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Usability Evaluation of Camel Thorn (*Alhagi maurorum*) in Broiler Diet and Its Effects on Lipid and Protein Oxidation of Broiler Breast Fillets During Frozen Storage

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Abstract

BACKGROUND: The decline in poultry meat quality can occur due to the oxidation of lipids and proteins during the storage period.

OBJECTIVES: This study aimed to evaluate the effects of using *Alhagi maurorum* in a broiler diet on the oxidation of the lipids and proteins of broiler breast fillets during frozen storage.

METHODS: A total of 54 male 1-day-old Ross 308 broiler chickens were divided into three groups of basal diet as the control group and basal diet supplemented with 10 and 20 g/kg of *A. maurorum* fed for 42 days. After slaughter, breast fillets were kept at -18℃ for 9 months and peroxide value (PV), thiobarbituric acid reactive substances (TBARS), protein carbonyl content, and organoleptic assays were performed on samples every 3 months.

RESULTS: The PV, TBARS, and carbonyl content of both treatment groups at all time points of frozen storage were significantly lower than that of the control group. Statistically, no difference was found between the samples of the two supplemented groups. Moreover, the sensory evaluation revealed no significant difference between the treatment and control groups.

CONCLUSIONS: According to the results of the present study, the incorporation of *A. maurorum* in broiler diets delayed lipid and protein oxidation in the breast meat.

KEYWORDS: *Alhagi maurorum*, Antioxidant, Broiler, Lipid oxidation, Protein oxidation

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Introduction

The decline in the poultry meat quality can occur due to the oxidation of lipid and protein over storage. With the risky impacts of chemical food preservatives, natural additives, particularly those with herbal sources are increasingly being taken into consideration (Jebelli Javan *et al.*, 2013; Raeisi *et al.*, 2014; Baghban Kanani *et al.*, 2017). *Alhagi maurorum* is the only species of genus *Alhagi* belonging to the family *Fabaceae* (Laghari *et al.*, 2014). *A. maurorum* contains diverse metabolites, including flavornoids, triterpenes, fatty acids, coumarins, glycosides, carbohydrates, steroids, resins, vitamin A, vitamin C, alkaloids, tannins, and unsaturated sterols (Alsnafi, 2015). Numerous researches have revealed *A. maurorum* as a selection of traditional medications. The antioxidant activity of this plant has been proved in previous studies. Therefore, it can be applied as a source of natural antioxidants in the food and pharmaceutical industries (Al-snafi, 2015; Ahmad *et al.*, 2015).

Applying a nutritional antioxidant additive is one of the approaches for improving the oxidative resistance of protein products. This technique is more efficient, compared to the direct addition of additives because of the uniform distribution of nutritional additives into the subcellular membrane leading to effective prevention from oxidative reaction (Mahmoudi *et al.*, 2015). Furthermore, the membrane phospholipids oxidation cannot be directly inhibited by the postmortem adding of synthetic antioxidants to meat (Zouari *et al.*, 2010).

Considering the proven nutritional and health effects of poultry diet pelleting, it is necessary to check the impacts of some parameters, such as the thermal markers of the pelletizing industry on the additive (Boroojeni *et al.*, 2016) following confirming the positive effects of additives. The current research is aimed to assess the usability of *A. maurorum* in the broiler diet and its effects on the oxidation of the lipids and proteins of broiler breast fillets during freezing.

Materials and Methods

The experimental protocols (number 49) were reviewed and approved by the Animal Care Committee of Semnan University, Semnan, Iran.

Effect of Pelleting Temperature on Antioxidant Activity

A. maurorum plant was collected from the lands around Semnan in late spring. After determining the species, the plant was dried and coarsely powdered using a mechanical grinder and was classified into two groups. One group was heat-treated at 85℃ for 1 min, while another group did not receive pelleting temperature. The extraction of the powder of *A. maurorum* was performed by maceration with methanol. The maceration of plant powder in methanol (80% v/v) was carried out for 3 days and the obtained mixture was filtered and concentrated under reduced pressure at 40℃.

