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Effects of the Dietary Supplementation of Sucupira (Pterodon Emarginatus Vog.) and Copaiba (Copaifera Langsdorffii) Resinoils on Chicken Breast and Thigh Meat Quality and Oxidative Stability

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■Keywords

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ABSTRACT

An experiment was conducted to evaluate the addition of the oil resins of *sucupira* (*Pterodon emarginatus* Vog.) and copaiba (*Copaifera langsdorffii*) to broiler diets on chicken meat composition, quality, and lipid peroxidation. 350 one-d-old broiler chicks were submitted to seven treatments, consisting of the diets supplemented with copaiba (COP) or *sucupira* (SUC) resin oils at three different concentrations (500, 900, and 1300 ppm) plus a negative control diet (CONT). At 37 days of age, 10 birds per treatment were selected according to the average weight of the experimental unit and slaughtered to collect breast and thigh meat, which was stored at 4°C for 24 hours to evaluate pH, color (L*, a*, b*), cooking weight loss (CWL), and shear force (SF). Raw meat was vacuum packed and stored frozen until lipid peroxidation analysis. Meat samples were pooled to prepare pre-cooked meatballs (30 ± 0.5g), stored under refrigeration (eight days), and analyzed every two days for TBARS concentration. Results were analyzed using the PROC GLM and MIXED procedures (SAS statistical software). Plant oils increased ($p<0.05$) breast meat humidity (HU) and crude protein (CP) levels and reduced ($p<0.05$) total lipid (TLC) and ash (AS) levels when compared with the CONT treatment. Plant oils increased ($p<0.05$) thigh meat HU when compared with the CONT. High COP dietary levels reduced ($p<0.05$) breast meat CWL, and increased ($p<0.05$) thigh meat L* values when compared to CONT, except for SUC500 and SUC900. The dietary inclusion of plant oil resins showed a pro-oxidant effect ($p<0.01$) on breast meat when compared with the CONT. Low SUC dietary supplementation levels significantly reduced ($p<0.01$) the concentration of secondary oxidation products in thigh meat.

INTRODUCTION

Oxidation is a natural process of cell metabolism that leads to the formation of free radicals. It normally occurs in the cytoplasm, primarily inside the mitochondria as a result of phosphorylation (Cardenas & Davies, 2000). However, when it occurs in a disorganized manner, it triggers a chain reaction with the uncontrolled formation of free radicals, which will negatively affect proteins, DNA, carbohydrates, pigments, vitamins and particularly lipids, and originate toxic volatile and non-volatile components (Min & Ahn, 2005; Lynch & Faustman, 2000; Kanner, 1994).

The susceptibility of meat to lipid peroxidation depends on several factors, such as animal species, muscle type and anatomical location. For instance, broiler meat is more sensitive to oxidation than red meat because it has a higher polyunsaturated fatty acid content. Also, chicken thigh meat has a higher lipid content, and therefore, it is more prone to oxidation compared with breast meat (Melton, 1983; Cortinas *et al*., 2004).

The process of meat lipid peroxidation probably starts immediately after slaughter. The biochemical changes that occur during the conversion of muscle into meat associated with the content of polyunsaturated fatty acid and the processing operations applied in the industry such as grounding, cooking and the addition of salt, promote meat oxidation, resulting in progressive degradation. This oxidative stress causes an imbalance between pro-oxidant and antioxidant meat contents, accelerating meat degradation (Morrisey *et al*., 1998; Araújo*et al.*, 2007; Gandemer, 2002).

Meat lipid peroxidation negatively affects meat nutrient content and leads to the production of volatile and non-volatile toxic substances, such as aldehydes, ketones, and alcohols, which are compounds that cause off-color, off-flavor (rancidity, warmed-over flavor), and off-odor changes, reducing the shelf life of meat and meat products (Gayatán *et al*., 2010).

Therefore, in an attempt to prevent meat degradation, antioxidant compounds may be supplemented in animal diets. Natural antioxidants are an alternative to the use of synthetic compounds, which have restricted use since reports indicate they pose risks to human health, such as hepatotoxicity and cancer (EU, 2012). Natural antioxidants derived from plants, especially those from the Brazilian Cerrado biome, have high antioxidant potential (Anand & Sati, 2013; Passoto *et al*., 1998).

