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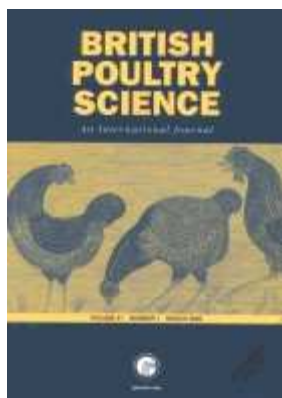
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Effects of α -tocopheryl acetate and α -carotene dietary supplementation on the antioxidant enzymes, TBARS and sensory attributes of turkey meat .

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Effects of α -tocopheryl acetate and β -carotene dietary supplementation on the antioxidant enzymes, TBARS and sensory attributes of turkey meat

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1 **Abstract** 1. The aim of the study was to evaluate the effects of α -tocopheryl
2 acetate (50 mg/kg) and β -carotene (15 mg/kg) dietary supplementation on the
3 oxidative status of raw turkey breast and leg muscles assessed by thiobarbituric
4 acid test values, the vitamin E levels and the antioxidant enzyme activities. In
5 parallel, a quantitative descriptive sensory analysis was carried out on cooked,
6 stored and reheated samples.

7 2. Vitamin E was present in sufficient quantity to reduce oxidation, since iron-
8 induced reactive substances (TBARS) were significantly lower in antioxidant
9 supplemented treatments. The results suggested that the presence of β -carotene in
10 the diet limits the accumulation of α -tocopherol in turkey muscles.

11 3. In the present study, there was no conclusive relationship between dietary
12 antioxidant supplementation and endogenous antioxidant enzyme activities.

13 4. Sensory evaluation showed that a longer supplementation time and dose may be
14 necessary in turkeys to prevent meat from rancidity and warmed-over flavour
15 (WOF). Leg pastiness and stringiness were modified by dietary antioxidant
16 supplementation, indicating the possible synergism between antioxidants and
17 cysteine proteinases in the perception of meat quality.

18 5. Given the modern trends that lead consumers to increase their consumption of
19 poultry meat, it would be interesting to evaluate the commercial potential and cost
20 effectiveness of routine dietary antioxidant supplementation.

21 INTRODUCTION

22 World consumption of turkey meat has increased not only because of its sensory
23 attributes of taste and texture but its moderate levels of total lipids, saturated fatty
24 acids and cholesterol. These characteristics are considered to provide beneficial
25 effects on human health, especially in the prevention of cardiovascular disease

1 (Krauss *et al.*, 2001); however, on the other hand, they increase the susceptibility
2 of meat to lipid oxidation (Morrissey *et al.*, 1998). Feeding antioxidant
3 supplemented diets and controlling conditions of rearing and slaughtering the
4 antioxidative status in the living animal may be influenced, producing beneficial
5 results for both the consumer and the processing industry. Dietary
6 supplementation with vitamin E has been widely reported to be effective in
7 protecting poultry muscle against oxidative damage (Carreras *et al.*, 2004; Grau *et*
8 *al.*, 2001; Maraschiello *et al.*, 1999; Nam *et al.*, 2003). Results on the
9 effectiveness of β -carotene as antioxidant are not conclusive, since its effect
10 depends on the dose and on the type of fat fed (King *et al.*, 1995; Ruiz *et*
11 *al.*, 1999).

12 Lipid oxidation can give rise to rancidity and the formation of undesirable
13 odours and flavours, which affect the sensory and nutritional values of products.
14 The term warmed-over flavour (WOF) (Tims and Watts, 1958) is used to describe
15 the sensory perception associated with the rapid development of oxidised flavours
16 in precooked, stored and reheated meat. WOF becomes apparent within a short
17 period of time, whereas common rancidity develops during lengthy storage. The
18 use of a trained panel has been demonstrated (Guerrero, 2000) to be appropriate
19 for assessing quality attributes, as they may be perceived by the consumers, and to
20 complement results obtained by analytical methods. In this sense, the oxidative
21 stability of meat can be studied assessing the enzymatic activities of glutathione
22 peroxidase (GSHPx), catalase (CAT) and superoxide dismutase (SOD) that
23 constitute an antioxidant cellular enzymatic system. Although, the thiobarbituric
24 acid (TBA) test has been criticised for its lack of sensibility and specificity

1 (Botsoglou *et al.*, 1994), it seems to be an appropriate method for routine
2 assessment of secondary oxidation involved in rancidity development.

