Meat physico-chemical composition of guinea fowl fed organic diets supplemented with dry oregano leaf

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SUMMARY

The present study was conducted to determine the meat quality and some fatty acids of standard guinea fowl genotype fed organic diets supplemented with dry oregano (*Origanum vulgare L.*) leaf. A total of 240-one day-old guinea fowl keets (mixed-sex) were randomly divided into four dietary groups with three replicate pens (20 keets per pen). The birds were fed on the basal diet with supplementation of the control (without supplement, 0 g/kg), 5 g/kg (low), 10 g/kg (medium) and 15 g/kg (high) dry oregano leaf (*Origanum vulgare L.*, OV) during 16 weeks. There were no significant differences for the values of L*, a*, b*, H* (Hue angle), C* (Chroma), $\Delta E^*((L^{*2}+a^{*2}+b^{*2})^{1/2})$ in right breast with skin (*Pectoralis major* and *Pectoralis minor*) and without skin between each group. No statistical differences were found between the mean values on physical characteristics (pH, water holding capacity), chemical composition (moisture, protein, fat and ash), saturated and unsaturated fatty acids of right breast meat of guinea fowl with the supplementation of the different levels of dietary oregano leaf. These findings showed that oregano supplementation had no practical adverse impact on the meat quality of guinea fowl reared in the organic system.

KEY WORDS

Meat quality, fatty acids, bird nutrition, guinea fowl, organic system.

INTRODUCTION

Although chicken meat production and consumption still rank first, consumers are paying increasing attention to the nutritional value and housing systems of other avian species. This tendency may become an opportunity to increase guinea fowl meat production[1,2]. Guinea fowls meet the poultry production requirements of a diversified eco-agriculture background. They are interesting gallinaceous birds that have been farmed for centuries and very hardy resistant to almost all common diseases affecting chicken[3,4]. Guinea fowl production is profitable in several countries like the United States, Canada, France and Italy[5,6]. Guinea fowl meat is white like chicken meat and is regarded as very lean, has higher protein content, is tender and flavorful, but its taste is more reminiscent of pheasant, without the excessive gamey flavor. Because of all these characteristics, nowadays their meat is popular for health-conscious consumers and has a higher price is more expensive than chicken meat in restaurants in comparison to chickens[7]. Nonetheless, Madzimure et al.[3] stated some of the important attributes of guinea fowl, which include resistance to many poultry diseases and cheap production costs. The information on the meat quality and composition of the various portions derived from these birds that are reared in organic breeding is lacking.

The stressful conditions in the intensive farming of poultry reduce animal welfare and performance causing physiological and metabolic problems[8]. Thereby, consumers of organic products are convinced in their beneficial properties and much better quality in relation to traditionally produced goods[9].

Guinea fowl raising in Turkey before the expansion of the poultry industry may be considered as traditional free-range or organic farming, and the animals reach 1.4-2.1 kg of body weight in 65-91 days[10], because of higher adaptability, that organs and muscles grow in harmony, natural behaviors show up easily, and they have excellent meat quality regardless of different environmental conditions. The low keeping costs have made guinea fowl an excellent poultry species for both local and foreign markets. These birds which were designed for outdoor production have growing periods of at least 94 days according to the European and Turkish organic programs[11,12].

There is a need to diversify the quality characteristics of other poultry species using alternative production methods. Therefore, it may contribute to the research that would lead to the continuation of such current studies. It is known from poultry specialist authorities that the popularity of an organic system of poultry rearing depends more on consumers' knowledge about birds' welfare, their belief in beneficial characteristics of such a kind of products. Actively, the ban of some feed additives (antibiotics, synthetic amino acid and the other artificial agents which are helpful to growing) in poultry feeding and its subsequent associated concerns has revealed efforts to use different plant compounds as possible natural alternatives. A large number of bioactive compounds were reported regarding the structures of plants and essential oils obtained from medicinal and aromatic plants enhancers' digestive support and appetite of birds. The use of these plants in mixed poultry feeds has recently become widespread due to lack of risk

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of releasing residues in animal products and their positive impact on performance in various bird species. On the other hand, it is necessary to investigate natural resources instead of the feed additive substances prohibited in adding into feed can take place. However, the utilization of plants and their extracts is rather limited in the feeding of guinea fowl in practical terms under the organic system[13].