The dietary supplementation of plant extracts is an efficient means to prevent meat peroxidation, because natural antioxidants are metabolized by the body and subsequently incorporated directly into the muscle. In addition, several research papers report an additional increase of α-tocopherol levels in the muscle of many animal species as a consequence of natural antioxidant dietary supplementation (Kim *et al*., 2006; Smet *et al*., 2008; Liu *et al*, 2010; Haak *et al*., 2008).

The plants *sucupira* (*Pterodon emarginatus* Vog.) and copaiba (*Copaifera langsdorffii*) are commonly found in the Cerrado biome. The oil resin extracted from both plants is composed of isoflavones, sesquiterpenes and diterpenes, which are phenolic compounds with high antioxidant capacity, specially their main component ß-caryophyilene (Dutra *et al.*, 2008; Herrero-Jáuregui *et al*., 2011).

Therefore, the objective of this study was to evaluate the antioxidant capacity of *sucupira* and copaiba oil resins supplemented in broiler diets on lipid peroxidation and on chicken breast and thigh meat quality.

MATERIAL AND METHODS

Sucupira and copaiba oil resins

The copaiba oil resin was mechanically extracted directly from the woody portion of the trees, while *sucupira* oil was produced by cold pressing of the seeds, obtaining 15% crude oil yield. Both oil resins were obtained in collaboration with a regional cooperative of sustainable production in Central Region of Brazil.

Oil resins were analyzed to determine their purity and then were standardized at the Natural Products Research Laboratory (Pharmacy Department, Federal University of Goiás, UFG), located in Goiânia, Brazil. Copaiba and *sucupira* oil resins contained 21.31% and 7.36% β-caryophyllene, respectively.

Birds and diets

The experimental procedures were approved by the Ethics Committee of UFG under protocol n. 030/2012 UFG/CEUA.

The experiment was conducted according to a completely randomized experimental design in 2x3 factorial arrangement (2 plants: SUC and COP; 3 dietary addition levels: 500, 900 and 1300 ppm), and a negative control treatment, totaling seven treatments, with five replicates of 10 birds each.

In total, 350 one-d-old male Cobb500® broilers were housed at the experimental facilities of the Veterinary Department, UFG, state of Goiás, Brazil. Birds were housed in distributed in 35 galvanized steel battery cages (0.5 m x 0.4 m x 0.4 m) at 10 birds per cage, which represented an experimental unit. Water and feed were supplied *ad libitum* in trough drinkers and feeders. The lighting program consisted of 23 hours of light plus one hour of darkness. For environmental control, 60W lamps were used for brooding until 14 days of age, plastic side curtains for the control of environmental temperature.

Birds were fed diets based on corn and soybean meal formulated to supply their nutritional requirements during pre-starter, starter and grower phases, according to Rostagno *et al*. (2011).

The dietary treatments consisted of a negative control diet (CONT, Table 1), and of the supplementation of three different *sucupira* and copaiba oil resin levels mixed with soybean oil and added to the CONT diet at the expense of corn starch, as follows: 500 mg of *sucupira* (SUC500) or copaiba (COP500) oil resin/kg of feed; 900 mg of *sucupira* (SUC900) or copaiba (COP900) oil resin/kg of feed; and 1,300 mg of *sucupira* (SUC1300) or copaiba (COP1300) oil resin/kg of feed.

Table 1 – Ingredient composition and calculated nutritional values of the basal diets, according to rearing phase.

Ingredients	Pre-starter (1-7days)	Starter (8-21 days)	Grower (22-37 days)
Ground corn	55.29	59.82	62.05
Soybean meal	38.25	34.67	31.54
Soybean oil	2.05	1.88	2.99
Dicalcium phosphate	1.90	0.99	1.28
Limestone	0.90	1.24	0.85
Salt	0.50	0.49	0.45
DL-Methionine 99%	0.36	0.29	0.26
L-Lysine HCl	0.29	0.21	0.19
Corn starch	0.20	0.20	0.20
L-threonine 98%	0.11	0.06	0.04
Vitamin Suplement[1]	0.10	0.10	0.10
Mineral Suplement[2]	0.05	0.05	0.05
Calculated Values			
Metabolizable energy (kcal/kg)	2,950	3,000	3,100
Crude Protein (%)	22.20	20.80	19.50
Digestible Lysine (%)	1.31	1.17	1.07
Digestible Methionine+Cystine	0.94	0.84	0.78
Calcium (%)	0.92	0.81	0.73
Available Phosphorus (%)	0.47	0.39	0.34
Sodium (%)	0.22	0.21	0.20