DPPH and Total Phenolic Contents (TPC)

The stable radical DPPH (2,2-diphenyl-1-picrylhydrazyl) was used as a reagent to perform the DPPH assay based on the method of Ahmad *et al.* (2015). Extract concentration with 50% inhibition (IC_{50}) was computed by plotting the percentages of inhibition versus extract concentration with PHARM/PCS version 4. All tests were performed in triplicate, and the means and standard deviations were calculated (Ahmad *et al.*, 2015). The TPC was measured in *A. maurorum* extract using the Folin-Ciocalteu reagent and the method of Keykhosravi *et al.* (2015) with some modifications. Results were reported as milligrams of gallic acid equivalent per gram of dry weight (mg GAE/g DW).

Animals and Diets

A total of 54 male 1-day-old Ross 308 broiler chickens (*Gallus gallus*) were prepared from a local commercial hatchery. The chickens were classified into three groups with three replicates, including six chickens each on a fully randomized design. A basal diet with no additives was administered to the control group. For the two test groups, 10 and 20 g/kg of *A. maurorum* was added to the food. Confounding factors, including humidity, temperature, light, ventilation, and vaccination were similar between the groups. Trial diets were used for 1-42 days of age. Nutrition and water were accessible ad libitum. The

formulations of trial diets for each reproduction period were provided by WUFFDA software (1992, University of Georgia, GA) (Table 1). The effects of 10 and 20 g/kg of *A. maurorum* on body weight, feed intake, and feed conversion ratio (FCR) were evaluated. Furthermore, the mortality rate was recorded.

Table 1. Composition of experimental diets.

Diet	Starter (0 to 10th day)	Grower (11 to 24th day)	Finisher (25 to 42nd day)
Ingredients (g kg^{-1})			
Corn	530	565	616
Soy bean meal (44% CP)	366	325	268
Wheat bran *	20	20	20
Concentrate[1]	50	50	50
Vegetable oil	21	28	36
Min premix[2]	3	3	3
Vit premix[2]	3	3	3
DL-Methionine	0.5	0.5	0.5
L-Lysine	0.5	0.5	0.5
Calcium carbonate	5	4	2
Salt	1	1	1
Calculated analysis (g kg^{-1})			
ME (Kcal Kg^{-1})[3]	2900	3000	3100
Crude protein	213	198	178
Calcium	9.3	8.8	8.0
Available phosphorus	4.1	4.1	3.9
Sodium	1.6	1.6	1.6
Arginine	15	13.8	12
Methionine	5.1	4.9	4.6
Lysine	13.4	12.3	10.8
Methionine + Cystine	8.7	8.3	7.7

[1] Concentrate contained per kilogram of supplement; Metabolizable energy: 1400 kcal, Crude protein: 210 g, Calcium: 120 g, Available phosphorus: 50 g, Sodium: 20 g, Lysine: 19 g, Methionine: 25 g, Methionine + Cystine: 27g, Threonine: 7 g, Arginine: 5 g.

[2] Vitamin and mineral mix supplied the following per kilogram of diet; Vitamin A: 10,801 IU, Cholecalciferol: 2,400 IU, DL-α-tocopheryl acetate: 21 IU, Menadione: 2.4 mg, Thiamine: 2.8 mg, Riboflavin: 7.9 mg, Niacin: 43.8 mg, Pantothenic acid: 12 mg, Cyanocobalamin: 18 µg, Biotin: 0.15 mg, Manganese: 120 mg, Zinc: 102 mg, Iron: 60 mg, Copper: 12 mg, Selenium: 0.24 mg, Iodine: 1.2 mg.

[3] ME: metabolizable energy.

* In the composition of the 10 g kg^{-1} and 20 g kg^{-1} treated groups, 50% and 100% of the wheat bran were replaced by A. maurorum, respectively.

Sampling Procedure

On day 42, two birds were selected randomly from each replicate (n=6) and slaughtered through

bleeding for 90 s. All samples were packaged in polyethylene bags and stored at -18℃ for 9 months. Peroxide value (PV), thiobarbituric acid reactive substances (TBARS), carbonyl content, and organoleptic assays were performed on samples every 3 months. For all sampling times, specimens were thawed at 4℃ for 8 h before analyses.