New dietary strategies such as including a plant in the animal's diet may also improve performance and meat quality under an organic system. Oregano (*Origanum vulgare* L.) is known for its antimicrobial[14], anti-fungal[15], insecticidal[16] and antioxidant properties[17]. However, unlike organic chickens, to our knowledge, there is a lack of studies on diet supplementation with oregano focused on the evaluation of meat quality of guinea fowl under organic system, while partial information is available on the performance and meat quality of chickens[18,19,20,21].

In our earlier study, we reported the performance and carcass characteristics of guinea fowls under an organic system[13]. This follow-up study intended to perform a post-slaughter evaluation involving the efficacy of dietary dry oregano (*Origanum vulgare* L.) leaf supplementation on the meat quality characteristics of guinea fowls raised under an organic system. It was hypothesized that meat from guinea fowls fed with an organic diet containing different levels of dry oregano leaves varies in its physico-chemical properties.

MATERIALS AND METHODS

The study was carried out at the experimental farm of Sivas, Turkey, situated at 39°42'24.41"N, 37° 2'4.48"E and 1278 m above sea level. The research study of feeding guinea fowl in the organic systems was dependently conducted accordance with the principles and the regulations of organic farming practices[11] and approved by the institutional committee on animal use (Protocol No: 2013–39).

Guinea fowl eggs were collected from the flock reared at the Turkish Ministry of Forests and Water Affairs' Yozgat Breeding Station. All eggs were collected and transferred to the Gaziosmanpasa University Agricultural Research and Application Center's hatchery on the same day. After a 25-day incubation period, 240 one-day old chicks were randomly selected for use in the experiment. In this research, a total of 240 one-day old (mixed-sex) guinea fowl (*Numidea meleagris*) keets were utilized after weighed and identified with a wing number. Although various sexing methods used for guinea fowl are known[22], the accuracy of sex identification at an early age remains a major problem. Moreover, according to Nahashon et al.[23], guinea fowls do not exhibit sexual dimorphism for growth characteristics. Therefore, sex identification of one-day old keets was omitted in this study. They were divided into four treatment groups each containing 20 chicks and were randomly distributed into 12 mobile shelters (1.5 x 1.5 m) placed in all and sundry the 100 m^2 grazing area. Moving shelters are secure and allow animal access to sunlight and fresh air while allowing them to forage and scratch the ground for food. It is made from wood and includes adequate[11] drinkers, feeders, heater and perch. As reported by Elero lu et al.[13], guinea fowl (*Numidea meleagris*) chicks were randomly allocated to 4 treatments (diets) containing 0 g/kg (control), 5 g/kg (low), 10 g/kg (medium) and 15 g/kg (high) dry oregano (*Origanum vulgare* L.) supplement. During research, all basal feed and water were provided *ad libitum* for all keets. The keets were allowed to go out and graze freely and all basal feed and water were provided between the hours 07.00-19.00 *ad libitum* for all the keets during the experimental period. Natural day length lighting was provided for keets from first days to slaughter age with no additional lighting. Ceramic heaters were used for heating by Far Infrared Rays and do not spread light. Starter (0-28 days), grower (29-56 days) and finisher (57-112 days) diets were formulated to provide adequate levels of all nutrients to guinea fowls (Table 1) in accordance with Blum et al.[24] and Baeza et al.[25]. The certified organic feed materials were used. Creating artificial poultry pasture, *Lotus corniculatus* (50%) and *Bromus inermis* (50%) were used by mixing.

An organically grown herb of oregano was harvested in Sivas/Turkey and the leaves were separated from the twigs. The herb material consisted of leaves that were dried at 70 °C for 48 hours and dry weights were determined. Dry samples were milled and became ready for laboratory analysis. The samples were treated with H_2O_2- HNO_3 acid mixture and burned in a microwave (Mars 6) for S-analysis. Following the digestions, S were then analyzed for their concentrations of Ca, P, K, S, Na, Mg, Al, Zn, Fe, Mn, Cu, B, Ni and Cd with an Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES; Varian Vista) instrument[26]. Nutrient composition of oregano leaves was measured[27] and also total phenolic compounds were determined by colorimeter, using Folin-Ciocalteu method[28].