[1]Supplied per kg of supplement: 3,125,000 IU Vitamin A; 550,000 IU Vitamin D3; 3,750 mg Vitamin E; 625 mg Vitamin K3; 250 mg Vitamin B1; 1,125 mg Vitamin B2; 250 mg Vitamin B6; 3,750mg Vitamin B12; 9,500 mg niacin; 3,750 mg calcium pantothenate; 125 mg folic acid; 350,000 mg DL-methionine; 150,000 mg choline chloride 50%; 50 mg selenium.

[2]Suppliedper kg of supplement: manganese 150,000mg; zinc 100,000mg; iron 100,000mg; copper 16,000mg; iodine 1,500mg.

Meat Samples

When broilers were 37 days old, 10 birds per treatment were selected according to the average bodyweight of the pen, and transported in crates inside an open truck to a commercial processing plant (state inspection n. 0221-98) located 47 km from the city of Goiânia. Broilers were slaughtered under commercial conditions, according to the Brazilian legislation (Brasil, 2000).

Breast was deboned, and thighs were separated from the carcass, identified according to treatments, packed in plastic bags, and immediately transported on ice to the Animal Nutrition Laboratory (UnB), located in Brasília, DF, Brazil.

Meat composition

The chemical composition of raw samples of breast and thigh meat was determined in triplicate. Moisture, crude protein, and ash contents were analyzed according to the AOAC (1990), and total lipid content according to the AOAC (1995).

Meat pH and color

After transportation, meat samples were stored under refrigeration (4°C) for24 hours, after which the pH and color of each breast and thigh meat sample were evaluated in triplicate. The pH was recorded using a portable pH meter (Testo®), and color (CIELAB System: L* = lightness, a* = redness and b* = yellowness) was measured using a Konica-Minolta colormeter (Chroma Meter CR-400).

Meat tenderness

Meat tenderness was evaluated by cooking weight loss (CWL) and shear force (SF) applied in breast meat only. Approximately one third of the right portion of *Pectoralis major* muscle from each bird was analyzed 24 hours *post mortem*. Ten samples per treatment were cut into 2.5-cm diameter cubes. For CWL determination, samples were weighed and cooked in an electric oven, preheated to 170°C, until 70°C internal temperature monitored with a Termopar thermometer (Testo®) inserted in the center of the cube presenting the average weight of the batch. After reaching the desired internal temperature, the cubes were cooled and weighed to calculate CWL. The cubes were then packed and stored in a refrigerator overnight. Shear force was evaluated as described by Froning & Uijttenboogaart (1988). Cylindrical samples measuring 1.27-cm diameter were cut from the meat cubes parallel to the muscle fibers. The samples were cut perpendicular to the fiber using a Warner-Bratzler® texture analyzer with a V type of blade, 1.016-cm thickness, and fixed speed of 20 cm/min. Results were presented in percentage (%) for CWL and in kg-force (kgf) for SF.

Meat lipid peroxidation

The remaining samples of breast and thigh meat were vacuum packed in oxygen-impermeable bags and stored frozen until two storage trials were carried out to evaluate the progress of lipid oxidation in breast and thigh meats individually.

Defrosted breast or thigh meat samples were minced and 0.5% of food grade salt was added to produce meatballs weighing 30 g (± 0.5 g). Meatballs were vacuum packed and precooked in water bath at 100°C for 10 minutes, according to Racanicci *et al*. (2004). Meatballs were repacked in oxygen-permeable bags and stored chilled at 4°C in the dark for eight days. Secondary lipid peroxidation products were evaluated on days 0, 2, 4, 6 and 8 of storage by quantification of malondialdehyde using TBARS (thiobarbituric

acid reactive substances). TBARS was determined in duplicate in two meatballs per treatment, according to Madsen *et al*. (1998). Absorbance was measured at 532 and 600 nm, using Gehaka model UV-340G spectrophotometer. Results were expressed in µmols of malondialdehyde (MAD) per kg of meat, using an 1,1,3,3-tetraethoxypropane (TEP) standard curve.

