JWPR

Journal of World's Poultry Research

2022, Scienceline Publication

J. World Poult. Res. 12(3): 171-180, September 25, 2022

Research Paper, PII: S2322455X2200020-12

DOI: https://dx.doi.org/10.36380/jwpr.2022.20

The Impacts of Locally Cultivated Herbs on Physical Parameters and Meat Quality of Broiler Chickens

Roger Al Hanna[1,2*]

[1]*University of Forestry, Sofia, Faculty of Veterinary Medicine, Department of Animal Science, Bulgaria*
[2]*Lebanese University, Faculty of Agriculture Engineering and Veterinary Medicine- Department of Animal Production, Lebanon*

Corresponding author's E-mail: hanna_roger@hotmail.com

Received: 18 July, 2022
Accepted: 03 September, 2022

ABSTRACT

Herbs greatly influence broiler chickens' performance and may alternate the use of antibiotics in the poultry sector. The study investigated the effects of local natural herbs on Ross 308 broiler chickens' physical characteristics and meat quality. A total of 702-day-old broiler chickens were divided into two trials consisting of 13 treatment groups fed 11 diets. Treatments included control groups (CGIa and CGIb); Basal diet (BD) free of antioxidants and antibiotics, and CGIIa, CGIIb; BD complemented with antioxidants and antibiotics, and experimental groups (EG); EGIII (1% peppermint + BD), EGIV (1% thyme + BD), EGV (0.5% peppermint + 0.5% thyme), EGVI (1% rosemary + BD), EGVII (1% chamomile flowers + BD), EGVIII (0.5% rosemary + 0.5% chamomile), EGIX (1% onion powder + BD), EGX (1% garlic powder + BD), and EGXI (0.5% onion powder + 0.5% garlic powder). Maximum and minimum feed intake averages were in EGV and EGIII (94.90 and 77.74 kg/group, respectively). Live body weight gains of both EGVI and CGIIa were significantly higher than EGIV, EGVIII, and CGIa. Chicks of EGVIII showed the lowest net weight percentage in relation to live body weight (carcass yield). Breast meat pH ranged between 5.26 and 6.14 (in EGVII and EGIV, respectively) 24 hours after cooling, and between 5.86 and 6.11 (in CGIa and EGVI, respectively) one month after freezing. Breast meat lightness was significantly higher in EGVI than EGVIII at 24 hours after cooling, and it was the highest in EGVI 1 month after freezing. Breast meat redness was the highest in CGIIa at 24 hours after cooling. EGIX showed a significantly higher redness value one month after freezing than EG X, CG Ib, and CG IIb. Yellowness ranged between 7.58 and 13.54 for EGX and CGIa, respectively, 24 hours after cooling, and between 8.29 and 13.95 a month after cooling for EGX and EGV, respectively. Tested herbs had comparable effects to antibiotics on chicken growth and meat quality. Rosemary (1%) had an ameliorative effect on chickens' body growth. Chamomile (1%) as well as thyme and peppermint mix (0.5% each), improved the palatability for feed.

Keywords: Broiler chicken, Chamomile, Garlic powder, Onion powder, Peppermint, Rosemary, Thyme

INTRODUCTION

The poultry industry's current goals are to improve the well-being of chickens and reduce the negative environmental effects. Regarding price and organoleptic qualities, broiler meat ought to be of adequate nutritional quality and palatable to the majority of consumers. Chick's growth and/or laying capacity augmented, the diseases were reduced and prevented, and the feed exploitation improved due to the use of feed additives. However, these additives were mainly antioxidants, antimicrobials, emulsifiers, enzymes, and pH control agents in poultry diets. Criticism is being directed at the use of antibiotics as growth enhancers, as reported by Iji et al. (2001) and Issa and Abo Omar (2012). Antibiotic resistance limits the use of antibiotics in microorganisms and drug residues in meat (CAFA, 1997). The elimination of antibiotics from chicken diets led to poor performance and increased susceptibility to diseases. Therefore, efforts were undertaken to discover other solutions to these problems. The European Union (EU) has also prohibited the use of antibiotics as growth promoters (Castanon, 2007), and research was done to find effective alternatives

To cite this paper: Al Hanna R (2022). The Impacts of Locally Cultivated Herbs on Physical Parameters and Meat Quality of Broiler Chickens. *J. World Poult. Res.,* 12 (3): 171-180. DOI: https://dx.doi.org/10.36380/jwpr.2022.20

for use in chicken. In case of poor management, herbs and herb extracts showed promise as natural feed additives and alternatives in flocks (Cross et al., 2003; Lewis et al., 2003; Hernandez et al., 2004) and have antioxidative and antibacterial effects on animals (Odoemelam et al., 2013). For instance, rosemary (*Rosemarinus officinalis*) has antimicrobial properties and stimulating effects on the digestive system (Al-kassie, 2008). The presence of thymol and carvacrol Thyme (*Thymus vulgaris*) has antibacterial and antioxidant properties (Wareth-Abdel et al., 2012). Active compounds of chamomile (*Matricaria chamomilla*) flowers increase resistance against microorganisms and improve final body weight gain (Mahmmod, 2013). Peppermint (*Mentha piperita*) added to basal diets enhanced feed conversion and broiler appetite (Ocak et al., 2008). Onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) plant parts contain compounds that have antibacterial and antifungal properties (Goodarzi, 2013). Poultry production is one of the major components of the Lebanese agricultural sector (Darwish, 2003), and antibiotic use is needed to reduce production costs and produce healthier meat to meet European standards. Therefore, the current research aimed to investigate the effects of feeding broiler chickens with peppermint meals, rosemary, chamomile, thyme, garlic, and onion powders on performance, carcass traits, breast cuts, and physical quality during the growing period.

MATERIALS AND METHODS

Ethical approval

The research was approved by the Bioethics Committees of the Lebanese University, Faculty of Agriculture, Department of Animal Production, and the University of Forestry, Sofia, Bulgaria. and strictly conformed with the internationally accepted standard ethical guidelines for laboratory animal use and care as described in the European Community guidelines; EEC Directive 86/609/EEC, of November 24, 1986.

Population under test

A total of 702 one-day-old unsexed broiler chickens (Ross 308 breed) were used for 31 days in an opened poultry house in Lebanon. From day one to day 10 of age, chicks were placed under an artificial gas brooder located at a height not exceeding 1 m above floor level. A circular cardboard guard of 40 cm in height was used to keep the chicks inside. Chicks were receiving continuous light for 24 hours. The house was supplied with 75W Tungsten pulp lamps and adjusted to achieve light intensity between 5-10 lux at floor level.