3 The aim of the current work was to evaluate the effect of diet
4 modifications with antioxidant supplementation on the oxidative status of raw
5 turkey breast and leg muscles assessed by the thiobarbituric acid test and
6 antioxidant enzyme activities. In parallel, sensory analyses were carried out on
7 cooked samples. Sensory analyses done together with chemical measurements are
8 one of the most appropriate tools to assess the lipid oxidation status of meat and
9 meat products. Our goal was to complement previous results obtained on the
10 oxidative stability of broiler muscles (Carreras *et al.*, 2004).

11 MATERIAL AND METHODS

12 **Birds and dietary treatments**

13 A total of 30 turkeys of BUT 9 strain were selected. They were placed in flat-deck
14 batteries (6 m²). The animals were raised according to routine practices in terms
15 of light and temperature. They were all fed on a basal diet containing lard as
16 saturated fat (Table 1) throughout the experiment, which lasted 12 weeks.
17 Animals were distributed randomly in three experimental treatments: T1 (control
18 group) that was only given the basal diets; T2 turkeys were given the basal diets
19 supplemented with 50 mg/kg of α -tocopheryl acetate during the last 4 weeks
20 before slaughter; T3 birds were fed on the basal diets supplemented with 50
21 mg/kg of α -tocopheryl acetate and 15 mg/kg of β -carotene for the last 4 weeks
22 before slaughter. The doses of α -tocopheryl acetate and β -carotene were chosen to
23 take into account the expected protective effect that dietary supplementation of
24 two antioxidants may produce in turkey meat. Previous studies pointed out the
25 antioxidant effect of dietary supplementation with 15 mg/kg of β -carotene against

1 the prooxidant results found with 50mg/kg of β -carotene supplementation in
2 poultry meat (Maraschiello, 1998., Ruiz *et al.*, 1999).

Table 1 near here

3 Ten animals from each treatment were slaughtered at a commercial
4 processing plant. The breast and leg were removed, vacuum packed in aluminium
5 foil bags (MET/MET Sacoliva, Spain) and stored at -20°C until analysis. The left
6 breast and leg of each bird was used for the chemical analyses and the other half
7 of each animal was used for the sensory analyses.

8 **Preparation of antioxidant enzymatic extract**

9 The enzymatic extract was prepared according to the procedure of DeVore and
10 Greene (1982). A portion of tissue was homogenised with 50 mM Tris-HCl
11 buffer, pH 7.0 (1/5 w/v). The homogenate was centrifuged at 17000 g for 30 min
12 at 4°C . The supernatant was recovered and filtered through deactivated glass
13 wool. The subsequent centrifugation of the filtrate, carried out at 100000 g for 1 h
14 at 4°C , gave the final supernatant extract used for SOD, CAT and GSHPx activity
15 assays. The protein content of the extract was determined by the procedure of
16 Lowry *et al.* (1951). All the assays were done in duplicate.

17 **Measurement of GSHPx activity**

18 The GSHPx assay (DeVore and Greene, 1982) medium consisted of 40 mM
19 potassium phosphate, pH 7.0, 0.5 mM EDTA, 1 mM NaN_3 (sodium azide), 0.5
20 units of glutathione reductase, 1 mM reduced glutathione, 0.15 mM NADPH, 0.12
21 mM H_2O_2 and 150 μl of the tissue extract, with a total volume of 1.5 ml. The
22 mixture was incubated in a water bath at 30°C for 5 min before the addition of
23 hydrogen peroxide. The decrease of absorbance at 340 nm was recorded for over
24 5 min. The activity was expressed as nmol of NADPH oxidised per minute per mg
25 of protein.

