sup>1</sup> 0.30.290.18Soliun bicarbonate0.280.240.16Soliun bicarbonate0.230.10.09L-Theronine0.120.090.05Chaline chloride0.10.050.05Anti-coccella0.050.050.05Anticoccella0.010.010.01Anticoccella0.010.010.01Anticoscella0.010.010.01Anto oxidans0.010.010.01Anto oxidans0.010.010.01Mi (cink Cal' Kg)3.010.763.115.043.207.57CP%23.0321.5219.52Crude fur4.96.047Digestible for poultry2.122.663.12Crude fur0.422.332.15Liaoleia ecid0.230.232.16Liaoleia ecid0.242.330.36Crude fur0.480.640.65Methionine0.680.660.56Methionine0.680.670.67Crude further0.830.660.67Alisobiencine0.680.660.67Methionine0.640.680.67Alisobiencine0.680.660.67Alisobiencine0.680.660.67Alisobiencine0.680.660.67Alisobi	Limestone	1.37	1.24	0.3
DL-Methonine0.360.30.27Vit & min premix '0.30.290.16Sodium bichrobate0.230.140.09Sodium bichrobate0.230.110.09L-Threonin0.120.090.05Choline choride0.130.050.05Anti-mycotoxin0.050.050.05Anticoccedia0.010.010.02Anticoccedia0.010.010.01Nutcokem extend '0.010.010.01Anti cotadrats0.010.010.01Anti cotadrats0.010.010.01Anto cotadrats0.010.010.01Phytase enzyme '0.10.010.01Anto cotadrats0.010.010.01Phytase enzyme '0.100.010.01Phytase enzyme '0.100.010.01Cotad fat4.900.047Digestible fat of poultry2.122.192.15Linokie aid2.222.663.12Code fiber2.422.332.33Lysine1.441.291.16digested Hysine0.710.630.56Methonine + dystein0.880.780.78Gigested Hysine0.810.790.21Undersine0.960.880.78Methonine + dystein0.810.76Methonine + dystein0.820.24Oppoland digsteid0.260.24	l- lysine	0.38	0.3	0.3
Vi & min premix '0.30.290.18Sodium shoring0.280.240.16Sodium shoring0.120.090.05L- Threonine0.120.090.05Anti-mycotxin0.050.050.05Anti-mycotxin0.050.030.04Nutrokem extend '0.030.010.02Antioscectin0.010.010.01Nutrokem extend '0.010.010.01Physice exzyme '0.10.010.01Physice exzyme '0.10.010.01Physice exzyme '0.10.010.01Physice exzyme '0.10.010.01Physice exzyme '0.10.010.01Physice exzyme '0.122.151.952Crude fish4.96.047Digestible fix of poultry2.122.163.12Crude fisher2.422.332.33Lysine1.441.291.16digested lysine0.710.630.58digested lysine0.880.890.83digested lineonine + digested cystnin0.960.880.83Methionine + digested cystnin0.960.880.81Availuel phosphorus0.480.440.4Phytophan digested0.240.230.23Chytophan digested0.240.230.24Choline + hytophan digested0.480.440.4Phytophan digested0.240.23 </td <td>DL –Methionine</td> <td>0.36</td> <td>0.3</td> <td>0.27</td>	DL –Methionine	0.36	0.3	0.27
Sedium bicarbonane0.280.240.16Sodium chloride0.120.090.05Choline chloride0.10.050.05Choline chloride0.10.050.05Anti-nycotoxin0.050.050.05Naticoccelia0.030.010.02Anticoccelia0.030.010.01Anticoccelia0.010.010.01Anticoccelia0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Anto oxidanta0.010.010.01Chuce fat4.96.047Digestich fet of poutry2.122.192.15Crude fat1.441.291.16digested lysine0.680.660.56Methionine + digested cysteine0.980.890.83Methionine + digested cysteine0.980.880.87Antibiphophorus0.480.440.4Antibiphophorus0.480.440.4Antibiphophorus0.260.250.24Cholina phophorus <t< td=""><td>Vit &amp; min premix <sup>1</sup></td><td>0.3</td><td>0.29</td><td>0.18</td></t<>	Vit & min premix <sup>1</sup>	0.3	0.29	0.18
Sedium chloride0.230.10.09L Threorine0.120.090.05Choline chloride0.10.050.05Anti-mycotoxin0.050.030.04Nutrokeen extend 20.030.010.01Antiosterchina0.010.010.01Antiosterchina0.010.010.01Antiosterchina0.010.010.01Antiosterchina0.010.010.01Matiosterchina0.010.010.01Physes crayme 30.10.010.01Matylical value0.010.010.01Chef fat0.010.010.01Digeatible fat of poultry2.122.191.52Crude fat4.96.047Digeatible fat of poultry2.122.192.15Linoleis acid2.242.332.33Lysine1.411.291.16digested fysine0.640.660.56Methionine + dysteine0.680.660.56Methionine + digested cysteine0.980.890.83Threorine0.260.240.23Chyster0.260.240.23Chyster0.260.240.23Chyster0.260.880.8Arabier of polyter0.260.240.23Chyster0.260.240.23Chyster0.260.240.23Chyster0.260.240.23 <td>Sodium bicarbonate</td> <td>0.28</td> <td>0.24</td> <td>0.16</td>	Sodium bicarbonate	0.28	0.24	0.16
L- Tarcenine0.120.090.05Choline chloride0.10.050.05Anti-nycotoxin0.050.050.05Anticocectia0.050.050.04Nutroksem extend <sup>2</sup> 0.030.010.02Anticosterdia0.010.010.01Anto oxidants0.010.010.01Anto oxidants0.010.010.01Anto oxidants0.010.010.01Antiyotaryane <sup>3</sup> 0.10.010.01Analytical value	Sodium chloride	0.23	0.1	0.09