Statistical Analysis

Dietary chemical composition, CWL, and SF data were analyzed using general linear model procedure (PROC GLM); whereas color (L*, a*, b*), pH, and TBARS data were analyzed using mixed procedure (PROC MIXED) of SAS 9.3 (SAS®) statistical software. In the analyses of lipid peroxidation results, storage period was considered a longitudinal factor (0, 2, 4, 6, and 8 days) in the PROC MIXED, with fixed effects for treatments and random effects for storage period. Lipid peroxidation results were fit to a linear regression model.

RESULTS AND DISCUSSION

Meat Composition

Averages of the evaluated breast meat composition parameters are shown in Table 2. The humidity (HU), ash (AS), and crude protein (CP) contents obtained in this study are consistent with the 74.8% HU, 1% AS, and 21.5% CP values presented in the Brazilian Table of Food Composition (NEPA, 2011). Although total lipid content (TLC) observed in the present experiment is not in agreement with the findings of Torres *et al*. (2000), the averages are similar to those described in the National Food Database (USDA, 2012).

The inclusion of the oil resins in the diet resulted in a significant HU increase ($p<0.05$) and in a significant TLC decrease ($p<0.05$) in the breast meat, when compared with the CONT diet. Ash content (AS) of the SUC500, COP900 and COP1300 diets were significantly lower ($p<0.05$) than that of the CONT diet, but similar to other treatments. On the other hand, diets with the oil resins presented higher CP content ($p<0.05$) relative to the CONT diet, except for the SUC500 and SUC900 diets.

Table 3 shows the average chemical composition of thigh meat. The obtained HU and TLC average results (72.21-75.62% HU and 4.51-6.14% TLC) are consistent with those obtained by Novello *et al*. (2008), but higher than those reported by Torres *et al*. (2000).

In the present study, the treatment COP900 promoted the highest HU content ($p<0.05$) in thigh meat when compared with other treatments, including CONT, which yielded the lowest HU value. Average CP contents were similar among treatments, except for COP1300, which resulted in the highest CP value ($p<0.05$). In addition, dietary treatments did not affect TLC values, except for SUC900, which resulted in the lowest TLC value ($p<0.05$).No differences in AS content were detected among treatments.

It is important to remember that many factors, such as genetics and nutrition, may influence the chemical composition of meat, especially CP and TLC contents (Lonergan *et al*., 2003; Wang *et al*., 2013), and may have contributed for the differences found between the results of this study and other literature reports.

Meat Quality

Breast meat quality results are described in Table 4. Averages values of pH, luminosity (L*), redness (a*), and yellowness (b*) were not affected by treatments, as previously reported by Leonel *et al*. (2007), when evaluating the supplementation of vitamin E in broiler diets. Similarly, the supplementation of broilers diets with oregano (3%) did not affect meat pH values, as described by Young *et al*. (2003). On the other hand, Simitzis *et al*. (2011) reported a significant ($p>0.05$) meat pH reduction with the supplementation of hesperidin, a bioflavonoid, in broilers diets.

Table 2 – Average chemical composition (humidity, HU; ashes, AS; crude protein, CP; and total lipid content, TLC) of breast meat samples, expressed as a percentage (%) of natural matter (NM).