1 **Measurement of SOD activity**

2 Superoxide dismutase (SOD) activity was measured according to the method of
3 Marklund and Marklund (1974), based on the ability of SOD to inhibit the
4 autoxidation of pyrogallol. Fifty μl of tissue extract were incubated at 30 °C for 10
5 min with 0.2 mM pyrogallol and 50 mM tris-cacodylic acid buffer, pH 8.2,
6 containing 1 mM diethylenetriaminepentaacetic acid (DTPA) with a total volume
7 of 2 ml. The rate of autoxidation was determined by the absorbance measured at
8 420 nm. The enzyme activity was calculated according to a SOD standard curve
9 (0 to 200 ng). One unit of enzyme activity was defined as the amount of the
10 enzyme that inhibited the autoxidation of pyrogallol by 50 %. Activity was
11 expressed as units of SOD per mg of protein

12 **Assay of CAT activity**

13 Catalase (CAT) activity was determined by measuring the decrease in hydrogen
14 peroxide at 240 nm for 5 min (Mei *et al.*, 1994). The assay medium consisted of
15 11 mM H_2O_2 , 50 mM potassium phosphate buffer, pH 7.0, and 100 μl of tissue
16 extract with a total volume of 3 ml. The blank mixture contained potassium
17 phosphate buffer, pH 7.0, instead of extract. A unit of CAT activity was defined
18 as the amount of CAT needed to decompose 1 μmol H_2O_2 per min. Activity was
19 expressed as μmol of H_2O_2 decomposed per minute per mg of protein.

20 **Measurement of lipid oxidation by the iron-induced TBA test**

21 The iron-induced TBA test carried out to measure lipid oxidation in raw muscles
22 was a modification of the method of Kornbrust and Mavis (1980). Each sample (3
23 g) was homogenised in 27 ml of 1.15 % KCl. A 200 μl aliquot of the homogenate
24 was mixed with 1 ml of 80 mM Tris/maleate buffer, pH 7.4, 400 μl of ascorbic

1 acid and 400 μ l of ferrous sulphate and incubated for different periods of time (0,
2 50, 100 and 150 min) in a 37 °C water bath with gentle stirring. Then, 4 ml of 26
3 mM TBA, 0.92 M TCA and 0.8 mM HCl were added and held for 15 min in
4 boiling water. Different incubation times were tested in order to determine which
5 showed higher correlation coefficients with sensory rancidity and discriminated
6 better between treatments. The samples were cooled and the absorbance was
7 recorded spectrophotometrically at 532 nm. Blanks containing all the reactants
8 except the homogenate were also measured. The extent of lipid oxidation was
9 expressed as nmol of malonaldehyde (MDA) per mg of tissue. TBARS were
10 calculated after 150 min of incubation.

11 **Determination of α -tocopherol levels**

12 A portion of muscle was sonicated in n-hexane/2-propanol (3:2, v/v) to achieve α -
13 tocopherol extraction. The sample was centrifuged and the supernatant was
14 evaporated to dryness in a stream of nitrogen. The residue was redissolved in 1ml
15 of n-hexane/ethyl acetate (80:20, v/v). A 20 μ l aliquot of the filtered extract was
16 injected into an HPLC system. Samples and standards (5 and 10 ng/ μ l of α -
17 tocopheryl acetate in mobile phase) were analysed by normal phase HPLC using a
18 LKB Bromma System (Stockholm, Sweden) with an aminopropylsilica NH₂-NP
19 (5 μ m, 250 mm x 4.6 mm i.d.) column (Supelco-Sigma, USA). The mobile phase
20 consisted of n-hexane/ethyl acetate (80:20, v/v) at a flow rate of 1.2 ml/min.
21 Detection was carried out by measurement of the fluorescence (290-330 nm)
22 (Casademont and García Regueiro, 2000).

23 **Sensory analysis**

24 Ten breasts and legs per treatment were evaluated. The samples were vacuum-
25 packed and cooked for 80 min and 120 min respectively, in an 80 °C water bath.

1 The exudate was removed and each breast was cut into 6 pieces, one for each
2 assessor. *M. gastrocnemius lateralis* and *M. gastrocnemius medialis* of each leg
3 were dissected and used for flavour and texture evaluation, respectively. In this
4 case, one complete leg of each treatment per assessor was evaluated in each
5 session. The samples were randomly coded and stored for 1 d at 4 °C in order to
6 facilitate rancidity development. Before sensory analysis, samples were reheated
7 for 25 min at 65 °C in an electric oven and served immediately in isothermic
8 containers at 70 °C to 6 previously trained sensory panellists according to
9 Guerrero *et al.* (2000).