The experiment consisted of two trials conducted at two different timings; the first trial on 432 chickens and the second trial on 270 chickens. In both trials, chicks were exposed to the same experimental conditions. The first trial investigated the effects of peppermint, thyme, chamomile, and rosemary, whereas the second one studied those of garlic powder and onion powder. In the first trial, chicks were randomly distributed among eight separate groups (treatments) of 54 chicks each and three replicates per group (18 chicks in each replicate). In the second trial, they were divided into five distinct groups (treatments) of 54 chicks each and three replicates per group (18 chicks in each replicate). Each group was provided approximately 5 m^2 of floor space.

All chicks were vaccinated against Gumboro disease (at days 10 and 20) via drinking water within two hours after the chickens were kept thirsty (Nobilis® Gumboro D78, MSD, Netherlands). Moreover, chickens were vaccinated against Infectious Bronchitis disease (Nobilis® IB Ma5, MSD, Netherlands) via drinking water (on day 15) and against Newcastle disease (Newcastle Disease Vaccine N-63, MSD, Netherlands) via drinking water (on day 20).

Feeding at starter period

During the starter period, all chicks received the same starter basal ration of commercial broiler starter diet (230 g CP/kg and 13.1 MJ ME/kg, Table 1) labeled and guaranteed by the manufacturer based on yellow corn-soybean meal mixture mash for 19 days (starting period) with neither addition of antibiotics and antioxidants nor herbs and spices.

Feeding at grower period

From day 20 to day 31, chicks were fed a commercial broiler grower diet (210 g CP/kg and 13.4 MJ ME/kg, Table 1) supplemented or not with the predefined herbs. Basal diets (BD) were formulated to meet minimum nutrient requirements established by the NRC (1994). Therefore, trial one consisted of eight treatment groups, including control groups (CGIa: BD free of antioxidants and antibiotics, and CGIIa: BD supplemented with antioxidants and antibiotics), and experimental groups (EGIII: 1% peppermint + BD, EGIV: 1% thyme + BD, EGV: 0.5% peppermint + 0.5% thyme, EGVI: 1% rosemary + BD, EGVII: 1% chamomile flowers + BD and EGVIII: 0.5% rosemary + 0.5% chamomile).

Trial II consisted of five groups, including control groups (CGIb: BD free of antioxidants and antibiotics, and CGIIb: BD supplemented with antioxidants and antibiotics) and experimental groups (EGIX: 1% onion powder + BD, EGX: 1% garlic powder + BD, and EGXI: 0.5% onion powder + 0.5% garlic powder).

Recorded indicators

Live body weight gain (LBWG) of chicks was recorded every time the feeding phase was changed using a digital balance (± 0.01g): at 19 days of age, marking the end of the growing period, and at 31 days, referring to the end of the finishing period on the total number of chicks of each group, then the average value of LBWG was calculated for each group. Feed intake (FI) was recorded to calculate feed conversion ratio (FCR) as follows: FCR=FI/LBW.

From each replicate of each group, three chicks aged 31 days of age were selected and left to fast for 24 hours and then weighed before and after slaughter, where they were left to completely bleed, after which the feather was manually plucked, and the troops eviscerated to obtain the net weight to live body percentage (Ragaa et al., 2016).

Post mortem breast muscle pH was measured at the two-time interval, 24 hours after cooling (4ºC) and a month after freezing at (-5ºC) using a portable pH meter (Adwa AD 131 Ph/mV Meter), equipped with a Piercing Tip Micro Probe. Each sample was measured in triplicate by direct insertion of the probe at 1-inch-deep in the muscle, and the average pH value was calculated for each treatment.

A whole piece of breast meat was evaluated for color in triplicates at 24 hours after cooling (4ºC) and 1 month (-5ºC) after freezing using the Hunter Lab colorimeter (ADCI-60-C instrument). The color of the breast meat was evaluated using the CIE color system, including L* (lightness), a* (greenness and redness), and b* (blueness and yellowness). All measurements were carried out on the surface of the scallop, in an area free of color defects (bruises, blood spots, and hemorrhages).

Left raw breast muscles were individually weighed at 24 hours post mortem, then they were reweighed after blotting dry by a paper towel. The samples were then placed in sealed polyethylene plastic bags, vacuum-packaged, and stored in a chiller at 4°C. The drip loss was calculated as a percentage relative to the initial muscle weight.

Drip loss (%) = ([Weight before treatment - weight after treatment] / weight before treatment) x 100.

Statistical analysis

One-way analysis of variance was conducted using “statistical 10 software” to evaluate significant differences between treatments and replicate means. The significance level was set at $p < 0.05$. The means (X) and standard deviation are used to display the results (SD).

Table 1. Recommended composition and nutrient content of the basic commercial diet

Nutrient	Starter diet (0-19 days of age)	Grower diet (20 to 31 days of age)
Energy (Kcal)	3100	3200
Protein (%)	21.5	19.5
Calcium (%)	0.87	0.79
Phosphorus (%)	0.435	0.395
Sodium (%)	0.16-0.23	0.16-0.20
Methionine (%)	0.51	0.47
Methionine+ cysteine (%)	0.99	0.91
Lysine (%)	1.29	1.16
Vitamin E (mg)	65	55
Vitamin B2 (mg)	6.5	5.4
Vitamin B12 (mg)	0.017	0.011

The diet is balanced based on NRC (1994), and recommendations of Ross 308 guideline (Aviagen, 2014)

RESULTS AND DISCUSSION

Daily observations revealed no health issues with the chicks. The chickens had strong legs, good size, and no signs of illness or inadequate nutrition. Among the 702 studied chickens, a total of 55 (7.83%) mortalities were recorded. However, a remarkable mortality rate was recorded in EGX (25.45%), where the diet fed to the chickens was supplemented with garlic. EGVII, EGVIII, CGIb, and CGIIb showed the lowest mortality rate (1.82%), followed by EGV (3.64%), EGIII, EGIV and CGIa (5.45%), CGIIa (7.57%), EGVI (10.91%), EGXI (12.73%), and EGIX (14.55%). Since all chickens were fed the same basic diet free of antibiotics and antioxidants, management and breeding practices can be blamed for the mortality rate. According to Yassin et al. (2009), management parameters adopted at breeder farms, including the breeder age, strain, and feed company, and at hatcheries, such as the management of egg storage and hatching, are related to mortality at broiler farms. Besides, the quality of the day-old broiler directly impacts a chick's chance of survival. Different factors affect the quality of day-old chick, such as breeder age and genetic line, egg storage conditions and weight, and incubation conditions (Decuypere et al., 2001; Tona et al., 2004).