In order to determine meat quality and properties, 48 birds (fasted for 10 h with free access to water) were slaughtered without stunning under Turkish slaughter procedure (these birds were slaughtered under conditions acceptable to the appropriate ethics committee on 16 weeks) by severing the throat and major blood vessels in the neck in local processing plant in organic system. The carcasses obtained after defeathering and eviscerating were refrigerated at +4 °C for 24 h. Then, the left and right breast muscles were removed from the carcass by an experienced slaughterhouse employee. These muscles were used for physical and chemical analysis. The left skinless breast muscle was used for chemical analysis and stored at -20 °C until analysis. Before the chemical analysis, the chickens were thawed at 4 °C for 48 h.

Water holding capacity (WHC), pH and color were measured in the right part of the skinless breast muscle (*Pectoralis major*) at 24 h postmortem. The pH of breast and thigh muscles from three different points was determined at 2.0 cm depth below the surface by a spear tip probe attached to a Hanna FC202D pH meter. The electrode was calibrated in buffers at between pH 4.00 and 7.00 at room temperature. Color parameter of skinless breast and thigh muscles were measured using a colorimeter (Minolta CR 600, Minolta GmbH, Langenhagen, Germany). The colorimeter was calibrated using the standard white ceramic reference (illuminant C). The average of 5 measurements were recorded for lightness (L*), redness (a*), and yellowness (b*) of the muscle according to the CIELab trichromatic system (CIE, Commission Internationale de l'Eclairage, Vienna, Austria). In order to evaluate the color changes of the breast and thigh meat color readings were taken over 24 h aging time at 4 °C and used to calculate psychometric color terms involving hue angle (hue, Arc tan (b*/a*), chroma (C*, $\sqrt{(a^{*2} + b^{*2})}$) and color difference over time (ΔE*, $(L^{*2}+a^{*2}+b^{*2})^{½}$). The WHC was measured as the method developed in Zayas and Lin[29] and recommended in Hamm[30]. Three 300 mg samples were taken from each group of breast muscles and placed on a 125 mm Whatman filter pa-

Table 1 - Ingredient and chemical composition of the experimental organic diets (g/kg as fed basis).

Ingredients	0–28 days	29–56 days	57–112 days
Maize	354.0	396.0	407.0
Wheat	70.0	54.0	54.0
Soybean meal	281.0	258.0	229.0
Triticale	55.0	67.5	97.5
Rye	12.0	22.0	24.0
Oat	14.0	29.4	31.0
Barley	25.0	25.4	26.0
Wheat Bran	51.8	68.0	68.0
Fish meal	98.0	38.0	19.0
Vegetable oil	11.0	8.5	11.0
Dicalcium phosphate	21.0	17.2	17.2
Limestone	1.7	10.5	10.8
Salt	3.0	3.0	3.0
Vitamin-mineral premix*	2.5	2.5	2.5
Calculated nutrients composition			
ME (MJ/kg of diet)	12.55	12.79	12.98
Dry matter	904.5	920.1	918.5
Crude protein	234.6	195.9	174.9
Crude fiber	43.7	43.4	43.6
Lysine	13.0	11.9	10.2
Methionine + Cystine	6.2	7.1	6.4
Calcium	10.1	9.4	9.0
Phosphorus	8.0	7.7	7.3
Phosphorus available	4.5	4.6	4.5

* Each kg of vitamin-mineral premix contained: vitamin A, 4400000 IU; vitamin D_3, 1600000 IU; vitamin E, 20000 mg; vitamin K_3, 1600 mg; vitamin B_1, 1200 mg; vitamin B_2, 3200 mg; vitamin B_3, 20000 mg; vitamin B_5, 6000 mg; vitamin B_6, 1600 mg; vitamin B_9, 800 mg; vitamin B_{12}, 8 mg; biotin, 80 mg; antioxidant dry, 50000 mg; Cu, 6000 mg; Fe, 20000 mg; Mn, 48000 mg; Se, 80 mg; Zn, 40000 mg; Co, 80 mg; I, 500 mg.