10 Two flavour (rancidity and WOF) and 5 texture (initial juiciness, hardness,
11 pastiness, stringiness and tooth adhesion) descriptors were evaluated. Rancid
12 flavour was described as the intensity of flavour perception similar to that of an
13 old olive oil odour; warmed-over flavour as the oxidised flavour of reheated meat;
14 initial juiciness as the moisture released by the product in the mouth as a result of
15 initial chewing; hardness as the force required to bite through the sample;
16 pastiness as the pasty feeling inside the mouth; stringiness as the perception of
17 long and parallel coarse particles in the meat during chewing and tooth adhesion
18 as the perception of mouth residue that remains stuck to the teeth once chewing is
19 finished.

20 Attributes were quantified on a rating scale from 0 to 10 (where zero is
21 absence and 10 maximum intensity). Sensory evaluations were conducted in a
22 standardised sensory testing room (ISO, 1988) equipped with red lights to mask
23 colour differences between samples. A complete block design was used. The
24 order of presentation of samples and the first-order carry-over effects were

1 blocked (Macfie *et al.*, 1989), as well as the piece served to each assessor in each
2 of the tasting sessions carried out (Guerrero, 2000).

3 **Statistical analysis**

4 All the data were analysed using the MEANS, GLM and CORR procedures of the
5 SAS statistical package (SAS Institute, 2000). An analysis of variance (ANOVA)
6 was carried out for chemical data on each tissue (breast and leg). The ANOVA
7 (GLM) model included the treatment as fixed effect. An additional ANOVA was
8 carried out to check the existence of significant ($P < 0.05$) differences between the
9 different tissues. In this case, for each treatment, the model included the tissue as
10 a fixed effect.

11 For sensory data the ANOVA was performed over the mean values (6
12 assessors) for each piece of breast. In this case the model included the treatment,
13 the taste session and their interaction as fixed effects. For legs, the model included
14 the treatment, the assessor and the taste session nested to the assessor as a fixed
15 effects. No significant interaction was observed between treatment and assessor.
16 In all cases, mean separation was performed using the Least Significant
17 Difference (LSD) test.

18 Correlation analysis between all the available information was carried out
19 within each treatment.

20 **RESULTS AND DISCUSSION**

21 **Antioxidant enzyme activities**

22 Table 2 shows the results of GSHPx, CAT and SOD activities in raw breast and
23 leg samples. The activity of antioxidant enzymes in meat is affected by such
24 factors as species, genotype, phenotype and the muscle type (Daun and Akesson,
25 2004; Sárraga *et al.*, 2002; Hernández *et al.*, 2004). In our study, leg muscles

1 exhibited more CAT and GSHPx activities than breast samples, while the
2 differences in SOD activity were not significant. Some reports (Lee *et al.*, 1996;
3 Renerre *et al.*, 1999) described higher antioxidant enzyme activities in oxidative
4 (leg) than in glycolytic muscles (breast) from turkey. This could be considered as
5 a protective system preventing or delaying the onset of oxidative stress in
6 susceptible muscles. Moreover, according to Daun and Akesson (2004), the
7 higher GSHPx activity observed in legs may be due to the greater content of total
8 and soluble selenium found in oxidative turkey muscles.

Table 2 near here

9 GSHPx and SOD activities were not influenced by antioxidant
10 supplementation. There are several contradictory reports in the literature about the
11 capability of endogenous antioxidant enzymes to induce a compensatory activity
12 in response to the exposure of tissue to an oxidative stress environment. Some
13 authors reported an inverse relationship between dietary vitamin E content and
14 GSHPx activity (Yamauchi *et al.*, 1984; Maraschiello *et al.*, 1999) contrary to the
15 findings of Renerre *et al.* (1999) in muscles from turkeys receiving 30 and 200
16 mg/kg of vitamin E and Rojas *et al.* (1996) in guinea pig heart where no effect on
17 antioxidant enzyme activities was reported. The observed relationship between
18 vitamin E and the enzyme activities may be related to parameters such as dietary
19 selenium or the level of unsaturation of the fat included in the diets.