The collected data showed that combining peppermint with thyme (EGV) resulted in the highest FI (94.90 kg/group, Table 2). Feed intake was also high (92.29 kg/group) when the chickens were fed with chamomile (EG VII). Moreover, chickens of groups EGIII, EGIV, and EGX showed the lowest values of FI (77.74, 77.87, and 77.89 kg/group, respectively). Feed conversion was inferior in EGX (1.72) and EGXI (1.68), compared to the remaining groups. The most effective FCR values were in EGIV (1.29) and EGVI (1.3). At the end of the starter period (19 days old), the average feed intake (FI) of the chickens was 657.14 g/chicken. The chickens' appetite was consistent among all groups.

Table 2. Feed intake and feed conversion ratio at 1-31days of age in Ross 308 broiler chickens

Group	Feed intake (kg)	Feed conversion ratio
EGIII (1% peppermint + BD)	77.74	1.36
EGIV (1% thyme + BD)	77.87	1.29
EGV (0.5% peppermint + 0.5% thyme)	94.90	1.59
EGVI (1% rosemary + BD)	83.02	1.30
EGVII (1% chamomile flowers + BD)	92.29	1.63
EGVIII (0.5% rosemary + 0.5% chamomile)	88.21	1.53
EGIX (1% onion powder + BD)	80.92	1.50
EGX (1% garlic powder + BD)	77.89	1.72
EGXI (0.5% onion powder + 0.5% garlic powder)	86.92	1.68
CGIa (BD free of antioxidants and antibiotics)	88.49	1.54
CGIb (BD supplemented with antioxidants and antibiotics)	88.35	1.49
CGIIa (BD free of antioxidants and antibiotics)	82.89	1.51
CGIIb (BD supplemented with antioxidants and antibiotics)	79.69	1.41

BD: Basal diet, CGI: Control groups in trial I, CGII: Control groups in trial II, EG: Experimental group

These findings are at odds with those of Langhout (2000), Kamel (2001), Williams and Losa (2001), and Hernandez et al. (2004), who claimed that increased feed intake is attributed to the enticing effects of borneol, the active ingredient of rosemary. However, Panda (2005), Santurio el al. (2007), and Windisch et al. (2009) supported the findings of the current study by reporting that chamomile enhances FI because of its active components; coumarin glycosides, azulene, flavonoids, and fatty acids possess sedative, anti-inflammatory, antiseptic, and carminative activities. Improvement of LBWG and FCR for chickens fed diets containing one percent each of peppermint and rosemary was consistent with those reported by Al-Kassie (2008). It also supports the findings of Ertas et al. (2005), who found that adding 200 ppm of an essential oil mixture made of oregano, clove, and anise to broiler feed increased LBW and FCR in comparison to control groups. Rahimi et al. (2011) claim that thymol, carvacolo, borneol, and geraniol, the volatile components of thyme, increase enzymes and endogenous hormones' secretion, which in turn affect broiler performance when plant extracts are added (amylase and chymotrypsin). This will increase the intestine's absorption rate, which will benefit the FCR (Feizi et al., 2013). According to Amouzmehr et al. (2012), the broilers' performance in terms of feed intake, weight gain, and feed conversion ratio were unaffected by the addition of thyme. According to Goodarzi et al. (2013), diets supplemented with onions decreased feed conversion compared to those supplemented with antibiotics.

The highest numerical results concerning LBWG (Figure 1) were obtained in EGVI supplemented with rosemary and CG IIa, where antibiotics and antioxidants were added to the basal diet. LBWG results of both groups were significantly higher ($p < 0.05$) than EG IV (1061.41 ± 63.82 g), EG VIII (1048.3 ± 30.36 g), CG Ia (1073.1 ± 191.25 g). This may be because the active substances in rosemary green meal inhibit the overgrowth of harmful intestinal microorganisms and increase the activity of the thyroxin hormone, which speeds up the biochemical reactions and metabolites of nutrients (Mahmmod, 2013). These effects have a positive impact on the health and productivity of poultry. This confirms the findings of Kolacz et al. (1997), Al-Kassie (2008), Osman et al. (2010), and Sarker et al. (2010), which demonstrated an improvement in LBW as a result of the primary ingredients of herbs and essential oils, responsible of the majority of the antimicrobial activity (Abaza, 2003; Cross et al., 2007). Additionally, Spernakova et al. (2007) observed that the addition of rosemary powder at 500 mg/kg in the poultry diet resulted in a larger body weight gain.

Carcass yield in EGVIII was significantly lower ($p < 0.05$) than in all remaining groups (around 63.77%, Figure 2). For the edible organs and carcass yield, the result of this experiment matched those of Sarica et al. (2005), indicating that the effects of the supplementation of thyme powder did not significantly differ on the weights of internal organs, such as heart and liver.

Breast meat pH 24 hours after cooling and one month after freezing were assessed for all the studied groups, and the results are reported in figures 3 and 4, respectively. There was a remarkable significant difference ($p < 0.05$) in meat pH 24 hours after cooling at the level of EGVII whose chickens were fed a basal diet supplemented with chamomile, with pH (5.26 ± 0.16) being the lowest among all groups. It is well-known that chicken carcasses' pH changes during rigor mortis. Glycolysis, lactic acid production, and muscle oxygen liability reduction all contribute to the abrupt pH drop. This outcome is consistent with Schreurs (2000) findings. According to Olivo (1999), a low rate of pH fall throughout the slaughter process shows that the animals are not under stress, which is frequently correlated with increased meat softness (Ali et al., 1999). As shown in Figure 4, there were no significant differences in pH across the tested groups a month after freezing, which is consistent with the research conducted by Sang-Oh et al. (2013), who found that the pH of chicken flesh did not alter significantly among groups fed various herb extracts.

Lightness (L*), redness (a*), and yellowness (b*) were all assessed for the experimental groups 24 hours after cooling and a month after freezing.