Determination of Lipid and Protein Oxidation

For the determination of PV, 25 mL of an organic solvent mixture (chloroform/acetic acid, 2:3 v/v) was used to treat 1 g of the lipid specimen. The obtained mixture was strongly stirred, and 1 mL of saturated potassium iodide solution was added to it. The resultant solution was stored in the dark for 5 min before the addition of 75 mL of distilled water. Next, 0.5 mL of starch solution (1% w/v) was added to the mixture as an indicator. The PV was evaluated based on titrating the iodine released from potassium iodide with standardized 0.01 N sodium thiosulfate solution and was expressed as milliequivalents (meq) of peroxide per kg of lipid (Kamkar *et al.*, 2014).

The TBARS, as a measure of lipid peroxidation, were assessed according to Botsoglou *et al.* (2010) method with some modifications (Botsoglou *et al.*, 2010). Briefly, the homogenization of the specimen was performed in the presence of 8 mL of 5 g/100 mL aqueous trichloroacetic acid (Merck, Darmstadt, Germany) and 5 mL of 0.8 g/100 mL butylated hydroxytoluene in hexane (Merck, Darmstadt, Germany) followed by the centrifugation of the mixture. The supernatant was discarded, and 2.5 mL of the bottom layer was combined with 1.5 mL of 0.8 g/100 mL 2-thiobarbituric acid (Merck, Darmstadt, Germany) and incubated at 70℃ for 30 min. After incubation, the resultant mixture was cooled by tap water and its absorbance was read at 532 nm.

The levels of TBARS were measured using the calibration curve of 1,1,3,3-tetraethoxypropane (Merck, Hohenbrunn, Germany) as the standard. Carbonyl measurement is the most usual approach for determining protein oxidation. Protein carbonyls evaluation was performed by estimating total carbonyl groups according to the method of Weber *et al.* (2015) with some modifications (Weber *et al.*, 2015). From two aliquots of 50 µL protein samples, one was selected for treatment using 2 mL of 2 N HCl (control) and the other one was selected to treat by 2 mL of 10 mM 2,4-dinitrophenylhydra-zine (DNPH) in 2 N HCl for 1 h at room temperature. Following incubation, 2 mL of 20% trichloroacetic acid was utilized to precipitate both of the aliquots. The sediment was washed two times applying 4 mL of ethanol:ethyl acetate (1:1 v/v) solution for removing DNPH and was blow-dried to not react. Next, the pellet was solved in 1.5 mL of 6 M guanidine hydrochloride with 20 mM potassium phosphate buffer (pH: 2.3). Absorbance was read at 370 nm. The concentration of protein carbonyl was reported as nmol per mg protein with an absorption coefficient of 2.2×10^4 M^{-1} cm^{-1} for protein hydrazones (Jongberg *et al.*, 2017).

Sensory Evaluations

A chosen ten-member panel, including trained students and researchers, was asked to evaluate the chicken samples. The sensory assessments were carried out in triplicate on every specimen using the sensory panelist in the 9^{th} month, which is the maximum storage time at -18℃. Sensory evaluation was accomplished under fluorescent lighting in a room without noises and odors. Moreover, a glass of drinking water was located in front of each panelist to cleanse palates between samples.

The inclusion criteria for the panelists were being healthy, not being allergic to poultry meat, and eating chicken meat at least once a week. It should be noted that the training of panelists and measurement of sensory thresholds were performed according to the guidelines of the book Sensory Evaluation of Foods (Lawless and Heymann, 2010). Chicken samples were cooked at 80℃ for 35 min, cut into quarters (width×length: 2×3 cm), and randomly delivered to the panelists. All samples were coded using random 3-digit numbers. The color, odor, taste, texture, and overall acceptability of the cooked specimens were evaluated based on a 9-point descriptive scale (1: very undesirable, 9: very desirable). This analysis was performed based on the hedonic experiment stated by Kortei *et al.* (2020) (Kortei *et al.*, 2020).

Statistical Analysis

A fully randomized design was used as three replicates per treatment. The data were statistically

analyzed by the one-way analysis of variance and Duncan's Multiple Range test using the SPSS software version 22. Mean values and mean standard deviations (SD) were reported for the descriptive statistics. Sensory evaluation data were analyzed by the Kruskal-Wallis test to compare the medians. *P*-value<0.05 was considered significant for all tests.

Results

Chicken Performance

The addition of 10 and 20 g/kg *A. maurorum* had no effect on FCR, live weight gain, or feed consumption (Table 2). Moreover, dietary treatment did not affect the mortality percentage (P >0.05). It should be noted that 2, 1, and 1 bird died in the control, 10 g/kg *A. maurorum*, and 20 g/kg *A. maurorum* groups, respectively.