20 Differences among treatments were found only in CAT activity of breast
21 muscles, increasing significantly when antioxidants were supplemented together
22 (T3). A positive correlation between CAT and SOD activities ($r = 0.66$) was also
23 observed. In the same way, GSHPx was correlated with SOD ($r = 0.74$) in leg
24 samples from T 3, indicating a possible synergism between the enzymes. This can

1 be explained because SOD catalyses the superoxide anion. The H₂O₂ produced is
2 removed by CAT and GSHPx activities

3 From our results, it is not possible to use any of these enzyme activities as
4 indicators of the oxidative stress prevailing in the muscle. In our conditions there
5 was no conclusive relationship between the antioxidant supplemented level and
6 the endogenous antioxidant enzymes system activity.

7 **Iron-induced TBARS and vitamin E levels**

8 The vitamin E and TBARS contents of turkey breast and leg muscles obtained for
9 each treatment are shown in Table 3. According to previous results (Ruiz, 1999;
10 Ruiz *et al.*, 1999) β -carotene was not detected in meat samples from broilers fed
11 on diets with 15 mg/kg; consequently β -carotene content was not measured in the
12 present study.

Table 3 near here

13 From our earlier results, vitamin E levels detected in turkey muscles were
14 lower than those obtained in chicken (Carreras *et al.*, 2004), in spite of the fact
15 that supplementation with the antioxidant was higher in turkey (50 mg/kg) than in
16 broiler (30 mg/kg) experimental treatments. In both studies, birds were fed on a
17 diet containing lard as saturated fat, which is the usual practice in feed
18 formulation (Table 1), in order to avoid the influence of dietary fat (Maraschiello
19 *et al.*, 1999; Grau *et al.*, 2001) and to evaluate the effect of the antioxidants.
20 Marusich *et al.* (1975) found that vitamin E concentrations in turkey liver and
21 breast muscles were 1/5 and 1/3 respectively, of those from broilers fed similar
22 dietary levels. In more recent studies, some authors pointed out that turkey meat
23 has a weak ability to store α -tocopherol in cell membrane phospholipids (Wen *et al.*,
24 1997); in consequence, longer periods of supplementation or higher doses of
25 antioxidant could be necessary to reach similar levels as with other kinds of

1 poultry (Sklan *et al.*, 1983; Morrissey *et al.*, 1998). Sklan *et al.* (1983) suggested
2 that the low levels of vitamin E could be due to a high production and excretion of
3 tocopheryl glucuronides in turkey.

4 The accumulation of vitamin E in legs was more than twice that in breasts
5 even in the control group that received only 30 mg/kg of vitamin E from the basal
6 diet (Table 1). Some authors (Jensen *et al.*, 1998; Gatellier *et al.*, 2000) have
7 reported that leg muscles are prone to oxidative processes and, therefore, showed
8 higher activities of antioxidant enzyme system (Table 2) and displayed higher
9 general antioxidant status than breast in agreement with the results obtained with
10 both vitamin E and TBARS levels (Table 3). It is worth noting that TBARS
11 values are higher in leg than in breast muscles and antioxidant supplemented
12 treatments (T2 and T3) showed significantly lower TBARS levels than the control
13 group in both types of muscles (Table 3).

14 Vitamin E content in muscles from turkeys supplemented only with α -
15 tocopheryl acetate (T2) increased ($P < 0.05$) compared with control samples (T1),
16 whereas no significant differences in vitamin E levels were found between
17 samples from T3 (birds fed on diets supplemented with 50 mg of α -tocopheryl
18 acetate/kg plus 15 mg of β -carotene/kg) and T1. These results suggest that the
19 presence of β -carotene in the diet seems to limit the accumulation of α -tocopherol
20 in turkey muscles.