Choline chloride0.10.050.05Anti-nycotoxin0.050.050.05Anti-oxcocdia0.050.030.04Nitarokem extend <sup>3</sup> 0.010.010.01Anti okasterdia0.010.010.01Anto soldants0.010.010.01Anto soldants0.010.010.01Anto soldants0.010.010.01Anto soldants0.010.010.01Anto soldants0.010.010.01Anto soldants0.010.010.01Code fat3.010.763.115.043.207.57Crefe fat4.96.047Digestible fat of poultry2.122.192.15Linolosic aid2.22.663.12Crude faber1.311.171.05Methionine0.710.630.58digested lysine1.080.990.91Methionine + systeine0.980.830.78Methionine + systeine0.960.880.83Threonine0.960.880.83Trypophan0.260.240.23Typiophan0.240.230.23Chicher0.970.840.83Analise physions0.880.83Analise physions0.840.83Choine0.27.75 m. kg21.45 m. kgChoine1.656.61 ppm1.607.19 ppmPistar educty latence27.75 m. kg21.45 m. kgCho	L- Threonine	0.12	0.09	0.05
Anti-mycotoxin0.050.050.05Anticosterdia0.050.030.04Nutrokeen extend 20.030.010.02Anticosterdia0.010.010.01Anticosterdia0.010.010.01Anticosterdia0.010.010.01Anticosterdia0.010.010.01Analytical value0.010.010.01Crew23.0321.5219.52Crude fat4.96.047Digestible fat of poultry2.122.19Crude fat2.222.663.12Crude fiber2.422.332.33Lysine1.441.291.16digested lysine0.710.630.58Methionine + digested cysteine0.980.890.83Trocoinia0.960.880.67Methionine + digested cysteine0.960.880.8Nurable phosphorus0.480.440.4Phytat0.260.240.23Crudia phosphorus0.480.440.4Phytat0.260.250.24Chirdia phosphorus0.990.830.63Chirdia phosphorus0.990.880.8Natibal phosphorus0.990.840.83Chirdia phosphorus0.990.210.2Chirdia phosphorus0.990.840.83Chirdia phosphorus0.990.840.83Distury electrolyte balance2	Choline chloride	0.1	0.05	0.05
Anticocecdia0.050.030.04Nutrokeen extend 20.030.010.02Anticolesterdia0.010.010.01Anto oxidants0.010.010.01Phytase enzyme 30.10.010.01Analytical value0.010.01CMe (diet Kcal \ Kg)3.01.0763.115.043.207.57CMe fat4.96.047Digestible fat of poultry2.122.192.15Cinde fat2.422.332.33Lysine1.441.291.16digested lysine0.710.630.56digested lysine0.980.890.81Urbinomine + digested oysteine0.960.880.78digested Threonine0.960.880.67Tryptophan0.260.230.21Chride hopolynu0.170.160.23Tryptophan0.260.230.23Chride hopolynu0.710.640.23Tryptophan0.260.240.23Tryptophan0.260.240.23Tryptophan0.260.240.23Chride0.240.230.21Chride0.240.230.23Chride0.270.480.83Chride0.270.240.23Chride0.270.240.23Chride0.240.230.23Chride0.270.240.23Chride </td <td>Anti-mycotoxin</td> <td>0.05</td> <td>0.05</td> <td>0.05</td>	Anti-mycotoxin	0.05	0.05	0.05
Nutrokeen extend <sup>2</sup> 0.03     0.01     0.02       Anticlosterdia     0.01     0.01     0.01       Anto scientaria     0.01     0.01     0.01       Anto scientaria     0.01     0.01     0.01       Analytical value     3.010.76     3.115.04     3.207.57       CP%     23.03     21.52     19.52       Digestible fir 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     1.144     1.29     1.16       Methionine     0.71     0.63     0.56       Methionine     0.98     0.89     0.83       digested Methionine     0.96     0.88     0.78       digested Thronine     0.83     0.76     0.67       Tryptophan digested     0.26     0.24     0.23       Thronine     0.96     0.88     0.88     0.88       Antioble phosphorus     0.48     0.44     0.4     0.25	Anticoccedia	0.05	0.03	0.04
Anticlosterdia0.010.01Anto oxidants0.010.01Piytase enzyme 3'0.00.01Analytical value0.01Met (det Kal Vag)3.010.763.115.043.207.57CP%23.0321.5219.52Crude far4.96.047Digestible fat of poultry2.122.192.15Linoleic acid2.22.663.12Crude fbr2.422.332.33Lysine1.441.291.16digested lysine0.710.630.58digested lysine0.880.60.56Methionine + ogtened0.980.890.83Threonine0.960.840.67Threonine0.560.240.23Typophan digested0.230.210.2Available phosphorus0.480.440.4Phytae0.260.250.24Cholrine0.990.880.8Available phosphorus0.480.440.4Phytae0.260.250.24Cholrine0.910.160.16Pottssium0.90.840.83Dietar ylectorlyte balance227.75 me /kg214.65 me /kg212.55 me /kgCholrin1.656.61 ppm1.607.19 ppm1.51.11 ppmPelse quality factor3.25%5.65%5.71%	Niutrokeem extend <sup>2</sup>	0.03	0.01	0.02