per under constant pressure of 1 kg for 20 min. After photographing the scale using Canon EOS 60D/18-135 Lens, the water spreading area and the meat spreading area were determined in Photoshop CS5. The ratio of the meat spread to the water spread was expressed as the water holding capacity. The concentrations of fat, protein, ash and dry matter (DM) were demonstrated according to the standard procedure of AOAC[27]. The dry matter content was determined by drying at 103 °C for 16 h. The ash content was analyzed after combustion at 600 °C for 24 h. Protein (N x 6.25) was measured by the Kjeldahl method. Fat was analyzed after acid hydrolysis and extraction in Soxtec System.

Fatty acid profile was demonstrated through methyl ester preparation by transmethylation according to the procedure of the TSI[31]. Fatty acid methyl esters (FAME) were analyzed using an Agillent 7890 A gas chromatograph equipped with a flame ionization detector and fused silica capillary column (60 m x 0.25 mm) with 0.25 μm of CP Sil-88. The column temperature was programmed to start at 175°C (maintained for 10 min) followed by a 3 °C /min until it increases to 220 °C (maintained for 20 min). The injection port and detector were maintained at 250 and 280 °C, respectively. The carrier gas was helium and hydrogen (54 mL/min) and the split ratio was 1/50. Identification was accomplished by comparing the retention times of peaks from samples with those of FAME standard mixtures. The peak areas were determined by the CG-300 computing integrator. Fatty acids were expressed as relative percentages of the fatty acids identified.

Data in the tables are presented as arithmetic means and the standard error of mean (SEM). The data were analysed by SPSS 16.0 software for Windows (Inc. Chicago, IL. USA)[32]. The differences between groups were determined by one-way ANOVA test. Duncan's multiple-range tests were performed according to the following model:

$Y_{ij} = \mu + T_i + e_{ij}$

where Y denotes the dependent variable; μ denotes the mean; T is the effect of treatment; and e is the random residual error term. All values were presented as means and standard error mean; the significance levels were set at $P < 0.05$.

RESULTS AND DISCUSSION

The total phenolic content of oregano leaf (dry matter) was 39.15 g gallic acid equivalents (GAE)/kg (Table 2). Regarding the evaluation of the mineral composition of oregano leaf, calcium and potassium concentrations were higher (16773.5 and 16525.3 mg/kg) than the other minerals.

The different levels of oregano leaf to diet of guinea fowl had no effect on L*, a*, b*, Hue (H*), Chroma (C*), ΔE* parameter of the breast and thigh meat ($P > 0.05$; Table 3 and 4). In regard to document findings from the literature review dietary oregano leaf supplementation and its effects on meat quality of guinea fowl have not been investigated under an organic sys-

Table 2 - Oregano leaf nutrient composition.

Analyzed nutrients composition (g/kg)	
Dry matter	966.0
Crude Protein	112.9
Crude fat	19.1
Ash	86.7
Total polyphenols, g GAE/kg	39.15
Analyzed mineral composition (mg/kg)	
Calcium	16773.5
Phosphorus	3575.5
Magnesium	3582.5
Sulphur	2887.6
Potassium	16525.3
Sodium	273.1
Aluminum	365.2
Iron	317.3
Manganese	31.6
Zinc	40.9
Copper	14.5
Boron	33.9
Nickel	7.11
Cadmium	0.40