Lightness measured 24 hours after cooling of EGVIII (51.13 ± 2.76) whose chickens were fed with a basal diet supplemented with a combination of rosemary and chamomile was significantly lower ($p < 0.05$) than the lightness of EGVI where rosemary was added only to the basal diet of the chickens (58.43 ± 1.9, Figure 5). After 1 month of freezing, EGVI showed a high L* value (53.43 ± 1.73), significantly differing from EGX (45.9 ± 0.43), EG XI (46.46 ± 0.58), CG Ib (46.24 ± 0.66), and CG IIb (46.32 ± 0.57, Figure 6). Moreover, EG X and EG XI showed significantly lower L* values (4.59 ± 0. 43; 46.46 ± 0.58), respectively, as compared to EGVI (53.43 ± 1.73), CGIa (52.33 ± 0.07), and CGIIa (51.62 ± 0.17). In addition, CGIa (52.33 ± 0.07) and CGIIa showed higher significantly different L* values than CGIb (46.24 ± 0.66) and CGIIb (46.32 ± 0.57, $p < 0.05$).

Obtained results of redness measured at 24 hours post mortem did not differ significantly among all the treatments ($p < 0.05$, Figure 7). However, the highest redness value was obtained in the positive control group CG IIa (8.33 ± 0.1), whereas the lowest values were in EGVII (6.39 ± 0.5) and EGVIII (6.39 ± 0.2). The chickens of EGIX showed a significantly higher ($p < 0.05$) a* value (9.91 ± 0.91) than EGX (6.57 ± 052), CGIb (7.25 ± 0.68) and CGIIb (7.1 ± 0.73). Moreover, a* value obtained for EGX was significantly lower ($p < 0.05$) than those of EGIX (9.91 ± 0.91), CGIa (9.37 ± 0.19, and CGIIa (10.27 ± 0.31) as shown in Figure 8.

As for yellowness, chickens belonging to EGIX (8.95 ± 0.51), EGX (7.58 ± 0.7), EGXI (8.31 ± 0.56), CGIb (8.41 ± 0.51) and CGIIb (8.45 ± 0.42) showed significant differences when compared to EGIII (12.9 ± 0.24), EGIV (12.1 ± 0.08), EGV (12.41 ± 0.19), EGVI (12.84 ± 0.03), EGVII (13.62 ± 0.06), EGVIII (12.07 ± 0.06), CGIa (13.54 ± 0.22) and CGIIa (11.57 ± 0.65, Figure 9).

According to yellowness variation, samples frozen for 1 month significantly differed from each other ($p < 0.05$, Figure 10). Chickens of EGV showed a significantly higher ($p < 0.05$) b* value (13.95 ± 0.15) than EGVIII (10.93 ± 0.68), EGIX (10.87 ± 0.45), EGX (8.29 ± 0.55), EGXI (9.27 ± 0.59), CGIb (9.01 ± 0.34) and CGIIb (9.00 ± 0.44). Moreover, yellowness of EGX (8.29 ± 0.55), EGXI (9.27 ± 0.59), CGIb (9.01 ± 0.34) and CGIIb (9.00 ± 0.44) were significantly lower ($p < 0.05$) than b* of EGIII (12.7 ± 0/06), EGIV (12.58 ± 0.32), EGV (13.95 ± 0.15), EGVI (12.91 ± 1.11) and EGVII (12.88 ± 1.27).

One of the main criteria used to assess the quality of meat is the color of the flesh, a sensorial quality that highly influences the consumers' acceptance of meat (Listrat et al., 2016). Lightness value is particularly significant in white muscles and is connected to pH and drip loss. Lightness value is the primary factor influencing the color of poultry flesh, according to Barbut (1997). The ideal lightness range (L*) for poultry fillets is between 49 and 50. While fillets with values above that range are lighter in color and have low pH (pH 5.6), those with values below that range are darker and have high pH (pH > 5.9). In the current study, among color indicators, only a*(redness) was affected by herbs added to the diet; at 24 hours after cooling, it was lower than control (CGIIa) following the addition of peppermint, thyme rosemary and chamomile, and one month after freezing it was higher than control (CGIb and CGIIb) following the addition of onion powder to the diet. Earlier, Tashla et al. (2019) reported a non-significant difference in meat color (L*, a *, and b*) as a result of diet supplementation with garlic. On the other hand, Kirkpinar et al. (2014) found that diet supplementation using garlic oil did not affect the pH and yellowness of breast meat, but it significantly decreased its meat's lightness. Keokamnerd et al. (2008) reported non-significant changes in meat redness due to dietary supplementation with rosemary. Supplementation of diets with thyme oil significantly affected redness values but did not affect the lightness and yellowness of breast fillets (Aksu et al., 2014). It was reported that the effects of supplementation of *Echinacea purpurea*, *Nigella sativa*, and their combined application on the meat color of broiler chickens are lower in L* than the control group (Nasir, 2009). Barbut (1997) found that L* (lightness) value was significantly higher in the cinnamon powder groups than in the control group, but there was no significant difference in a* (redness) and b* (yellowness) values among groups. Overall, the variation between L* and a* and b* values reflect the broad distribution of muscle pH values and myoglobin content in broiler breast meat, respectively (El Rammouz et al., 2004).

Drip loss measured 24 hours after cooling showed that chickens belonging to EGIV was significantly ($p < 0.05$) lower (1.6 ± 0.02%) than EGIII (3.17 ± 0.04%), EGV (3.24 ± 0.05%), EGVI (2.94 ± 0.12%), EGVII (3.4 ± 0.05%), CGIa (2.63 ± 0.07%) and CGIIa (3.16 ± 0.07%). EGVII whose chickens received chamomile as feed additive showed a significantly ($p < 0.05$) higher (3.4 ± 0.05%) yellowness than EGIV (1.6 ± 0.02%), EGVIII (2.28 ± 0.13%), EGIX (2.37 ± 0.3%), EGX (2.3 ± 0.47%), EGXI (1.8 ± 0.2%), CGIb (2.15 ± 0.17%) and CGIIb (2.1 ± 0.26%). The present result contradicted the findings of Begum et al. (2014) who postulated that drip loss did not differ among treatment groups fed with different types of herbs. According to Santos et al. (2004), who provided an illustration, fresh meat from slaughtered animals retains about 70% water, which is crucial to its quality but starts to leak away shortly after the animal dies. Additionally, boning and cutting may cause losses of 1% to 2%, and additional long-term storage may result in losses of up to 12%.