Treatment*	HU	AS	CP	TLC
CONT	$74.16^{f} \pm 0.01$	$1.62^{a} \pm 0.01$	$22.88^{c} \pm 0.03$	$1.00^{a} \pm 0.00$
SUC500	$74.66^{b} \pm 0.01$	$1.57^{b} \pm 0.00$	$22.86^{c} \pm 0.15$	$0.83^{bc} \pm 0.02$
SUC900	$74.71^{a} \pm 0.01$	$1.60^{ab} \pm 0.00$	$23.33^{bc} \pm 0.13$	$0.83^{b} \pm 0.03$
SUC1300	$74.55^{c} \pm 0.01$	$1.60^{ab} \pm 0.00$	$23.65^{ab} \pm 0.10$	$0.82^{bc} \pm 0.02$
COP500	$74.44^{d} \pm 0.00$	$1.59^{ab} \pm 0.01$	$23.85^{ab} \pm 0.02$	$0.81^{bc} \pm 0.03$
COP900	$74.25^{e} \pm 0.02$	$1.57^{b} \pm 0.02$	$24.10^{a} \pm 0.17$	$0.73^{c} \pm 0.01$
COP1300	$74.68^{ab} \pm 0.00$	$1.57^{b} \pm 0.01$	$23.67^{ab} \pm 0.04$	$0.87^{b} \pm 0.01$

^{a,b,c} Means with different letters in the same row are statistically different ($p<0.05$).

* Negative control without antioxidants (CONT) or dietary supplementation of500, 900, or 1300 ppm of *sucupira* (SUC) or copaiba (COP) oil resins.

Table 3 – Average chemical composition (humidity, HU; ashes, AS; crude protein, CP; and total lipid content, TLC) of thigh meat samples, expressed as a percentage (%) of natural matter (NM).

Treatment*	HU	AS	CP	TLC
CONT	74.45^{e} ± 0.01	1.48 ± 0.00	20.13^{b} ± 0.04	4.77^{a} ± 0.09
SUC500	74.88^{b} ± 0.01	1.51 ± 0.01	19.90^{b} ± 0.01	4.63^{a} ± 0.12
SUC900	74.70^{cd} ± 0.02	1.50 ± 0.00	19.88^{b} ± 0.12	4.15^{b} ± 0.07
SUC1300	74.65^{d} ± 0.02	1.48 ± 0.01	19.86^{b} ± 0.07	4.66^{a} ± 0.09
COP500	74.88^{b} ± 0.01	1.49 ± 0.00	19.50^{b} ± 0.10	4.57^{a} ± 0.03
COP900	74.98^{a} ± 0.00	1.47 ± 0.01	20.16^{b} ± 0.32	4.69^{a} ± 0.10
COP1300	75.74^{c} ± 0.01	1.50 ± 0.01	20.87^{a} ± 0.10	4.60^{a} ± 0.02

^{a,b,c} Means with different letters in the same row are statistically different ($p<0.05$).

* Negative control without antioxidants (CONT) or dietary supplementation of 500, 900, or 1300 ppm of *sucupira* (SUC) or copaiba (COP) oil resins.

Average lightness values (L*) obtained in this study (Table 4) ranged between 48 and 50, and therefore, can be considered normal, according to Qiao *et al*. (2001) findings (normal = 48 < L* > 53).The treatments did not influence L*, a* and b* values, which are consistent with the results of Zhang *et al*. (2012), when evaluating the supplementation of broilers diets with different levels of α-tocopherol acetate.

The addition of oil resins affected ($p<0.05$) cooking weight loss of the breast meat samples, with the lowest value (11.90) obtained with the supplementation of COP900.On the other hand, the breast meat of broilers fed the SUC1300 and COP500 diets presented higher CWL values (20.95 and 20.58) compared with those fed the CONT diet (14.51). Overall, these values are different from those reported by Almeida *et al*. (2002) and Castro *et al*. (2008), but are consistent with the results of Barbut *et al*. (2005), who determined11.25% CWL in chicken breast meat classified as normal. In the present study, SF averages were not affected by treatments.

According to Aaslyng *et al*. (2003), there is a correlation between pH and CWL, in which lower pH values are associated with reduced water holding capacity in poultry meat. Therefore, higher CWL values are expected when meat presents reduced pH values (Northcutt *et al*., 1994; Shafey *et al*., 2014). However, this correlation was not detected in breast meat in the present study (Table 3), because, although the dietary addition of SUC oil resin influenced CWL ($p<0.05$), no meat pH changes were detected. This correlation may not have been detected due to the influence of other factors on meat CWL, such as cooking, mincing, and chilling (Bouton *et al*., 1971; Cheng & Sun, 2008).

