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Original Article

Effect of the Supplementation of Plant Extracts Based Additive in Broiler Chicken Diets on Productive Performance, Carcass Yield, and Meat Quality

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■Keywords

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ABSTRACT

The study aimed to evaluate the effect of supplementation of an additive based on plant and spice extracts in broiler chicken diets on the productive performance, carcass yield, and meat quality. 704 male broiler chicks were distributed in a completely randomized experimental design with 4 treatment, 4 replicates of 44 broiler chickens each. The experimental diets consisted of Diet 1: Control diet; Diet 2: Control diet + antibiotic growth promoters (AGP); Diet 3: Control diet + vegetable extracts (100 g/ton) and Diet 4: Control diet + vegetable extracts (150 g/ton). The vegetable extracts used were carvacrol, cinnamaldehyde, and eugenol extracted from oregano, cinnamon, and cloves. The supplementation of vegetal extracts did not affect (p>0.05) broiler chickens' productive performance or carcass yield. The lipid peroxidation (MDA nmol/mg protein) in the meat *in natura* was decreased (p<0.05) for broilers supplemented with vegetable extracts. The supplementation of 100 or 150 g/ton of vegetal extracts based on carvacrol, cinnamaldehyde, and eugenol did not affect broiler chickens' productive performance, carcass characteristics, and meat quality, and inhibited MDA production in broilers' *in natura* meat.

INTRODUCTION

The rapid rise and increase in intensity in the production of broiler chickens have increased the challenge of searching for alternatives capable of providing improvement in the productive parameters of performance, carcass yield, benefits to animal health, and improvements in the quality of meat. Consumers' pressure and worries regarding the harmful effects of antibiotic growth promoters (AGP) use and the ban of antibiotics in the EU have prompted researchers to think about alternatives to antibiotics (Mehdi *et al.*, 2018). The aim of these alternatives is to maintain a low mortality rate and a good level of animal yield, while preserving the environment and consumer health. Much research has been carried out to look for natural products with similar beneficial effects to those of growth promoters.

Plant extracts have been studied as an interesting strategy for the replacement of AGP, since they do not have market restrictions, are considered natural products without risk of residues in the final product, bring health benefits, and also antimicrobial (Hosseinzadeh *et al.*, 2014), anti-oxidant (Hashemipour *et al.*, 2013) and digestive (Hafeez *et al.*, 2015) effects.

Natural plant supplements in poultry diets can be used to enhance antioxidant defence mechanisms and reduce the intensity of oxidation processes, which negatively affect the quality of poultry products (Ognik *et al.*, 2016). Lipid oxidation directly affects the quality of meat, especially chicken meat: due to the high proportion of polyunsaturated

fatty acids (PUFA), there is a greater susceptibility to oxidative processes, especially lipid oxidation (Delles *et al.* 2014). As a result of this process, there occur changes related to color, flavor, formation of toxic compounds, shorter shelf life, loss of nutrients, and water (Contini *et al.* 2014). Consumers' preference continues to grow for high quality products that provide a long period of shelf life and keep sensory and taste characteristics after processing.

The food industry uses synthetic antioxidants to prevent lipid peroxidation, however, despite the benefits, there is evidence of potential carcinogenic effects (National Toxicology Program, 2016), which has raised questions about the safety of the use of these additives.

Koiyama *et al.* (2014) evaluated the addition of a mixture of cinnamon, sage, white thyme, and copaiba essential oils, associated or not to the plant extracts mixture of rosemary, cloves, ginger, and oregano, finding similar performance results to use of AGP. Silva *et al.* (2011) found similar results when they evaluated the essential oil of rose pepper. Fascina *et al.* (2012) reported higher carcass yields when the diet of broiler chickens was supplemented with a *blend* of plant extracts and organic acids.

Although there is sufficient literature on the growth promoting effects of plant extracts, the number of published studies on the effects on meat quality and carcass characteristics is still very limited. Therefore, this study aimed to evaluate the effect of the supplementation of plants extracts based products in broiler chicken diets on the productive performance, carcass yield, and meat quality.

MATERIAL AND METHODS

The experiment was carried out in the Experimental Poultry of Federal University of Paraná - Palotina. The project was evaluated and approved by the Ethics Committee on animal use. 1408 broiler chicks of Cobb Slow lineage were distributed in a completely randomized experimental design, with 1 control treatment and 3 diets, totalizing 4 treatments with 8 replicates of 44 broiler chickens per box (12.5 kg/m²).

The experimental diets consisted of Diet 1: Control diet; Diet 2: Control diet +AGP; Diet 3: Control diet + vegetable extracts (100 g/ton); and Diet 4: Control diet + vegetable extracts (150 g/ton).