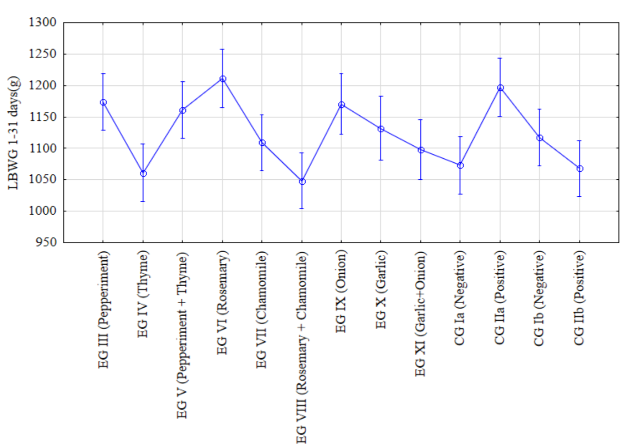

Figure 1. Variations in average live body weight gain (LBWG) during the whole experimental period (1-31 days of age of Ross 308 broiler chicken) among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

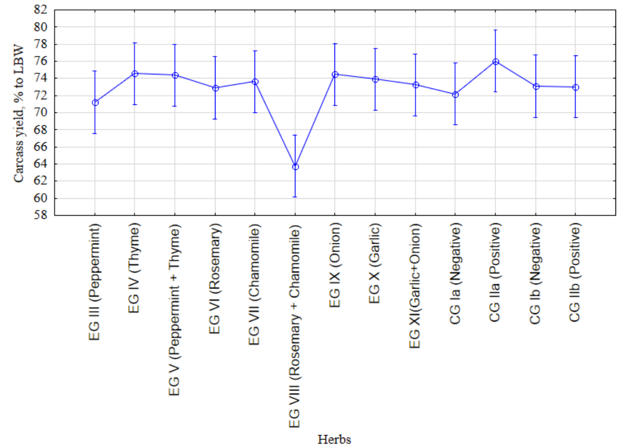

Figure 2. Variation of net weight percentage to live body weight (carcass yield) of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

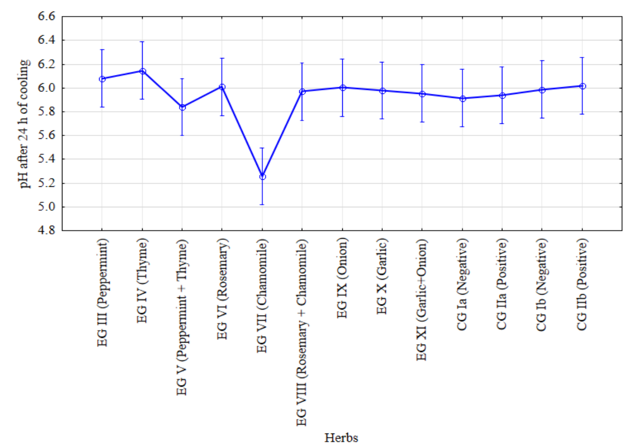

Figure 3. Breast meat pH variation after 24 hours of cooling of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

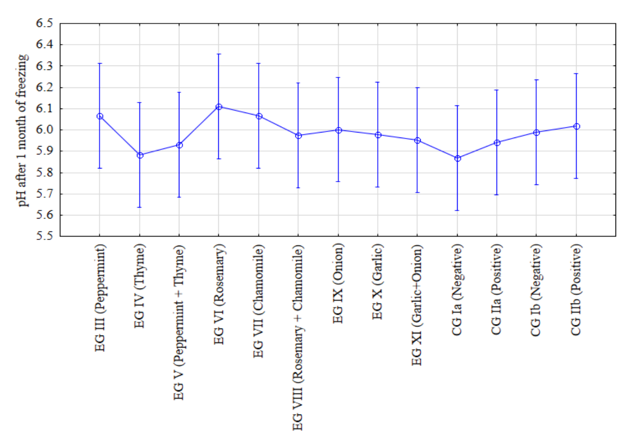

Figure 4. Breast meat pH variation after one month of freezing of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

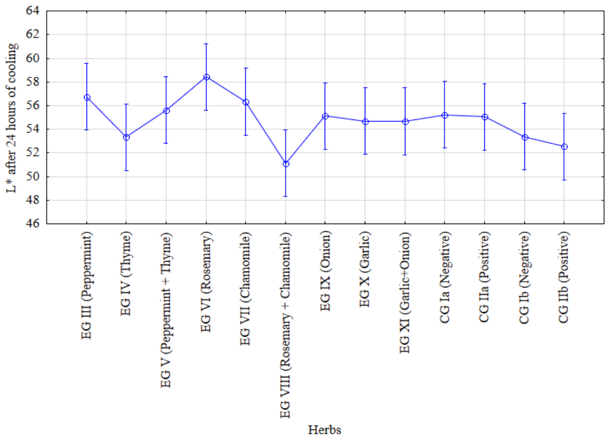

Figure 5. Breast meat lightness (L*) after 24 hours of cooling of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

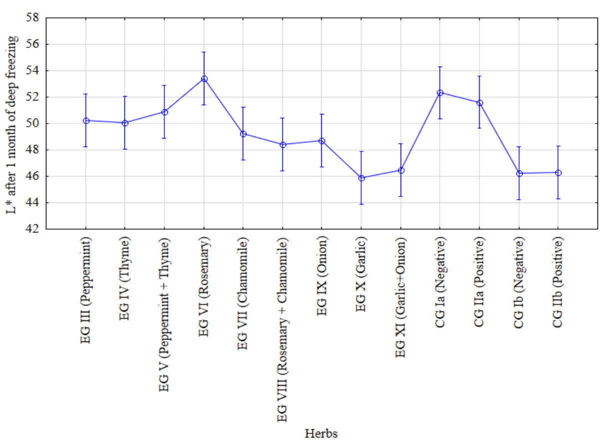

Figure 6. Breast meat lightness (L*) after one month of freezing of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

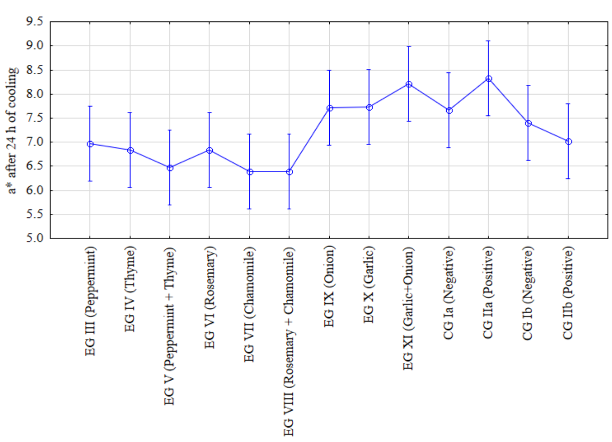

Figure 7. Breast meat redness (a*) after 24 hours of cooling of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