GAE: gallic acid equivalent

tem. Thus, cross referencing of our findings will be based on data available in the literature regarding other poultry species. As it is well known, meat color is one of the first characteristics noted by consumers and a valuable indicator of quality, especially in boneless products[33]. Genotype and environmental conditions such as feed and housing conditions might affect meat color[34]. The L* value indicates the degree of paleness and is associated with poor meat quality. Pale, soft, and exudative meat is an increasing problem in the poultry industry[8]. Toto-saus et al.[35] reported that chicken breast meat could be divided into three classes of color according to their instrumental L* values causing dark meat (L* < 47), normal meat (L* = 47–50) and pale meat (L* > 50). The L* values found in this study for lightness are considered to be in the normal range and not too pale[7]. Tufarelli and Laudadio[36] studied the breast meat color in guinea fowl broilers fed with different dietary proteins (soybean and faba bean) at 12 weeks of age. They found the mean ranges of L*, a* and b* values among all groups to be 47.03 *vs.* 49.01; 16.15 *vs.* 16.55 and 5.74 *vs.* 5.87, respectively. The same researcher Tufarelli et al.[33] determined the mean L*, a* and b* values of guinea fowl broilers at 12 weeks of age to be between 47.03 and 48.23; 16.15 and 17.19 and 5.74 and 5.61, respectively. In this study, the same parameter (*Pectoralis major*) values were 48.49~51.98, 7.13~7.85 and 16.97~18.31, respectively for guinea fowls raised in a conventional controlled environment housing. This was consistent with previous results, except for a* and b* values.

The breast (*Pectoralis major* and *Pectoralis minor*) and thigh meat (without skin) from the group fed diet with 15 g/kg OV had a higher b* value (18.31, 19.20 and 14.52) in comparison to those from the control (0), 5 and 10 g/kg OV groups. The relatively high values of yellowness of breast and thigh meat, comparatively to different observations reported in the literature, might be due to the access of outdoors, diets and the natural pigments present in the legume-based pasture[37,38]. However, contrary to these reports, Laudadio et al.[39] reported lower L* (47.03 *vs.* 49.21 and 41.78 *vs.* 43.22), higher a* (16.15 *vs.* 16.89 and

Table 3 - The effects of different levels *Origanum vulgare* leaf supplement on guinea fowl meat colour (L*, a*, b*).

		OV (g/kg)					
Parameters		0	5	10	15	SEM[1]	*P*
Breast meat							
	L*	51.98	48.49	48.90	49.70	0.510	ns
Pectoralis major	a*	7.13	7.66	7.17	7.85	0.265	ns
	b*	17.82	17.50	16.97	18.31	0.360	ns
	L*	53.43	51.67	51.21	52.42	0.446	ns
Pectoralis minor	a*	6.94	8.37	7.79	8.32	0.300	ns
	b*	17.31	17.88	17.74	19.20	0.487	ns
	L*	63.65	64.82	62.69	64.59	0.564	ns
With skin	a*	3.44	4.09	4.15	4.01	0.265	ns
	b*	12.65	11.23	12.82	11.77	0.791	ns
Thight meat							
	L*	48.29	47.30	46.66	47.26	0.321	ns
Without skin	a*	9.71	9.59	10.60	11.41	0.281	ns
	b*	12.46	11.92	13.74	14.52	0.627	ns
	L*	59.67	59.87	60.04	59.56	0.568	ns
With skin	a*	1.61	2.19	2.03	1.40	0.188	ns
	b*	5.9667	5.3500	5.4800	5.3267	0.183	ns

[1]SEM: Standard error of the mean; OV, *Origanum vulgare*; ns, not significant (*P* >0.05);
L*: lightness, a*: redness, and b*: yellowness

Table 4 - The effects of different levels *Origanum vulgare* leaf supplement on guinea fowl meat colour (H*, C*, ΔE*).

Parameters		OV (g/kg) 0	5	10	15	SEM[1]	*P*
Breast							
	H*	68.41	66.39	67.16	66.82	0.464	ns
Pectoralis major	C*	19.20	19.10	18.43	19.92	0.421	ns
	ΔE*	55.45	52.12	52.27	53.55	0.497	ns
	H*	68.23	64.79	66.30	66.61	0.766	ns
Pectoralis minor	C*	18.65	19.76	19.42	20.92	0.512	ns
	ΔE *	56.63	55.37	54.77	56.44	0.395	ns
	H*	74.57	70.12	72.00	70.55	1.048	ns
With skin	C*	13.12	11.96	13.51	12.46	0.801	ns
	ΔE *	65.05	65.96	64.18	65.82	0.573	ns
Thigh							
	H*	51.93	50.72	52.38	51.39	1.130	ns
Without skin	C*	15.82	15.36	17.36	18.50	0.610	ns
	ΔE *	50.84	49.76	49.78	50.81	0.272	ns
	H*	75.40	67.73	69.55	75.78	1.804	ns
With skin	C*	6.21	5.79	5.85	5.53	0.196	ns
	ΔE *	60.00	60.16	60.33	59.82	0.556	ns

[1]SEM: Standard error of the mean; H* (Hue)=Arc tan (b*/a*); C* (Chroma)= $\sqrt{(a^{*2} + b^{*2})}$; $\Delta E^*=(L^{*2}+a^{*2}+b^{*2})^{½}$); ns, not significant (*P* >0.05).