Anto oxidants     0.01     0.01       Phytase enzyme <sup>3</sup> 0.1     0.01       Analytical value	Anticlosterdia	0.01	0.01	0.01
Physise enzyme <sup>1</sup> 0.1     0.01       Analytical value	Anto oxidants	0.01	0.01	0.01
Analytical value     Analytical value       ME (diet Keal \ 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     0.68     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     0.67       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	Phytase enzyme <sup>3</sup>	0.1	0.01	0.01
ME diet Keal \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 fibr     2.42     2.33     2.33       Lysine     1.44     1.29     1.16       digested lysine     0.71     0.63     0.58       digested Methionine     0.68     0.6     0.56       Methionine + eysteine     0.88     0.99     0.91       Methionine + digested cysteine     0.96     0.88     0.67       Tryptophan     0.26     0.24     0.23       Tryptophan digested     0.23     0.21     0.2       Calcium     0.96     0.88     0.84       Available phosphorus     0.48     0.44     0.4       Phytae     0.26     0.23     0.23       Choirde     0.27     0.26     0.24     0.23          Choirde	Analytical value			
CP%23.0321.5219.52Crude fat4.96.047Digestible fat of poultry2.122.192.15Linoleic acid2.22.663.12Crude fibr2.422.332.33Lysine1.441.291.16digested lysine1.311.171.05Methionine0.710.630.58digested Methionine0.680.60.56Methionine +cysteine1.080.990.91Methionine +digested cysteine0.960.880.78digested Threonine0.960.880.67Tryptophan0.260.240.23Calum0.960.880.8Available phosphorus0.480.44Ohytate0.260.24Choride0.910.25Choride0.240.23Calum0.960.880.8Available phosphorus0.480.4Phytate0.260.240.23Choride0.970.160.16Protasium0.90.840.83Dictary electrolyte balance27.75 m. kg21.465 m. kg21.25 m. kgChoride1.656.61 prm1.612.11 prmPellet quality factor5.63%5.67%5.71%	ME (diet Kcal \ Kg)	3,010.76	3,115.04	3,207.57
Crude fat     4.9     6.04     7       Digestible fat of poultry     2.12     2.19     2.15       Linoletic 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 + crysteine     1.08     0.99     0.91       Methionine + digested crysteine     0.96     0.88     0.78       digested Threonine     0.96     0.88     0.78       digested Threonine     0.96     0.88     0.67       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     0.23     0.23       Colcium     0.97     0.84     0.83       Obsphorus	CP%	23.03	21.52	19.52
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     0.67       Tryptophan     0.26     0.24     0.23       Tryptophan digested     0.23     0.21     0.2       Calcium     0.96     0.88     0.88     0.88       Navilable phosphorus     0.48     0.44     0.4       Phytate     0.26     0.25     0.24       Choirde     0.24     0.23     0.23       Sodium     0.17     0.16     0.16       Phytate	Crude fat	4.9	6.04	7
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 + eysteine     1.08     0.99     0.91       Methionine + digested cysteine     0.98     0.89     0.83       Threonine     0.96     0.88     0.78       digested Threonine     0.96     0.84     0.23       Tryptophan digested     0.23     0.21     0.23       Tryptophan digested     0.26     0.24     0.23       Calcium     0.26     0.25     0.24       Chloride     0.26     0.25     0.24       Chloride     0.26     0.25     0.24       Chloride     0.24     0.23     0.23       Chloride     0.24     0.23     0.23       Sodium     0.17 <td< td=""><td>Digestible fat of poultry</td><td>2.12</td><td>2.19</td><td>2.15</td></td<>	Digestible fat of poultry	2.12	2.19	2.15
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     0.67       digested Threonine     0.23     0.21     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       Potaseium     0.9     0.84     0.83       Sodium     0.9     0.84     0.83       Dietary electrolyte balance     227.75 me/kg	Linoleic acid	2.2	2.66	3.12