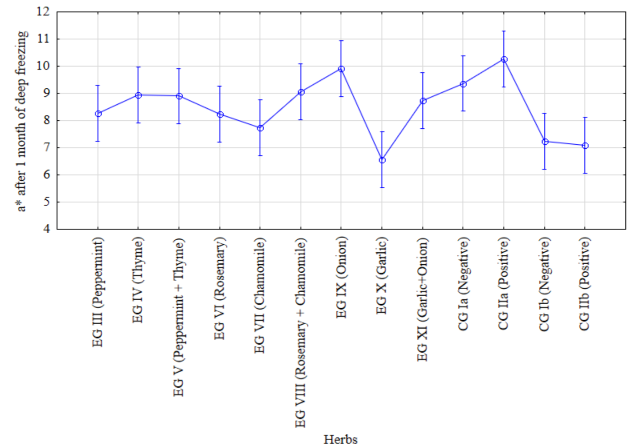

Figure 8. Breast meat redness (a*) after one month of freezing of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

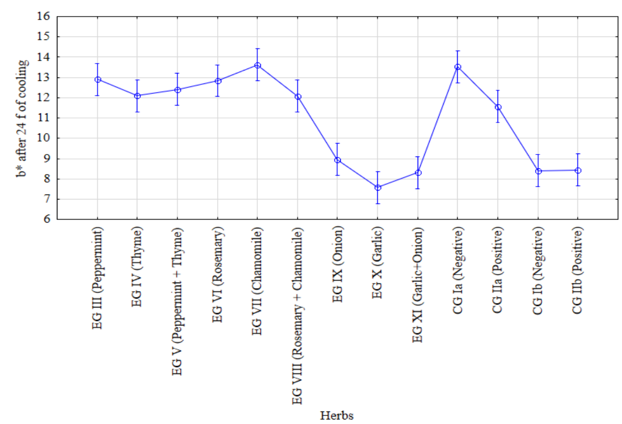

Figure 9. Breast meat yellowness (b*) after 24 hours of cooling of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

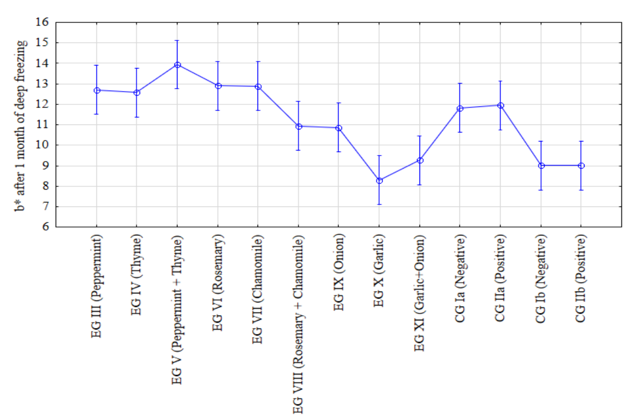

Figure 10. Breast meat yellowness (b*) after one month of freezing of Ross 308 broiler chicken among groups (EG: experimental groups, CGI: control groups of trial I, CGII: control groups of trial II)

CONCLUSION

Tested herbs had varying impacts on the overall chickens' performance. Their effects on physiology and meat quality were mostly comparable and sometimes better than that of antibiotics. In particular, adding rosemary to the diets could enhance chickens' body growth. Moreover, supplementing the diets with chamomile or a mixture of thyme and peppermint could increase the palatability of feed. Rosemary and thyme are more effective on feed conversion alone than in combination with other herbs. Although garlic (1%) and onion (1%) powders did not ameliorate feed conversion, they are well-known for enhancing chickens' immune systems. Overall, the use of the tested herbs as growth stimulants may reduce the need for antibiotics while offering farmers a practical answer. Future studies should be conducted on using the different herbs in other combinations and higher inclusion rates.

DECLARATION

Acknowledgments

The author declares that he had no source of funds. However, the author would like to thank the staff members, as well as the supervisors of the Lebanese University (Faculty of Agriculture) and the University of Forestry, Sofia, for logistic and scientific support.

Authors' contribution

Roger Al Hanna conception of the idea, administration of the project, data collection and processing, and drafting and editing of the manuscript. The author checked and approved the final version of the manuscript for publishing in the present journal.

Competing interests

The author declares no conflict of interest.

Ethical consideration

The author has made sure that the work complies with the journal's ethical issues for submission and publication.

REFERENCES

Abaza IMK, Asar MA, Elshaarrawi GE, and Hassan MF (2003). Effect of using nigella seeds, chamomile flowers, thyme flowers and harmala seeds as feed additives on performance of broiler. Egypt Journal of Agricultural Research, 81(2): 735-750. Available at: http://www.arc.sci.eg/InstsLabs/Pub_Details.aspx?OrgID=7&PUB_ID=71538&lang=en

Aksu T, Aksu MI, Önel SE, Yakan A, Kaya DA, and Baylan M (2014). Effect of thyme oil (Thymbra spicata L. var. spicata) on meat quality in Japanese quails. European Poultry Science, 78: 6. DOI: https://www.doi.org/10.1399/eps.2013.6

Ali ASA, Harrison AP, and Jensen JF (1999). Effect of some ante-mortem stressors on peri- mortem and post-mortem biochemical changes and tenderness in broiler breast muscle: A review. World's Poultry Science Journal, 55(4): 403-414. DOI: https://www.doi.org/10.1079/WPS19990028

Al-Kassie GAM (2008). The effect of anise and rosemary on broiler performance. International Journal of Poultry Science, 7(3): 243-245. DOI: https://www.doi.org/10.3923/ijps.2008.243.245

Amouzmehr A, Behrouz D, Jalil GN, Kyung II S, Jayant L, and Fereidoun F (2012). Effects of garlic and thyme extracts on growth performance and carcass characteristics of broiler chicks. Journal of Animal Science and Technology, 54(3): 185-190. Available at: https://koreascience.kr/article/JAKO201222350109000.page

Aviagen (2014). Ross 308 broiler: Nutrition specifications. Aviagen: Huntsville, AL, USA. Available at: https://eliasnutri.files.wordpress.com/2012/04/ross308broilernutritionspecs2014-en.pdf

Barbut S (1997). Problem of pale soft exudative meat in broiler chickens. British Poultry Science, 38(4): 355-358. DOI: https://www.doi.org/10.1080/00071669708418002

Begum M, Hossain MM, and Kim IH (2014). Effects of the plant extract YGF251 on growth perfor-mance, meat quality, relative organ weight, nutrient digestibility and blood profiles in broiler chickens: Possible role of insulin-like growth factor 1. Veterinarni Medicina, 59(9): 415-423. DOI: https://www.doi.org/10.17221/7681-VETMED