Table 2. Growth performance of chickens in control and test groups at the end of experiment.

Treatments	Number of chickens	Feed intake (g)	Body weight (g)	Feed conversion ratio (g/g)
Control	18	4308	2380	1.81
***A. maurorum* 10 g kg^{-1}**	18	4345	2414	1.80
***A. maurorum* 20 g kg^{-1}**	18	4362	2397	1.82

Effect of Pelleting Temperature on Antioxidant Activity

The results presented that a raise in *A. maurorum* content increases free radical scavenging activity. *A. maurorum* extract could reduce the purple-colored stable free radical DPPH to the yellow-colored diphenylpicrylhydrazin. The IC_{50} was 4.24±0.09 and 4.57±0.44 mg/mL in the control and heated groups, respectively. No significant difference was found between the two groups of control and treatment (P>0.05). Treatment under various conditions showed that temperature significantly influenced the TPC of *A. maurorum* extracts. Statistical analysis demonstrated that the TPC of the control group (19.29±0.16 mg GAE/g DW) was significantly lower than the heated group (37.48±2.81 mg GAE/g DW) (P<0.05).

Lipid and Protein Oxidation

Figure 1 exhibits the variations in PVs (meq O_2/kg fat) of chicken breast meat in the control and treatment groups. The PV in 10 and 20 g/kg treatment groups at all the time points of frozen storage was significantly lower than the control group (P<0.05). The minimum oxidation rate was for the chickens supplemented with 10 g/kg *A. maurorum*. However, no statistically significant difference was found between and 10 and 20 g/kg supplemented samples (P>0.05). Analysis of the linear gradient of PV revealed an increasing trend in the control group (slope=1.293±0.075), which was significantly different from the 10 g/kg (slope=0.801±0.086) and 20 g/kg (slope=0.881±0.077) groups (P<0.001). Moreover, a significant difference was not found between the augmenting trends of 10 and 20 g/kg groups (P=0.26).

Figure 2 presents variations in TBARS number (mg/kg MDA) of chicken breast meat. The groups supplemented with 10 and 20 g/kg had significantly lower lipid oxidation than the control group (P<0.05). We found that *A. maurorum* caused a reduction in TBARS levels, in comparison with the control group. However, no significant difference was observed between samples treated with 10 and 20 g/kg (P>0.05). The TBARS amounts of the specimens elevated at the start of frozen storage and then diminished at the 6th month in all groups. Analysis of the linear gradient of the TBARS test revealed that the increasing trend of TBARS in the control group (slope=0.049±0.009) was significantly higher than 10 g/kg (slope=0.026±0.004) and 20 g/kg (slope=-0.03±0.005) treated groups (P<0.05). Furthermore, no significant difference was reported between the rising trends of 10 and 20 g/kg supplemented groups (P=0.472).

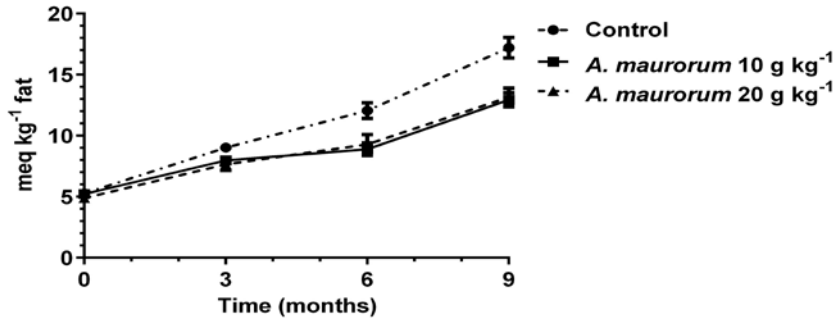

Figure 1. Changes in PVs (meq O2 per kg fat). All values are means ± SD.