17.04 *vs.* 18.89) and lower b* (5.74 *vs.* 5.96 and 2.11 *vs.* 2.23) values of breast and thigh of guinea fowl broilers (12 weeks of age) fed with a soybean meal-based control diet and dehulled-micronized pea meal in a commercial poultry facility. The findings of this study were inconsistent with the findings of Mohamed et al.[40], while they found that breast meat from guinea fowl was lighter (52.27~59.22) and redder (11.94~13.39) under a typical poultry intensive pen system. In contradiction, Musundire et al.[7] illustrated that a* and b* values of breast meat under a communal scavenging production system with the age of 6 months were 14.4 and 6.45, respectively. Besides, in this study, the skinless breast and thigh meat had a higher L* and lower a* and b* values than the breast and thigh meat with skin. The breast (*Pectoralis major* and *Pectoralis minor*) muscles of the control group had a numerically higher (*P* >0.05) hue value (68.41 and 68.23) and ΔE* value (55.45 and 56.63) in comparison to those of the 5, 10 and 15 g/kg OV groups. Likewise, the breast (*Pectoralis major* and *Pectoralis minor*) and thigh muscles of the 15 g/kg OV group were numerically higher (19.92, 20.92 and 18.50) than those of the control (0 g/kg), 5 and 10 g/kg OV groups (*P* >0.05). It could be important to note that the ΔE* value is an indicator of the total color difference[8].

The pH value of breast, thigh meat and the WHC value of breast meat were not affected by treatment groups during the organic feeding trial (*P* >0.05; Table 5). The pH value of breast (*Pectoralis major*, *Pectoralis minor*) and thigh muscles were changed as 5.64~5.71, 5.70~5.78 and 6.11~6.18 at 24 h, respectively. These values of breast were lower than the values relative to guinea fowls in another study (5.94~6.12) carried out by Mohamed et al.[40].

In this study, the pH values of breast meat were in good agreement with those in a previous study by Tufarelli and Laudadio[36] who found these values as 5.72 and 5.69 for the soybean and faba bean groups, respectively. Laudadio et al.[39] and Tufarelli et al.[33] also found that the pH value of breast meat ranged from 5.70 to 5.72 and 5.72 to 5.76, respectively. The pH of the muscles is stabilized at a value that is called the ultimate pH, usually between 5.7 and 5.9 in poultry[41]. The WHC of different levels of OV groups' breast meat ranged from 0.29 to 0.32. Previous studies on beef and chicken[35,38] showed an association between the ultimate pH and WHC; particularly, the meat with higher ultimate pH value usually had higher WHC. In this study, therefore, no differences in pH values showed similar WHC values among the groups. The differences in the results that were obtained by some researchers[33,39,40] for the WHC values could be associated with the differences in the reference method that was used specificity of guinea fowl meat or post mortem conditions such as pH change.

Regarding the evaluation of the chemical characteristics of breast meat showed almost the same values of all nutrient composition among groups (*P* >0.05; Table 5). Chicken and turkey muscles contain about 75 g of water (per 100 g of raw meat), while the guinea fowl meat is a drier (69 g and 73.3 g) meat as reported by Cerioli et al.[42] and Favier et al.[43]. This content varies little between the breast and drumstick or thigh meat whatever the bird species is[44].

While some researchers[42,44] claimed that guinea fowl meat is richer in protein than other poultry species (turkey, chicken, quail) with an average protein content of 25.8 g per 100 g muscle, Hamm et al.[30] found a lower value as 21 g. This fact implies that guinea fowls may be a valuable alternative to traditional chickens as a protein source. The content of dry matter in the breast meat of guinea fowl in our study was consistent with previous reports where guinea fowl broilers[33,36] were fed faba bean and lupin-based diets. Furthermore, the dry matter values of this study were in agreement with those recently observed by Penkov et al.[45] who found that these were in the range of 27.08%

Table 5 - The effect of *Origanum vulgare* leaf supplement on physico-chemical composition of in Guinea fowl meat.