21 **Sensory evaluation**

22 The effects of antioxidant supplemented diets on sensory parameters (2 flavour
23 parameters and 5 texture attributes) of cooked, 24 h stored and reheated turkey
24 samples are shown in Table 4. WOF and rancidity attributes were not
25 significantly affected by experimental treatments. Samples from treatments 2 and

1 3 showed a tendency to lower WOF values than samples from control group. The
2 same trend was observed in rancidity scores from leg muscles. This tendency was
3 not detected in breast samples, possibly because of the action of the β -carotene
4 supplementation. These results may indicate that vitamin E was present in the
5 correct quantity to reduce oxidation, since TBARS values were significantly
6 lower, but not at a sufficient level to protect meat from rancidity and WOF
7 detectable by trained panellists.

Table 4 near here

8 Few significant differences were observed in the texture attributes
9 assessed. Breast samples did not presented any statistical differences between
10 treatments. A tendency to a high degree of hardness and stringiness, and less
11 juiciness was observed in breasts from T2. Significant differences were found in
12 pastiness and stringiness evaluations of leg muscles. The stringiness was lower in
13 leg muscles of turkeys fed with antioxidant supplemented diets compared to
14 control samples ($P < 0.05$), whereas T3 presented significantly higher pastiness
15 than control group. An early study (Sárraga and García Regueiro, 1999) about the
16 relationship between membrane lipid oxidation and cysteine proteinases in broiler
17 breasts suggested that cathepsins B and L activities were favoured by vitamin E
18 supplementation. These enzyme activities are closely related to texture of meat
19 and meat products (Arnau *et al.*, 1998; Gil *et al.*, 1999). In this sense, higher
20 proteolytic activity could have produced greater pastiness as a result of the protein
21 breakdown and lower stringiness caused by the myofibrillar structure breakdown.

22 In summary, a dose and a longer supplementation time might be necessary
23 for turkeys to achieve equivalent perception of quality and protection against
24 oxidative stress as in our previous studies with broilers (Carreras *et al.*, 2004).
25 Given the effectiveness of vitamin E dietary supplementation for poultry and the

1 resultant improvement in overall meat quality, along with the modern trends that
2 lead consumers to avoid food rich in saturated fatty acids, it would be interesting
3 to evaluate the commercial potential and cost effectiveness of these nutritional
4 methods.

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Table 1. *Composition and stimated nutrient content of the basal diets*

Ingredient	0 to 4 weeks (g/kg)	5 to 8 weeks (g/kg)	9 to 12 weeks (g/kg)
Wheat	418.34	484.63	564.77
Lard	34.09	39.78	60.00
Soybean meal 48%	473.63	416.18	328.16
Extruded soybean	20.0	20.0	-
DL-methionine	2.27	1.69	1.16
L-lysine	0.37	0.95	1.90
Calcium carbonate	19.50	11.09	22.63
Dicalcium phosphate	23.64	18.46	15.01
Sodium chloride	3.74	3.18	2.38
Choline chloride 50%	0.42	0.04	-
Monensin (mg/kg)	90	90	-
Minerals and vitamins ¹	4.00	4.00	4.00
ME (MJ/kg)	11.7	12.1	12.55
Crude protein (g/kg)	280	260	220
Crude fibre (g/kg)	31	31	28

¹One kg of feed contained the following: retinol, 4128 µg; cholecalciferol, 60 µg; all-rac- α -tocopheryl acetate, 30 mg; menadione, 3 mg; thiamine, 2.2 mg; riboflavin, 8 mg; pyridoxine, 5 mg; cyanocobalamin, 11 µg; folic acid, 1.5 mg; biotin, 150 µg; calcium pantothenate, 25 mg; nicotinic acid, 65 mg; Mn, 60 mg; Zn, 40 mg; I, 0.33 mg; Fe, 80 mg; Cu, 8 mg; Se, 0.15 mg; ethoxyquin, 150 mg.