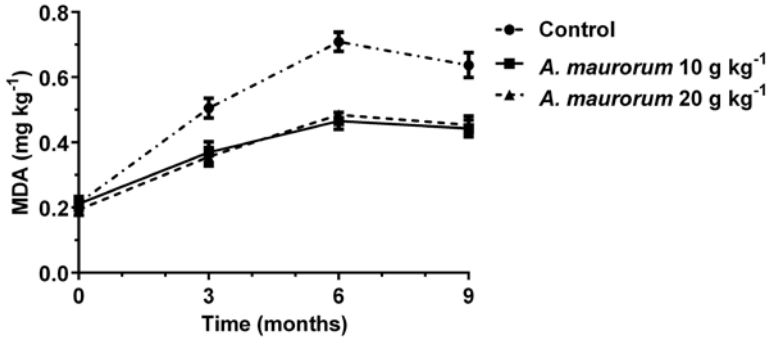

Figure 2. Changes in TBARS number (mg kg^{-1} MDA). All values are means ± SD.

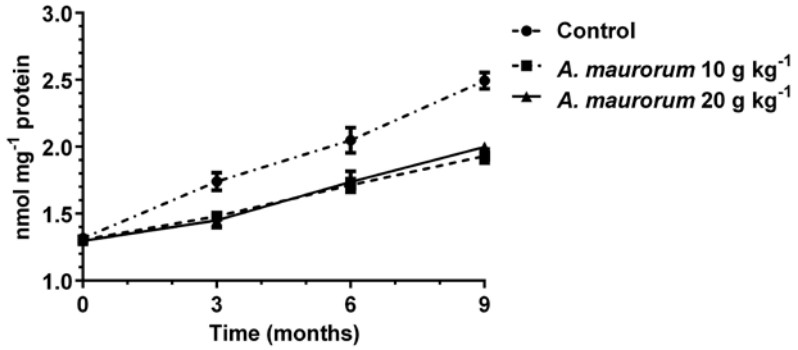

Figure 3. Changes in Carbonyl content (nmol mg-1 protein). All values are means ± SD.

Figure 3 represents the protein oxidative deterioration of chicken breast meat. Similar to PV and TBARS assays, there was an increase in the carbonyl content of the control and treatment groups. The total carbonyl values of control meat were significantly higher than 10 and 20 g/kg supplemented groups during the study (P<0.05). No significant difference was observed in terms of the carbonyl content of chicken breast meat between the two treatment groups (P>0.05). Analysis of the linear gradient of carbonyl content revealed that the elevating trend of carbonyl content in the control group (slope=0.128±0.006) was significantly higher than 10 g/kg (slope=0.07±0.003) and 20 g/kg (slope=0.079±0.005) groups (P<0.001). However, a significant difference was not observed between the increasing trends of the two supplemented groups (P=0.063).

Sensory Properties

The results of the sensory evaluation on the 9th month are presented in Table 3. The texture, color, odor, taste, and overall acceptability of the two supplemented groups were not significantly different from the control group (P>0.05). In the present investigation, the effects of 10 and 20 g/kg of dietary *A. maurorum* on sensory attributes were acceptable.

Table 3. Sensory attributes of cooked breast specimens.

	Control	*A. maurorum* 10 g kg^{-1}	*A. maurorum* 20 g kg^{-1}
Color	7.7^{a*}	8^{a}	7.7^{a}
Odor	7.2^{b}	7.4^{b}	7.2^{b}
Taste	8.4^{c}	8.2^{c}	8^{c}
Texture	7.7^{d}	8^{d}	7.5^{d}
Overall acceptability	7.6^{e}	7.7^{e}	7.6^{e}

All values are median of three replicates.

* Different letters at each row show significant differences (P≤0.05).

Discussion

Oxidation of proteins and lipids are the chief concerns that affect meat quality. It has been shown that the main active components of the genus *Alhagi* encompassed alkaloids, flavonoids, and fatty acids. *A. maurorum* plant contains protein (65.6±0.2 g/kg), fat (48.8±0.1 g/kg), fiber (280±0.1 g/kg), carbohydrate (565.2±1.2 g/kg), energy values (330.51±0.01 Kcal/100 g), and trace elements (Al-snafi, 2015). In addition, it contains flavonoids, triterpenes, coumarins, vitamin A, vitamin C, lupeol, and tannins that are probably responsible for the antioxidant properties of *A. maurorum*. Coumarins and flavonoids have been reported to be associated with beneficial impacts on human health and radical scavenging effect owing to their antioxidant properties (Borges Bubols *et al.*, 2013). However, we cannot firmly state what component is responsible for the antioxidant activity of *A. maurorum*. This plant was considered a cheap antioxidant and an available source for lupeol due to its wild nature and ability to grow throughout the year (Laghari *et al.*, 2014; Al-snafi, 2015). Lupeol is a pentacyclic triterpene that exhibits antioxidative activity through the direct scavenging of free radicals and protects membrane permeability (Santiago and Mayor, 2014).