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     0.67       digested Threonine     0.83     0.76     0.67       Tryptophan     0.26     0.24     0.23       Tryptophan digested     0.96     0.88     0.8       Available phosphorus     0.48     0.44     0.4       Phytate     0.26     0.25     0.24       Cholinde     0.24     0.23     0.23       Sodium     0.17     0.16     0.16       Phytate     0.26     0.25     0.24       Cholinde     0.9     0.84     0.83       Dietary electrolyte balance     27.75 me/kg     214.65 me/kg     212.55 me/kg       Choline	Crude fiber	2.42	2.33	2.33
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       Phytate     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 <tr< td=""><td>Lysine</td><td>1.44</td><td>1.29</td><td>1.16</td></tr<>	Lysine	1.44	1.29	1.16
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     0.96     0.83     0.76       digested Threonine     0.83     0.76     0.67       Tryptophan     0.26     0.24     0.23       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%	digested lysine	1.31	1.17	1.05
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       Pytats     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%	Methionine	0.71	0.63	0.58
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     0.23     0.21     0.2       Chloride     0.96     0.88     0.8     0.8       Oystat     0.96     0.88     0.8     0.4       Phytate     0.26     0.25     0.24     0.23     0.23       Sodium     0.17     0.16     0.16     0.16     0.16       Potassium     0.9     0.84     0.83     0.83     0.83     0.84     0.83     0.84     0.83     0.84     0.83     0.16     0.16     0.16     0.16     0.16	digested Methionine	0.68	0.6	0.56
Netholnik (*ystelle     1.65     6.99     6.91       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     0.23     0.21     0.2       Chloride     0.26     0.25     0.24     0.23       Sodium     0.17     0.16     0.16     0.16       Potassium     0.9     0.84     0.83     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%	Mathionina +oystaina	1.08	0.99	0.91
Intentional C fugisted cysteme     0.95     0.89     0.89       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     0.21       Sodium     0.17     0.16     0.16       Ptatasium     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%	Mathionine + digested systeme	0.98	0.89	0.83
Intentine     0.30     0.38     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%	Threenine	0.96	0.89	0.78
Information     0.05     0.70     0.07       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%	digested Threonine	0.83	0.76	0.67
Tryptophan 0.20 0.24 0.25   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%	Tryptophan	0.26	0.24	0.07
11 yptophal 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%	Tryptophan Tryptophan digested	0.23	0.21	0.2
Cardinal     0.50     0.60     0.50       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%	Calcium	0.25	0.88	0.8
Available phospholds     0.46     0.44     0.44       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%	Available phosphorus	0.48	0.44	0.4
Injuite 0.10 0.12   Chloride 0.24 0.23   Sodium 0.17 0.16   Potassium 0.9 0.84   Dietary electrolyte balance 227.75 me /kg 214.65 me /kg   Choline 1,656.61 ppm 1,607.19 ppm   Pellet quality factor 3.25% 2.82%   Press quality factor 5.63% 5.67%	Phytate	0.46	0.25	0.4
Children     0.17     0.125     0.125       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%	Chloride	0.24	0.23	0.23
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       Petlet quality factor     3.25%     2.82%     2.39%       Press quality factor     5.63%     5.67%     5.71%	Sodium	0.17	0.25	0.25
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%	Potassium	0.9	0.84	0.83
Decary electry is sufficient     227.75 mic/kg     212.55 mic/kg     212.55 mic/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%	Dietary electrolyte balance	227 75 me /kg	214.65 me /kg	212 55 me /kg
Pellet quality factor     3.25%     2.82%     2.39%       Press quality factor     5.63%     5.67%     5.71%	Choline	1 656 61 ppm	1 607 19 npm	1 512 11 nnm
Press quality factor     5.63%     5.67%     5.71%	Pellet quality factor	3 25%	2 87%	2 39%
	Press quality factor	5.63%	5.67%	5.71%