It is well established that CWL and SF values are related to breast meat tenderness and water holding capacity when it is submitted to heat, maintaining water inside intramuscular fibers (Müller *et al*., 2012). Therefore, it seems that the increase in dietary SUC oil resin levels negatively affected ($p<0.05$) CWL; on the other hand, the results suggest that the increase in dietary COP levels may improve meat tenderness.

No significant pH differences ($p>0.05$) were detected among treatments, as shown in Table 5. These values are consistent with the results of Mirshekar *et al*. (2009), who evaluated the dietary supplementation of 1,000 ppm of rosemary, echinacea, green tea extracts, and ascorbic acid on meat quality, and did not find any broiler meat pH differences (pH 6.29 to 6.37). On the other hand, the addition of copaiba oil resin (COP500,

Table 4 – Average pH, color (L*, a*, b*), cooking weight loss (CWL), shear force (SF) values and their respective standard deviation in breast meat samples.

		Color				
Treatment*	pH	L*	a*	b*	CWL	SF
CONT	5.95	48.00	3.19	6.87	14.51^{bc}	1.76
SUC500	6.03	49.15	2.99	7.58	15.28^{bc}	1.82
SUC900	6.04	48.05	3.44	6.99	17.49^{ab}	2.08
SUC1300	6.00	48.48	3.98	6.97	20.95^{a}	1.93
COP500	6.01	49.12	2.38	5.60	20.58^{a}	1.63
COP900	5.99	49.08	2.54	5.78	11.90^{d}	1.33
COP1300	5.97	50.40	3.44	6.14	13.56^{cd}	1.74
Stand. Dev.	0.05	1.25	0.86	1.02	1.23	0.66

^{a,b,c} Means with different letters in the same row are statistically different ($p<0.05$).

* Negative control without antioxidants (CONT) or dietary supplementation of 500, 900, or 1300 ppm of *sucupira* (SUC) or copaiba (COP) oil resins.

900, and 1300), as well as SUC1300, resulted in higher ($p<0.05$) L* averages compared with the CONT diet. In general, thigh meat L* average values in the present study are lower than those reported by Mirshekar *et al*. (2009), of 60.80 to 65.20 after 24 *post mortem*, but are close to those obtained by Leonel *et al*. (2007) when evaluating the effects of vitamin E supplementation (300mg/kg) on chicken meat quality (L*: 46.56-48.32).

Table 5 – Average pH, color (L*, a*, b*), cooking weight loss (CWL), shear force (SF) values and their respective standard deviation in thigh meat samples.

		Color		
Treatment*	pH	L*	a*	b*
CONT	6.41	47.71^{c}	10.80	8.17
SUC500	6.38	48.51^{bc}	10.47	8.53
SUC900	6.50	48.42^{bc}	11.14	8.76
SUC1300	6.49	49.09^{ab}	11.98	8.77
COP500	6.47	49.85^{a}	12.19	8.23
COP900	6.35	49.55^{a}	11.98	8.70
COP1300	6.38	49.92^{a}	12.24	8.70
Stand. Dev.	0.06	0.41	0.94	0.35

^{a,b,c} Means with different letters in the same row are statistically different ($p<0.05$).

* Negative control without antioxidants (CONT) or dietary supplementation of 500, 900, or 1300 ppm of *sucupira* (SUC) or copaiba (COP) oil resins.

In this study, the dietary addition of SUC and COP oil resins did not affect ($p>0.05$) thigh meat a* and b* values, as previously described by Mirshekar *et al*. (2009); however, the redness (a*) values detected by latter were slightly lower (8.23 to 9.53).

Lipid peroxidation

Malondialdehyde (MAD) concentration was measured in breast and thigh meatballs on days 0, 2, 4, 6, and 8 of storage under refrigeration. The results are shown in Figures 1 and 2, respectively. As expected, TBARS increased for all treatments during the storage period.

On day zero (Figure 1), the breast and thigh meat of broilers fed the COP500, COP900, and COP1300 diets presented lower ($p<0.0001$) MAD levels when compared with those fed the CONT diet. Similar results were detected for the treatments SUC500, SUC900, and SUC1300 in the breast meat ($p<0.0001$). However, TBARS thigh meat values were not affected by the SUC treatments.