Castanon JIR (2007). History of the use of antibiotic as growth promoters in European poultry feeds. Poultry Science, 86(11): 2466-2471. DOI: https://www.doi.org/10.3382/ps.2007-00249

Commission on Antimicrobial Feed Additives (CAFA) (1997). Antimicrobial feed additives. Swedish Official Government Reports 132. Ministry of Agriculture, Stock-holm. Available at: https://www.scirp.org/(S(lz5mqp453edsnp55rrgjct55))/reference/ReferencesPapers.aspx?ReferenceID=429241

Cross DE, Mcdevith RM, Hillman K, and Agamovic T (2007). The effect of herbs and their associated essential oils on performance, digestibility and gut microflora in chickens 7 to 28d of age. British Poultry Science, 48(4): 496-506. DOI: https://www.doi.org/10.1080/00071660701463221

Cross DE, Svoboda K, McDevitt RM, and Acamovic T (2003). The performance of chickens fed diets with and without thyme oil and enzymes. British Poultry Science, 44(1): 18-19. DOI: https://www.doi.org/10.1080/713655293

Darwish AH (2003). Analysis and assessment of the poultry sector in Lebanon. Ministry of agriculture/food and agriculture, agricultural census project. Available at: http://www.agriculture.gov.lb/getattachment/Statistics-and-Studies/Studies-and-Publications/agri-production-chains/الانتاج-الحيواني/AVICULTURE_EN.pdf?lang=ar-LB

Decuypere E, Tona K, Bruggeman V, and Bamelis F (2001). The day-old chick: A crucial hinge between breeders and broilers. World's Poulry Science Journal, 57: 127-138. DOI: https://www.doi.org/10.1079/WPS20010010

El Rammouz R, Babile R, and Fernandez X (2004). Effect of ultimate pH on the physicochemical and biochemical characteristics of turkey breast muscle showing normal rate of postmortem pH fall. Poultry Science, 83(10): 1750-1757. DOI: https://www.doi.org/10.1093/ps/83.10.1750

Ertas ON, Guler T, Çiftçi M, DalkIlIç B, and Simsek UG (2005). The effect of an essential oil mix derived from oregano, clove and anise on broiler performance. International Journal of Poultry Science, 4(11): 879-884. DOI: https://www.doi.org/10.3923/ijps.2005.879.884

Feizi A, Peyman B, and Kamarouz K (2013). Effects of thyme volatile oils on performance of broiler chickens. European Journal of Experimental Biology, 3(1): 250-254. Available at: https://www.entomoljournal.com/archives/2018/vol6issue3/PartA/6-2-220-276.pdf

Goodarzi M, Nasir L, and Shahram N (2013). Effect of onion (*Allium cepa* L.) as an antibiotic growth promoter substitution on performance, immune responses and serum biochemical parameters in broiler chicks. Health, 5(8): 1210-1215. DOI: https://www.doi.org/10.4236/health.2013.58164

Hernandez F, Madrid J, Garcia V, Orengo J, and Megias MD (2004). Influence of tow plant extract on broiler performance, digestibility and digestive organ size. Poultry Science, 83(2): 169-174. DOI: https://www.doi.org/10.1093/ps/83.2.169

Iji PA, Saki A, and Tivey DR (2001). Body and intestinal growth of broiler chicks on a commercial starter diet. 1. Intestinal weight and mucosal development. British Poultry Science, 42(4): 505-513. DOI: https://www.doi.org/10.1080/00071660120073151

Issa KJ and Abo Omar JM (2012). Effect of garlic powder on performance and lipid profile of broilers. Open Journal of Animal Sciences, 2(2): 18526. DOI: http://www.doi.org/10.4236/ojas.2012.22010

Kamel C (2001). Tracing modes of action and the roles of plant extracts in non-ruminants. In: P.C. Garnsworthy, and J. Wiseman (Editors), Recent Advances in Animal Nutrition. Nottingham University Press, Nottingham, UK, pp. 135-150. Available at: https://www.cabdirect.org/cabdirect/abstract/20013121996

Keokamnerd T, Acton JC, Han IY, and Dawson PL (2008). Effect of commercial rosemary oleoresin preparations on ground chicken thigh meat quality packaged in a high-oxygen atmosphere. Poultry Science, 87(1): 170-179. DOI: https://www.doi.org/10.3382/ps.2007-00066

Kirkpinar F, Ünlü HB, Serdaroğlu M, and Turp GY (2014). Effects of dietary oregano and garlic essential oils on carcass characteristics, meat composition, color, pH and sensory quality of broiler meat. British Poultry Science, 55(2): 157-166. DOI: https://www.doi.org/10.1080/00071668.2013.879980

Kolacz R, Switala M, and Gajewczyk P (1997). Herbs as agents affecting the immunological status and growth of piglets reared with body weight deficiency. Journal of Animal and Feed Sciences, 6: 269-227. Available at: https://pdfs.semanticscholar.org/6240/c59622170f73b12e0abc30a600bbe2384a62.pdf

Langhout P (2000). New additives for broiler chickens. World Poultry, 16(3): 22-27. Available at: https://www.cabdirect.org/cabdirect/abstract/20001416551

Lewis MR, Rose SP, Mackenzie AM, and Tucker LA (2003). Effects of dietary inclusion of plant extracts on the growth performance of male broiler chickens. British Poultry Science, 44(1): 43-44. DOI: https://www.doi.org/10.1080/713655281

Listrat A, Lebret B, Louveau I, Astruc T, Bonnet M, Lefaucheur L, Picard B, Bugeon J (2016). How muscle structure and composition influence meat and flesh quality. The Scientific World Journal, 2016, Article ID 3182746.