Vitamin and Mineral mix consisted of: Each 2 kg contained: Vitamin A, 1200000 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 / 100g = (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 hydro-chloric 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<sup>3</sup> (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  $\pm$  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<sup>\*</sup>), (a<sup>\*</sup>) and ,(b<sup>\*</sup>) 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.

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

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

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

Items —		Groups			
	Group 1	Group 2	Group 3	P value	
pH	5.78±0.014ª	5.70±0.019 <sup>b</sup>	5.66±0.013 <sup>b</sup>	0.00	
TVN mg%	5.22±0.25ª	3.61±0.13 <sup>b</sup>	3.01±0.19°	0.00	
TBA mg/kg	$0.25{\pm}0.02^{a}$	$0.16{\pm}0.01^{b}$	$0.12{\pm}0.01^{b}$	0.00	

70

60

50 40

30

20

10

0

L

a

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





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 de-

lay 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.

B. color

control

**#** 300 µl

■ 600 ul

b

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  $\mu$ l and 600  $\mu$ l 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.

# ACKNOWLEDGMENTS

The authors would like to thank members of the Department of Nutrition and Clinical nutrition, Faculty of Veterinary Medicine, Benha University, Egypt for their technical assistance.

# **CONFLICT OF INTEREST**

The authors declare that they have no conflict of interest.