Figure 1 shows that the TBARS values of the breast meat balls derived from broilers fed the SUC diets increased ($p=0.0020$) from day 2 of storage, suggesting a pro-oxidant effect as the dietary concentration of the oil resin of this plant increased. On day8, the dietary inclusion of SUC and COP – particularly of SUC900 – significantly increased ($p=0.0912$) TBARS levels compared with the CONT diet.

Relative to thigh meat (Figure 2), the COP1300 treatment resulted insignificantly lower ($p=0.0344$) TBARS concentration of than the CONT treatment on day 4. On day 8, the treatments with low SUC and COP concentrations (SUC500 and COP500)

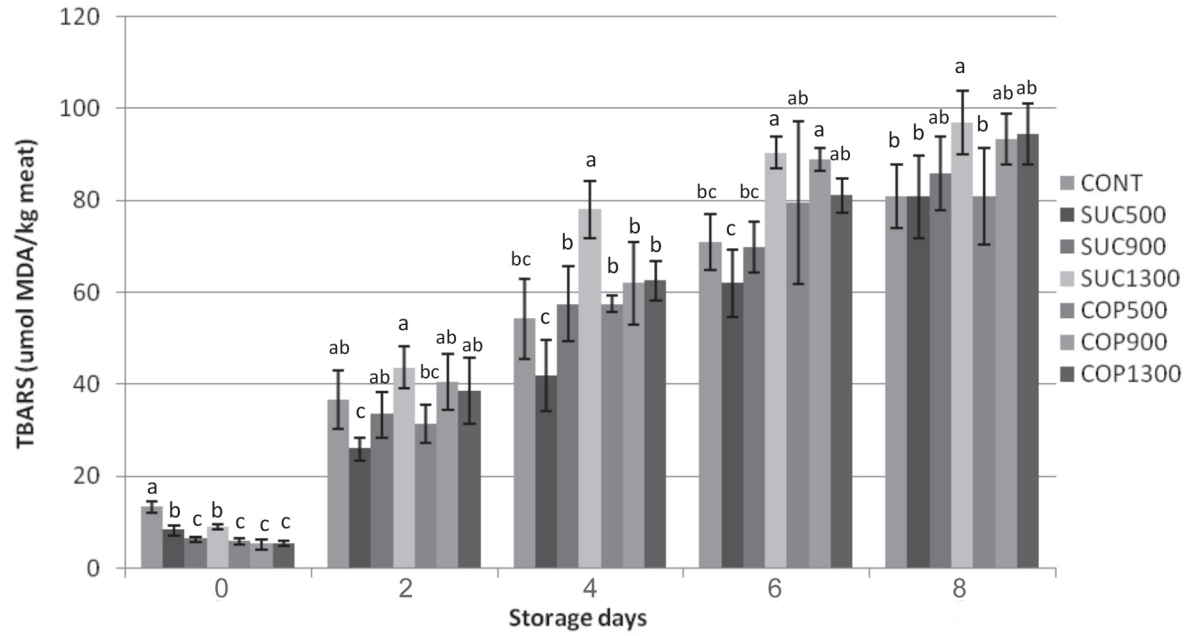

Figure 1 - Secondary compounds of lipid peroxidation (TBARS, µmol MDA/kg meat) in precooked breast meatballs during chilled storage (0, 2, 4, 6 e 8 days).* Negative control without antioxidants (CONT) or supplementation of 500, 900 and 1300 ppm of *sucupira* (SUC) or copaiba (COP) oil resin.^{a,b,c} Means with different letters in the same day are statistically different ($p<0.1$).

promoted significantly lower ($p<0.1$) TBARS values when compared with the CONT. However, meat MDA concentration increased as the dietary levels of both oil resins increased. These results indicate that the supplementation with the lowest dosages of SUC and COP may be effective for the prevention of lipid peroxidation in thigh meat.

Smet *et al*. (2008) evaluated the effect of the dietary supplementation of different concentrations of green tea (100 and 200mg/kg) on the quality of raw chicken breast meat patties stored under refrigeration at 4°C for 10 days. The authors verified a significant pro-oxidant effect ($p<0.05$) with the inclusion of the high dose (200mg/kg) of green tea extract when compared with the low dose.