Parameters	OV (g/kg) 0	5	10	15	SEM[1]	*P*
Physical characteristics						
Breast *P. major* pH	5.64	5.67	5.68	5.71	0.02	ns
Breast *P. minor* pH	5.75	5.78	5.70	5.74	0.01	ns
Thigh pH	6.11	6.16	6.18	6.17	0.04	ns
Breast WHC, %	0.29	0.31	0.30	0.32	0.01	ns
Breast meat composition						
Dry matter, %	27.59	27.03	27.43	27.16	0.10	ns
Protein%	25.86	25.42	25.66	25.31	0.27	ns
Fat, %	0.68	0.53	0.70	0.77	0.06	ns
Ash,%	1.05	1.08	1.07	1.08	0.02	ns
Fatty acids						
SFA, %	38.15	39.04	37.36	38.17	0.38	ns
MUFA, %	22.96	24.00	22.11	22.61	0.52	ns
PUFA, %	35.54	35.35	36.39	35.96	0.44	ns
UFA, %	58.50	59.36	58.50	58.57	0.46	ns

[1]SEM, Standard error of the mean, SFA, saturated fatty acids, MUFA, mono unsaturated fatty acids, PUFA, poly unsaturated fatty acids; UFA, unsaturated fatty acids (mono unsaturated fatty acids + poly unsaturated fatty acids); WHC, water-holding capacity; OV, *Origanum vulgare;* ns, not significant (*P* >0.05).

to 28.82% in different durations (at 16, 20 and 24 weeks of age) of the fattening period of poultry raised in a free-range, semi-intensive production system. Moreki et al.[46] also stated that the dry matter in guinea fowls fed on compound forages containing sorghum ranged between 25.77% and 29.39% at the age of 6-12 weeks, respectively. Additionally, this result was inconsistent with those reached by Saina[47] who reported the dry matter content of guinea fowl meat under intensive and semi-intensive management systems to be 22.9% and 26.1%, respectively.

The protein values obtained in this study for breast muscles were higher (25.31%~25.86%) than those reported by several studies[7,33,36,39,48]. The high protein content in the breast could be due to larger fibers that imply less cellular membrane, making the protein more concentrated. Guinea fowl meat could therefore be nutritionally favorable because of this low-fat and high protein content, which supports the findings of Say[49] and Ayorinde[50]. The values of protein for breast muscles were closer to the findings of Penkov et al.[45], who found these to be 22.92% to 24.54% on average in breast muscles. However, the protein content of the meat could be influenced by species, age, carcass parts and breeding systems[7].

The content of fat in breast meat was incomparable to those found by Tlhong[48], Moreki et al.[46], Penkov et al.[45] and Tufarelli and Laudadio[36] who reported the fat contents as 2.26% at 15 weeks; 2.18% at 6 weeks to 2.99% at 12 weeks; 5.93% at 16 weeks, 6.55% at 20 weeks, 4.94% at 24 weeks, 1.84% *vs.*2.09% (soybean *vs.* faba bean) at 12 weeks, respectively. Tejerina et al.[51], however, established that the fat content in breast muscles of this bird species was 1.10% *vs.* 0.92 in confinement *vs.* free-range systems. Furthermore, Musundire et al.[7] showed a closer fat content value averaging 0.85% in guinea fowl breast meat, which was lower than that in chickens. In the light of the results that were found a lower intramuscular fat content and higher protein content of breast muscles in guinea fowls were observed under an organic system. Some researchers[7,39,48,51] emphasized that the ash content in breast muscles of guinea fowl was 1.01%; 1.09% *vs.* 1.14 (in confinement *vs.* free-range systems); 0.89% *vs.* 1.05% (soybean *vs.* pea) and 0.9%, respectively, which were close to our results. Moreki et al.[46] reported a higher ash content value averaging 2.56% at 6 weeks to 5.54% at 12 weeks of age in guinea fowl breast meat. Moreover, the ash content in this study was lower than those reported by Tufarelli and Laudadio[36], Tufarelli et al.[33] and Penkov et al.[45]. Factors such as slaughter age, nutrition and production system contribute to these variations.