## REFERENCES

- Antonioli, G., Fontanella, G., Echeverrigaray, S., Longaray Delamare, A.P., Pauletti, G.F., Barcellos Poly, T., 2020. Nano capsules containing lemongrass essential oil for postharvest decay control: In vitro and in vivo evaluation against phytopathogenic fungi. Food Chemistry 326, Article 126997.
- AOAC (Association of Official Analytical Chemists), 2005. Official Meth-

ods of Analysis. 14<sup>th</sup> Ed., Horwitz. W; D. (Editor), Academic Press, Washington D.C, USA.

- Atay, A., 2023. The Effect Medicinal Plants on Performance, Carcass Parameters and Meat Quality in Broiler Chickens. Journal of the Institute of Science and Technology 13, 1418-1428.
- Bahakaim, A.S., Abdel-Halim, H.A., Mousa, M.M., Fadl, A., 2020. Effect of dietary oregano supplementation on productive, physiology and immunological performance of broiler chicks. Egypt. Poult. Sci. 40, 507- 524.
- Biesek, J., Kuźniacka, J., Banaszak, M., Adamski, M., 2020. The quality of carcass and meat from geese fed diets with or without soybean meal. Animals 10, 200. https://doi.org/10.3390/ani10020200.
- Bourne, M.C., 1978. Texture profile analysis. Food Technology 35, 62-67
- Cardador, M.J., Gallego, M., 2018. Determination of several common disinfection by-products in frozen foods Food Additives and Contaminants: Part A 35, 56-65.
- Chang-Song, R.I., Xian-Ren,J., Myong, H.O., Kim, J., Shu-Geng, W.U., Valentino, B., Guang-Hai, Q.I., 2017. Effects of dietary oregano powder supplementation on the growth performance, antioxidant status and meat quality of broiler chicks. Italian Journal of Animal Science 16, 246-252.
- De Silveira Deminicis, R.G., Meneghetti, C., de Oliveira, E.B., Júnior, A.A., Farias Filho, R.V., Deminicis, B.B., 2021. Systematic review of the use of phytobiotics in broiler nutrition. Revista de Ciências Agroveterinárias 20, 098–106.
- Demirok, E., Veluz, V., Stuyvenberg, W., Castañeda, M., Byrd, A., Alvarado, C., 2013. Quality and safety of broiler meat in various chilling systems. Poultry Science. 92, 1117-1126.
- ES (Egyptian Organization for Standardization), 2006a. Methods of analysis and testing for meat. Part 9: determination of total volatile nitrogen (TVN).ES:63-9/2006.
- ES (Egyptian Organization for Standardization), 2006b. Methods of analysis and testing for meat. Part 10: determination of thiobarbituric acid (TBA). ES: 63-10/2006.
- Ghasemian, S. O., Gholami-Ahangaran, M., Pourmahdi, O., AhmadiDastgerdi, A., 2021. Dietary supplementation of protexin and artichoke extract for modulating growth performance and oxidative stress in broilers. Ankara Üniversitesi Veteriner Fakültesi Dergisi. 69, 281-288.
- Gholami-Ahangaran, M., Haj-Salehi, M., Ahmadi-Dastgerdi, A., Zokaei, M., 2021b. The advantages and synergistic effects of Gunnera (*Gundelia tournefortii* L.) extract and protexin in chicken production. Veterinary Medicine and Science 7, 2374-2380.
- Gholami-Ahangaran, M., Moravvej, A.H., Safizadeh, Z., Sadeghi Nogoorani, V., Zokaei, M., Ghasemian, S.O., 2021a. The evaluation of ESBL genes and antibiotic resistance rate in Escherichia coli strains isolated from turkey meat and intestinal contents in Isfahan, Iran. Iranian Journal of Veterinary Research 22, 318–325.
- Hijazeen, M., Lee, E., Mendoka, A., Ahn, D., 2016. Effect of Oregano essential oil (Origanum vulgare subsp. hirtum) on the storage stability and quality parameters of ground chicken breast meat. Antioxidants 18, 1-11.
- Hong, J.C., Steiner, T., Aufy, A., Lien, T.F., 2012. Effects of supplemental essential oil on growth performance, lipid metabolites and immunity, intestinal characteristics, microbiota and carcass traits in broilers. Livestock Science 144, 253-262.
- Honikel, K. O., Hamm, R., 1994. Measurement of water-holding capacity and juiciness. In A. M. Pearson and T. R. Dutson (Eds.), Quality Attributes and their Measurement in Meat, Poultry and Fish Products. pp. 125–161.
- Ismail, I.E., Alagawany, M., Taha, A.E., Puva`ca, N., Laudadio, V., Tufarelli, V., 2021. Effect of Dietary Supplementation of Garlic Powder and Phenyl Acetic Acid on Productive Performance, Blood Haematology, Immunity and Antioxidant Status of Broiler Chickens. Anim. Biosci. 34, 363–370.
- Katiyo, W., de Kock, H.L.R., Coorey, R., Buys, E.M., 2020. Sensory implications of chicken meat spoilage in relation to microbial and physicochemical characteristics during refrigerated storage LWT-Food Science and Technology 128, 109468.
- Khattak, F., Ronchi, A., Castelli, P., Sparks, N., 2014. Effects of natural blend of essential oil on growth performance, blood biochemistry, cecal morphology, and carcass quality of broiler chickens. Poultry Science 93,132-137.
- Kirkpinar, F., Ünlü, H.B., Serdaroğlu, M., Turp, G.Y., 2014. Effects of dietary oregano and garlic essential oils on carcass characteristics, meat composition, colour, pH and sensory quality of broiler meat. British Poultry Science 55, 157-166.
- Lambert, R.J., Skandami, P.N., Coote, P.J., Nychas, G.J., 2001. A study of the minimum inhibitory concentration and mode of action of oregano essential oil, thymol and carvacrol. Journal of Applied