Previous studies indicated SUC and COP oil resins present *in-vitro* and *in-vivo* antioxidant effect due to the composition of these extracts, with high concentrations of phenolic compounds, especially sesquiterpene compounds, such as ß-caryophyllene (Romero, 2007; Desmarchelier *et al*., 2000; Dutra *et al*., 2009; Maciel, 2002). It is well established that the antioxidant capacity of phenolic compounds is related to their molecular structure (Fukumoto & Mazza, 2000). In addition, the antioxidant efficacy of these compounds increases with the number of hydroxyl groups. However, the study of Brazilian plants as sources of natural antioxidants is a relatively new topic, and therefore, information relative to their phenolic composition and to the *in-vitro* and *in-vivo* antioxidant activity of SUC and COP oil resins is very limited. Therefore, further studies are needed to determine *sucupira* and copaiba oil resin inclusion levels in broiler diets and their influence on meat sensorial properties.

CONCLUSION

The dietary supplementation of broilers with *sucupira* oil resin did not improve meat physical quality; however, the addition of copaiba oil resin to the diet resulted in lighter thigh meat and lower cooking weight loss of breast meat, suggesting it effectively retains water inside muscle fibers, possibly improving meat texture and enhancing meat tenderness.

The addition of *sucupira* oil resin did not promote antioxidant protection of precooked breast meat during storage. However, the addition of 500 mg of *sucupira* and copaiba oil resins reduced the lipid peroxidation of precooked thigh meat, suggesting antioxidant activity.

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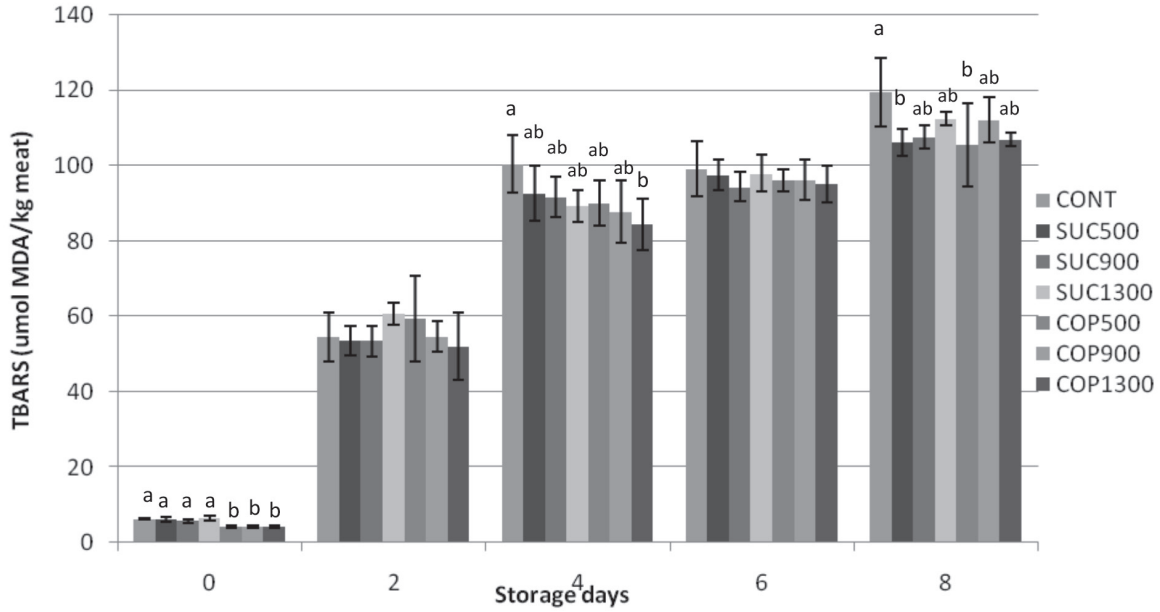

Figure 2 - Secondary compounds of lipid peroxidation (TBARS, µmol MDA/kg meat) in precooked thigh meatballs during chilled storage (0, 2, 4, 6 e 8 days).* Negative control without antioxidants (CONT) or supplementation of 500, 900 and 1300 ppm of *sucupira* (SUC) or copaiba (COP) oil resin. [a,b,c] Means with different letters in the same day are statistically different ($p<0.1$).

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