The fatty acids (FA) profiles of breast muscle when birds at 16-week-old of age were fed the different level dietary oregano leaf reported a similar fraction of total saturated FA (SFA), monounsaturated FA (MUFA), polyunsaturated FA (PUFA) and unsaturated FA (UFA) (*P* >0.05) when compared to those fed a diet control (Table 5). There are however, little published data on the fatty acid contents of guinea fowl breast meat, and similarly, no comparative information on the effect of oregano leaves or their products on the fatty acids in the meat under organic production. The content of SFA that was determined in our study (ranged from 37.36% to 39.04%) was higher (21.83 to 24.5%) than in the fat of breast muscles from slow growing chickens of different genotypes under an organic system studied by Elero lu et al.[8]. The mean values of SFA and PUFA that were recorded in this study for breast muscles were higher than those reported by Tufarelli et al.[33] in the guinea fowl broiler genotype at the age of 12 weeks (26.78~24.99 and 32.92~35.95), by Tufarelli and Laudadio[36] in guinea fowl broilers at the age of 12 weeks (26.78~23.96 and 32.92~35.28), which may be attributed to access to pasture and the difference in feed composition. Indeed, the organic production of meat containing high levels of PUFA is of considerable interest, because PUFA is considered to be a functional ingredient capable of reducing the incidence of coronary heart disease and other chronic diseases in humans[39]. The MUFA content (22.11%~24.0%) of the breast muscles from the analyzed guinea fowl was lower (36.67% to 39.15%) than those found in slow-growing chickens, whereas PUFA content (35.35% to 36.39%) was slightly higher (31.81 to 36.43%) than that found for slow-growing chickens studied by Elero lu et al.[8]. The PUFA contents of 60.97% of total UFA in this study for breast muscles was higher than that (47.6%) reported by the same researchers. The meat of guinea fowls compared to commercial genotypes under a conventional system was characterized by a high concentration of total PUFA both in the total content and in different fractions (n-3 and n-6 FAs). The high level of PUFA may be an advantage of guinea fowl meat in terms of the nutritional value of the species. Bernacki et al.[2] explained that the PUFA and UFA of 14-week-old white and grey guinea fowl breast muscles were 36.2% and 37.2%; 56.5% and 57.2%, respectively in confinement under a controlled environment. However, Laudadio et al.[39] noted that guinea fowls tend to have a greater content of n-3 FA in their meat than broiler chickens. The higher numbers of very long-chain n-3 PUFAs may be explained by the fact that guinea fowl meat has more phospholipids, and very long chain n-3 PUFAs are preferentially incorporated into phospholipids *vs.* triglycerides. The fatty acid content of animal muscles depends on breed, the content of external and internal fat, climate, nutrition and housing conditions[2,52].

CONCLUSIONS

In conclusion, to our best knowledge, this was the first study that evaluated the effects of oregano leaf in guinea fowl feeding under an organic system. The present feeding trial demonstrated the dried oregano leaves at levels ranging from 5 to 15 g/kg feed had no negative effect on improving the meat quality of the organically produced guinea fowl meat. The guinea fowl is one of the favorable poultry species to breeding under organic systems. Breast muscle fat from guinea fowl was characterized by a higher content of UFA in comparison to SFA, with a predominance of PUFA over MUFA. Moreover, organic diets with pasture enriched guinea fowl meat with protein and PUFA, thereby improving their nutritional value and offering a valid alternative way for enhancing the quality and marketability of guinea fowl meat. Further larger scale studies, comparing with other poultry species and different breeding systems, are therefore needed to extend the present work.

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AUTHOR'S CONTRIBUTION

AY and HE conceived and designed the study, AY and MD conducted the analyses. AY, HE, and MD drafted the manuscript. AY, HE, and MD contributed to the data collection. All authors read and approved the final manuscript.

CONFLICT OF INTEREST STATMENT

The authors declare that they have no competing interests.

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