Microbiolgy. 91, 453–462.

- Leyva-Lopez, N., Gutierrez-Grijalva, E.P.G., Vazquez-Olivo, G., Heredia, J.B., 2017. Essential oils of oregano: Biological activity beyond their antimicrobial properties. Molecules. 22, 989.
- Li, X.X., Wang, B., Yi, C., Gong, W.W., 2022. Gas sensing technology for meat quality assessment: A review. Journal of Food Process Engineering 45, Article e14055.
- López-Ferrer, S., Baucells, M. D., Barroeta, A.C., Grashorn, M. A., 2001. N-3 Enrichment of Chicken Meat. 1. Use of Very Long-Chain Fatty Acids in Chicken Diets and their Influence on Meat Quality: Fish Oil. Poult. Sci. 80, 741–752.
- Marcincak, S., Cabadaj, R., Poplka, P., 2008. Ant oxidative effect of oregano supplemented to broilers on oxidative stability of poultry meat. Slov. Vet. Res. 45, 61-66.
- Méndez-Zamora, G., García-Macías, J.A., Durán-Meléndez, L.A., Herman-Lara, E., Santellano-Estrada, E., Silva-Vazquez, R., 2015. Aceite esencial de oregano (*Lippiaberlandieri schauer*) en variables de calidad de la canal de pollo. Ecosistemas y Recursos Agropecuarios. 4, 41-51.
- Mili'cevi'c, D., Vrani'c, D., Maši'c, Z., Parunovi'c, N., Trbovi'c, D., Nedeljkovi'c-Trailovi'c, J., Petrovi'c, Z., 2014. The Role of total Fats, Saturated/Unsaturated Fatty Acids and Cholesterol Content in Chicken Meat as Cardiovascular Risk Factors. Lipids Health Dis. 13, 42.
- Mustafa, M.M., Karadas, F., Tayeb, I.T., 2021. Adding different levels of turmeric powder and curcumin in the diet on broiler performance, carcass traits, immunity and gut morphology of broiler chicken under normal and heat stress condition. Iraqi Journal of Agricultural Sciences 52, 512-526.
- Oliveros, M.C.R., Batungbacal, M.R., Roxas, N.P., Sevilla, C.C., Acdal, S.P., Mabesa, R.C., 2006. Quality of meat from broilers fed diets supplemented with either alpha-tocopherol acetate or oregano (*Origanum vulgare*) extract. Philippine Journal of Veterinary and Animal Sciences. 32,177-186.
- Park, J.H., Kang, S.N., Chu, G.M., Jin, S.K., 2014. Growth performance, blood cell profiles, and meat quality properties of broilers fed with Saposhnikovia divaricata, Lonicera japonica, and Chelidonium majus extracts. Livestock Science. 165, 87-94.
- Pearson, D., 2006. Chemical Analysis of Foods. 11th Ed, Publishing Co.,
- Petracci, M., Bianchi, M., Mudalal, S., Cavani, C., 2013. Functional Ingredients for Poultry Meat Products. Trends Food Sci. Technol. 33, 27–39.
- Phillips, C.A., 2016. Bacterial biofilms in food processing environments: A review of recent developments in chemical and biological con-