Herbal phenolic and flavonoid compounds are secondary metabolites with antioxidant potential (Bazargani-Gilani *et al.*, 2014). *A. maurorum* could be a suitable candidate as a natural antioxidant for preventing the oxidation of lipids and proteins. To the best of our knowledge, there has been no earlier report on the usage of *A. maurorum* in the broiler diet, and its effects on lipids and proteins oxidation in chicken meat.

Thigh meat tends to oxidize quicker, compared to breast meat at the same conditions, which is elucidated by a greater level of polyunsaturated fatty acids in the thigh and the high level of pro-oxidative types originating from myoglobin and other iron-comprising proteins (Zouari *et al.*, 2010). The breast meat was selected for the analysis as it is the most valuable cut of the chicken and has higher antioxidant minerals and vitamins that assist oxidative stability (Delles *et al.*, 2014). Performance parameters of broiler chickens should not be reduced as the result of adding an additive to the diet. Weight gain, feed consumption, mortality percentage, and FCR were not affected by the addition of 10 and 20 g/kg of *A. maurorum*. These outcomes were in accordance with those reported earlier (Nobakht, 2013).

Some chemical and physical changes happen due to the heat, moisture, and mechanical pressure used for conditioning and pelleting that may have useful or destructive impacts on feed ingredients (Boroojeni *et al.*, 2016). The results of the current research showed that phenolic compounds in *A. maurorum* were increased and released by heat treatments. The slight heat treatment can convert insoluble phenolic compounds to soluble phenolics. It should be stated that the covalent bonds of phenolic compounds are not affected by heat. In other words, herbal phenolic compounds with antioxidant property have several types of bound states, and utilization of a simple heat can elevate the phenolic compounds of *A. maurorum* (Jalali Jivan *et al.*, 2013). On the other hand, the antioxidant activity of *A. maurorum* was not affected by the pelleting temperature in the DPPH assay. Despite the apparently simple

structure of DPPH, it may react with diverse kinetics and many antioxidants or may not react at all owing to its stable nitrogen radical (Mishra *et al.*, 2012). Kim *et al.* (2003) observed a weak relation between antioxidant capacity and phenolic compounds (Kim *et al.*, 2003). However, it is not constantly the case that the number of the hydroxyl groups has a direct relation with more radical scavenging activity. The TPC and antioxidant characteristic of *A. maurorum* were not reduced by the pelleting temperature. Therefore, it is practically possible to use this plant in pellet forms.

The PVs in all samples were augmented during the study. Our results are consistent with the findings of other investigations (Soyer *et al.*, 2010; Zouari *et al.*, 2010). Hydroperoxides (ROOH) are considered, as the primary products of lipid oxidation, and MDA, as a secondary product of lipid oxidation, are obtained following lipid hydroperoxides hydrolysis (Botsoglou *et al.*, 2016). Although lipid oxidation rises during storage, TBARS does not essentially keep increasing during frozen storage. The TBARS content of the samples elevated first and then initiated to reduce at the 6th month in all groups. This behavior could be due to the reaction of MDA with other compounds in meat, such as amino acids, proteins, and glucose, as well as the secondary metabolites, namely carbohydrates, alkenals, furfural, alkadienals, aldehydes, and ketones (Jebelli Javn *et al.*, 2013). Oxidation of proteins is a free radical chain reaction same as the oxidation of lipids and in meat is related to various factors, including heme pigments, oxidative enzymes, high levels of oxidizable lipids, and transition metal ions (Jongberg *et al.*, 2017). Carbonyl derivatives may result from the oxidation of several amino acid residues, such as arginine, lysine, and proline. These derivatives can be formed due to glutamyl residues oxidation. Furthermore, oxidative cleavage corresponding to the peptide backbone through the α-amidation pathway can generate carbonyl derivatives. Secondary reactions of some amino acids with reducing sugars or products of lipid oxidation can produce the carbonyl derivatives (Jongberg *et al.*, 2017). In the current research, muscle tissue protein carbonyl level enhanced over storage in all groups. However, adding 10 and 20 g/kg dietary *A. maurorum* effectively delayed the production of total carbonyl. The values of protein carbonyl content in this study were similar to those previously observed in chicken meat (Soyer *et al.*, 2010; Delles *et al.*, 2014). No statistically significant difference was observed between the groups supplemented with 10 and 20 g/kg extract. However, in some samples, the beneficial effects of 10 g/kg *A. maurorum* supplementation on lipid and protein oxidation were better than 20 g/kg probably because of the pro-oxidant impact of *A. maurorum* at higher quantities. Our results are in agreement with those of Rietjens *et al.* (2002) who described the pro-oxidant chemistry of the natural antioxidants vitamin C, vitamin E, carotenoids, and flavonoids (Rietjens *et al.*, 2002).