Mahmmod Z (2013). The effect of chamomile plant (*Matericaria chamomile* L.) as feed additives on productive performance, carcass characteristics and immunity response of broiler. International Journal of Poultry Science, 12(2): 111-116. DOI: https://www.doi.org/10.3923/ijps.2013.111.116

Nasir Z (2009). Comparison of effects of Echinacea purpurea juices and Nigella sativa seeds on performance, some blood parameters, carcass and meat quality of broilers. PhD thesis, Department of Farm Animal Ethology and Poultry Science (Dissertation), University of Hohenheim, Germany. Available at: https://www.semanticscholar.org/paper/Comparison-of-effects-of-Echinacea-purpurea-juices-Nasir/a8ba250c850fab299d7fb856cd1571cc5636b66c

National Research Council (NRC) (1994). Nutrient Requirements of Poultry, 9th Revised Edition: 3-34. The National Academies Press., Washington DC. DOI: https://www.doi.org/10.17226/2114

Ocak N, Erener G, Burak AkF, Sungu M, Altop A, and Ozmen A (2008). Performance of broilers fed diets supplemented with dry peppermint (*Mentha piperita* L.) or thyme (*Thymus vulgaris* L.) leaves as growth promoter source. Czech Journal of Animal Sciences, 53(4): 169-175. DOI: http://www.doi.org/10.17221/373-CJAS

Odoemelam V, Etuk I, Ndelekwute E, Tobechukwu C, Iwuji T, and Ekwe C (2013). Herbs and spices: Options for sustainable animal production. Biology Agriculture and Healthcare, 3(7): 116-124. Available at: https://www.iiste.org/Journals/index.php/JBAH/article/view/6296/6403

Olivo R (1999). Carne PSE em frangos. Tese Ph.D em Ciências dos Alimentos, - Faculdade de Ciências Farmacêuticas, Universidade de São Paulo. Available at: https://www.teses.usp.br/teses/disponiveis/9/9131/tde-11112008-105159/publico/9131_5255675_FABIO_DE_OLIVEIRA_FRANCO.pdf

Osman M, Yakout HM, Motawe HF, and El-Arab WFE (2010). Productive, physiological, immunological and economical effects of supplementing natural feed additives to broiler diets. Egyptian Poulry Science Journal, 30(1): 25-53. Available at: https://www.cabdirect.org/cabdirect/abstract/20113051693

Panda H (2005). Handbook on medicinal herbs with uses. Asia Pacific Business Press Inc., Delhi, India. Available at: https://www.niir.org/books/book/handbook-on-medicinal-herbs-with-uses-h-panda/isbn-817833058x/zb,,7d,a,0,0,a/index.html

Ragaa NM, Korany RM, and Mohamed FF (2016). Effect of thyme and/or formic acid dietary supplementation on broiler performance and immunity. Agriculture and Agricultural Science Procedia, 10: 270-279. DOI: http://www. doi.org/10.1016/j.aaspro.2016.09.064

Rahimi S, Teymouri Zadeh Z, Karimi Torshizi MA, Omidbaigi R, and Rokni H (2011). Effect of the three herbal extracts on growth performance, immune system, blood factors and intestinal selected bacterial population in broiler chickens. Journal of Agricultural Science and Technology, 13(4): 527-539. Available at: https://www.jast.modares.ac.ir/article-23-5732-en.html

Sang-Oh P, Ryu C-M, Park B-S, and Hwangbo J (2013). The meat quality and growth performance in broiler chickens fed diet with cinnamon powder. Journal of Environmental Biology, 34: 127-133. Available at: http://www.jeb.co.in/journal_issues/201301_jan13/paper_20.pdf

Santos HC, Brandelli A, and Ayub MAZ (2004). Influence of post-mortem aging in tenderness of chicken breast fillets. Ciência Rural, 34(3): 905-910. DOI: https://www.doi.org/10.1590/S0103-84782004000300038

Santurio JM, Santurio DF, Pozzatti P, Moraes C, Franchin PR, and Alves SH (2007). Atividade antimicrobial dos leos esenciáis de oregano tomiho ecanela frente as orovares de Salmonella enteric de origem avicola. Ciencia Rural, 37(3): 803-808. DOI: https://www.doi.org/10.1590/S0103-84782007000300031

Sarica S, Ciftci A, Demir E, Kilinc K, and Yildirim Y (2005). Use of an antibiotic growth promoter and two herbal natural feed additives with and without exogenous enzymes in wheat-based broiler diets. South African Journal of Animal Science, 35(1): 61-72. DOI: https://www.doi.org/10.4314/sajas.v35i1.4050

Sarker MSK, Kim GM, and Yang CJ (2010). Effect of green tea and biotite on performance, meat quality and organ development in Ross broiler. Egyptian Poultry Science Journal, 30(1): 77-88. Available at: https://www.cabdirect.org/cabdirect/abstract/20113051695

Schreurs FJG (2000). Post-mortem changes in chicken muscle. World's Poultry Sciences Journal, 56(4): 319-346. DOI: https://www.doi.org/10.1079/WPS20000023

Spernakova D, Mate D, Rozanska H, and Kovac G (2007). Effect of dietary rosemary extract and α-tocopherol on the performance of chickens, meat quality and lipid oxidation in meat storage under chilling conditions. Bulletin of Veterinary Institute in Pulawy, 51(4): 585-589. Available at: https://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-6ad8a8e0-3dee-483d-841e-5e3a21e5c0c8

Tashla T, Puvača N, Ljubojević Pelić D, Prodanović R, Ignjatijević S, Bošković J, Ivanišević D, Jahić M, Mahmoud O, Giannenas I, and 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. DOI: https://doi.org/10.12681/jhvms.22229

Tona K, Onagbesan O, De Ketelaere B, Decuypere E, and Bruggeman V (2004). Effects of age of broilers breeders and egg storage on egg quality hatchability, chick quality, chick weight and chick post hatch growth to forty-two days. Journal of Applied Poultry Research, 13(1): 10-18. DOI: https://www.doi.org/10.1093/japr/13.1.10

Wareth-Abdel AAA, Kehrausa S, Hippenstiela F, and Südekuma KH (2012). Effects of thyme and oregano on growth performance of broilers from 4 to 42 days of age and on microbial counts in crop, small intestine and caecum of 42-day-oldbroilers. Animal Feed Science and Technology, 178(3-4): 198-202. DOI: https://www.doi.org/10.1016/j.anifeedsci.2012.10.006

Williams P and Losa R (2001). The use of essential oils and their compounds in poultry nutrition. World's Poultry, 17(4): 14-15. Available at: https://www.poultryworld.net/poultry/the-use-of-essential-oils-and-their-compounds-in-poultry-nutrition

Windisch W, Rohrer E, and Schedle K (2009). Phytogenic feed additives to young piglets and poultry: Mechanisms and application. In: T. Steiner (Editor). Nottingham University Press., Nottingham, UK. DOI: https://www.doi.org/10.3390%2Fani11123471

Yassin HA, Velthuis GJ, Boerjan M, and Van Riel J (2009). Field study on broilers' first-week mortality. Poultry Science, 88(4): 798-804. DOI: https://www.doi.org/10.3382/ps.2008-00292