trol. International Journal of Food Science and Technology 51, 1731-1743.

- Puvaca, N., Kostadinovic, L., Popovic, S., Levic, J., Ljubojevic, D., Tufarelli, V., Jovanovic, R., Tasic, T., Ikonic, P., Lukac, D., 2016. Proximate Composition, Cholesterol Concentration and Lipid Oxidation of Meat from Chickens Fed Dietary Spice Addition (*Allium Sativum, Piper Nigrum, Capsicum Annuum*). Anim. Prod. Sci. 56, 1920–1927.
- Rahimi, E., Hormozipoor, H., Gholami-Ahangaran, M., Yazdi, F., 2012. Prevalence of Arcobacter species on chicken carcasses during processing in Iran. Journal of Applied Poultry Research 21, 407–412.
- Roofchaee, A., Irani, M., Mohammad, A.E., Mohammad, R.A., 2011. Effect of dietary oregano (*Origanum vulgare* L.) essential oil on growth performance, cecal microflora and serum antioxidant activity of broiler chickens. Afr J Biotechnol. 10, 6177–6183.
- Shi, Z.D., Jiang, Y.P., Sun, Y.J., Min, D.D., Li, F.J., Li, X.A., Zhang, X.H., 2021. Nanocapsules of oregano essential oil preparation and characterization and its fungistasis on apricot fruit during shelf life. Journal of Food Processing and Preservation 45, e15649.
- Symeon, G. K., Zintilas, C., Ayoutanti, A., Bizelis, J. A., Deligeorgis, S.G., 2009. Effect of dietary oregano essential oil supplementation for an extensive fattening period on growth performance and breast meat quality of female medium-growing broilers. Canadian Journal of Animal Science. 89, 331–334.
- Tashla, T., Puvača1, N., Ljubojević Pelić, D., Prodanović, R., Ignjatijević, S., Bošković1, J., Ivanišević, D., Jahić, M., Mahmoud, O., Giannenas, I., Lević, J., 2019. Dietary medicinal plants enhance the chemical composition and quality of broiler chicken meat. Journal of the Hellenic Veterinary Medical Society 70, 1823-1832.
- Velasco, V., Williams, P., 2011. Improving meat quality through natural antioxidants. Chilean Journal of Agricultural Research 71, 313.
- Wu, P., Golly, M.K., Guo, Y., Ma, H., He, R., Luo, X., Luo, S., Zhang, C., Zhu, J., 2020. Effect of partial replacement of soybean meal with high-temperature fermented soy bean meal in antibiotic-growth-promoter-free diets on growth performance, organ weights, serum indexes, intestinal flora and histomorphology of broiler chickens. Anim. Feed Sci. Technol. 269, 114616.
- Yanishlieva- Maslarova, N.V., Pokorny, J., Gordon, M., 2001. Antioxidants in Food. Practical Applications, Cambridge, England, pp. 22–70.
- Zaazaa, A., Mudalal, S., Alzuheir, I., Samara, M., Jalboush, N., Fayyad, A., Petracci, M., 2022. The Impact of Thyme and Oregano Essential Oils Dietary Supplementation on Broiler Health, Growth Performance, and Prevalence of Growth-Related Breast Muscle Abnormalities. Animals 12, 3065.