Conclusion

In conclusion, *A. maurorum* could be considered as a nutritional supplementation in the diet of chicken and a potential candidate to delay the oxidation of the lipids and proteins of chicken breast fillets over frozen storage. Owing to economic considerations, the lack of significant difference between and 10 and 20 g/kg supplemented samples, and even the higher efficacy of 10 g/kg than 20 g/kg in some cases, the adding of *A. maurorum* plant to the broiler diet at a rate of 10 g/kg is recommended.

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Conflict of Interest

The authors declared no conflict of interest.

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مجله طب دامی ایران، ۱۴۰۰، دوره ۱۵، شماره ۳، ۳۳۵-۳۴۵

ارزیابی قابلیت استفاده از گیاه خارشتر (*Alhagi maurorum*) در جیره طیور گوشتی و تاثیر آن بر اکسیداسیون لیپید و پروتئین فیله های سینه مرغ در زمان نگهداری در حالت انجماد

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چکیده

زمینه مطالعه: اکسیداسیون چربی ها و پروتئین ها از دلایل مهم کاهش کیفیت گوشت طیور هستند.

هدف: هدف از این مطالعه، بررسی قابلیت استفاده از گیاه خارشتر در جیره غذایی جوجه‌های گوشتی و اثرات آن بر اکسیداسیون لیپید و پروتئین گوشت سینه، طی مدت نگهداری در زمان انجماد است.

روش کار: ۵۴ قطعه جوجهٔ گوشتی یک روزهٔ راس ۳۰۸، در سه گروه تقسیم‌بندی شده (گروه دریافت کنندهٔ جیره پایه به‌عنوان گروه کنترل، گروه دریافت کنندهٔ گیاه خارشتر به میزان $10\ g\ kg^{-1}$ در جیره، گروه دریافت‌کنندهٔ گیاه خارشتر به میزان $20\ g\ kg^{-1}$ در جیره) و به مدت ۴۲ روز تغذیه شدند. پس از کشتار، فیلهٔ سینهٔ جوجه‌ها به مدت ۹ ماه در دمای $-18^{\circ}C$ نگهداری شد و هر سه ماه، آزمایش‌های سنجش عدد پراکسید (PV)، ترکیبات واکنش‌دهنده با تیوباربیتوریک اسید (TBARS)، کربونیل و ارزیابی حسی انجام گرفت.

نتایج: میزان کربونیل، عدد پراکسید و TBARS در گروه‌های تیمار $10\ g\ kg^{-1}$ و $20\ g\ kg^{-1}$، در تمامی طول دورهٔ نگهداری، به صورت معنی‌داری از گروه کنترل کمتر بود. از لحاظ آماری، تفاوت معنی‌داری میان گروه‌های $10\ g\ kg^{-1}$ و $20\ g\ kg^{-1}$ دیده نشد. در نتایج به‌دست‌آمده از ارزیابی حسی نیز، تفاوت معنی‌داری میان گروه کنترل و آزمایشی، دیده نشد.

نتیجه‌گیری نهایی: در مجموع، استفاده از گیاه خارشتر در جیره غذایی جوجه‌های گوشتی، منجر به تاخیر در اکسیداسیون لیپید و پروتئین گوشت سینهٔ آنان در مدت زمان نگهداری شد.

واژه‌های کلیدی: خارشتر، آنتی‌اکسیدان، جوجهٔ گوشتی، اکسیداسیون لیپید، اکسیداسیون پروتئین

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