Table 2. GSHPx¹ (nmol NADPH/min per mg protein), CAT (μmol H₂O₂/min per mg of protein) and SOD (units of SOD/mg of protein) activities in tissues from turkeys fed supplemented diets²

	GSHPx			CAT			SOD		
	Breast	Leg	RMSE	Breast	Leg	RMSE	Breast	Leg	RMSE ³
T1	6.14 ^x	10.70 ^x	1.70	0.17 ^{bx}	0.67 ^x	0.20	3.58	4.01	0.55
T2	5.95 ^x	11.50 ^x	1.35	0.21 ^{abx}	0.69 ^x	0.20	3.44	4.09	0.95
T3	6.12 ^x	11.40 ^x	1.60	0.25 ^{ax}	0.76 ^x	0.30	3.42	4.11	0.70
RMSE³	1.03	1.37		0.06	0.10		0.32	0.47	

^{ab}Means within the same column not sharing a common superscript are significantly different ($P < 0.05$).

^xMeans within the same row treatment and enzyme differ significantly ($P < 0.05$) between tissues.

n = 10 for each dietary treatment.

¹GSHPx: glutathione peroxidase; CAT: catalase; SOD: superoxide dismutase.

²Experimental treatments: **T1**: basal diet; **T2**: basal diet supplemented with 50 mg of α-tocopheryl acetate/kg of diet; **T3**: basal diet supplemented with 50 mg of α-tocopheryl acetate plus 15 mg of β-carotene/kg of diet.

³RMSE: root mean square error.

1 **Table 3.** *α -Tocopherol ($\mu\text{g/g}$ of tissue) concentration and TBARS¹ (nmol of*
 2 *MDA/mg of tissue) values in tissues from turkeys fed on supplemented diets²*
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 4

	Vitamin E			TBARS		
	Breast ^x	Leg ^x	RMSE	Breast ^x	Leg ^x	RMSE ³
T1	0.66 ^b	1.61 ^b	0.14	0.13 ^a	0.51 ^a	0.08
T2	0.80 ^a	2.06 ^a	0.27	0.08 ^b	0.27 ^b	0.09
T3	0.70 ^{ab}	1.74 ^b	0.14	0.09 ^b	0.28 ^b	0.14
RMSE³	0.12	0.24		0.03	0.15	

5
 6 ^x All means values were statistically different ($P < 0.05$) between tissues in all
 7 treatment and for both parameters determined.

8 ^{ab}Means within the same column not sharing a common superscript are
 9 significantly different ($P < 0.05$).

10 n = 10 for each dietary treatment.

11 ¹ TBARS: Thiobarbituric-reactive substances; MDA: malonaldehyde.

12 ² Experimental treatments: **T1**: basal diet; **T2**: basal diet supplemented with 50 mg
 13 of α -tocopheryl acetate/kg of diet; **T3**: basal diet supplemented with 50 mg of α -
 14 tocopheryl acetate plus 15 mg of β -carotene/kg of diet.

15 ³ RMSE: root mean square error.

1 **Table 3.** Flavour and texture descriptors in cooked tissues from turkeys fed
 2 supplemented diets¹
 3

	Breast				Leg			
	T1	T2	T3	RMSE ³	T1	T2	T3	RMSE ³
Rancidity	1.9	1.4	1.9	0.7	1.6	1.5	1.3	1.2
WOF²	2.4	2.2	2.1	0.6	3.5	3.0	2.1	1.5
Juiciness	3.4	3.2	3.4	0.6	3.2	3.5	2.8	1.1
Hardness	3.8	4.2	3.8	0.9	4.5	4.2	4.7	1.3
Pastiness	2.6	2.4	2.4	0.8	1.6 ^b	2.0 ^{ab}	2.7 ^a	0.9
Stringiness	3.3	3.6	3.3	0.8	4.6 ^a	3.6 ^b	3.5 ^b	1.0
Tooth adhesion	3.3	3.0	3.1	0.5	3.4	2.4	2.9	1.0

4
 5 ^{ab}Means within the same column not sharing a common superscript are
 6 significantly different ($P < 0.05$).

7 Breasts: n = 10 for each dietary treatment. Legs: n = 6 for each dietary
 8 treatment.

9 ¹ Experimental treatments: **T1**: basal diet; **T2**: basal diet supplemented with
 10 50 mg of α -tocopheryl acetate/kg of diet; **T3**: basal diet supplemented with
 11 50 mg of α -tocopheryl acetate plus 15 mg of β -carotene/kg of diet.

12 ² WOF: warmed-over flavour.

13 ³ RMSE: root mean square error.