The AGP used was enramycin at a dose of 125 g/ton of AGP (Enramax® - Farmabase Animal Health Ltd.) and the of additive based on plant and spice extracts used consists of carvacrol, cinnamaldehyde, and eugenol extracted from oregano, cinnamon, and cloves, respectively, at the doses of 100 and 150g/ton of feed (Oleobiotec® - Phodé Solutions).

The room temperature was maintained within the range of thermal comfort. The temperature was controlled and gradually reduced from 32 °C to 23 °C on day 42. The broiler chickens received water and food *ad libitum* during the entire experimental period of 42 days.

The nutritional program was divided into three stages: initial (1 - 18 days of age), growth (19 - 35 days of age), and slaughter (35 - 42 days of age). The experimental rations, based on corn meal and soybean meal, were formulated to meet the nutritional requirements of the different stages in accordance with the recommendations of the local agroindustries (Table 1).

For the calculation of growth performance, broiler chickens were weighed at 7, 21, 35, and 42 days, as well as the remainder of the supplied ration, for the evaluation of average weight, weight gain, feed intake, and feed conversion. Feed conversion was corrected by weekly mortality of broiler chickens according to the methodology described by Sakomura & Rostagno (2007).

At 42 days, carcass yield was determined in 3 birds per replicate pen (24 birds/treatment). Birds with body weights closest to the average body weight of the pen were submitted to pre-slaughter fasting for 6 hours, duly identified, euthanized by electric stunning (11 V and 11 mA for 11 seconds), and killed manually. This included cutting the carotid artery and jugular vein, followed by scalding (53.8 °C for 2 min), feathering, and eviscerating, following the MAPA normative instruction (BRASIL, 2000).

The weight considered for carcass yield calculation was that of the warm eviscerated carcass, without feet, head and abdominal fat, relative to the live weight obtained individually before slaughter of birds. Cut yields were calculated in relation to the weight of the eviscerated carcass. Abdominal fat present around the cloaca, cloacal bursa, gizzard, proventriculus, and adjacent abdominal muscles was removed. It was then weighed and also calculated based on the eviscerated carcass weight.

24 breasts/treatment were used for the analyzes of meat quality properties. The breasts were placed in the decubitus position and the pH was measured in the cranial portion of the right Pectoralis major muscle, 1 hour after the slaughter.

Table 1 – Composition and calculated nutritional levels of the experimental diets.

Ingredients, Kg/T	Initial[1]	Grower[2]	Slaughter[3]
Corn	550	617	640
Soybean Meal	390	329	300
Meat Meal	20	18	14
Soybean Oil	16	15	26
Dicalcium phosphate	5.00	5.00	5.00
Limestone	6.40	5.20	5.40
Salt	3.20	3.90	3.80
Methionine (DL, 98%)	2.85	2.15	1.95
Lysine (L, 70%)	-	-	0.220
Threonine (L, 98%)	0.380	0.550	0.300
Sodium bicarbonate	2.00	-	-
Choline Chloride	0.180	0.440	0.400
Premix starter[1]	3.00	-	-
Premix grower[2]	-	3.00	-
Premix finisher[3]	-	-	3.00
Maxiban 80/80	0.500	0.500	-
Kaulim[4]	0.300	0.300	0.300
Nutrients			
ME (Kcal/Kg)	2.960	3.051	3.147
CP (%)	23.64	21.19	19.83
Calcium, %	0.943	0.847	0.793
Available Phosphorus, %	0.448	0.429	0.401
Lys Dig. %	1.157	1.008	0.942
Met+Cys Dig. %	0.919	0.796	0.746
Thr Dig. %	0.817	0.750	0.681
Trp Dig. %	0.255	0.224	0.209
Leuc Dig. %	1.777	1.633	1.551
Ile Dig. %	0.937	0.829	0.772
Val Dig. %	1.005	0.900	0.842
Arg Dig. %	1.464	1.291	1.198

[1]Level by kg of initial premix: Vitamin A (KUI / KG 4,000.00); Vitamin D3 (KUI / KG 1,167., 000); Vitamin E (UI/kg 10,000.00) Vitamin K3 (mg/kg 1,000.00); Vitamin B1-Thiamine (mg/kg 1,000.00); Vitamin B2 - Riboflavin (mg/kg 2,666,666); Vitamin B6 - Pyridoxine (mg/kg 1,667.00); Vitamin B12 - Cyanocobalamin (mg/kg 6,666.00); Pantathenic acid (mg/kg 6,000.00) Niacin (mg/kg 13,000.00); Folic Acid (mg / kg 833.33); Biotin (mcg/kg 80,000.00); Manganese (ppm 40,000.00); Zinc (ppm 33,333.33); Iron (ppm 23,333.00); Copper (ppm 2,666.67); Iodine (ppm 333.33); Selenium (ppm 80.00); Ethoxyquin (mg / kg 22,200.00); Phyzyme phytase (g / kg 16,667); AXTRA XAP 101 TPT (g/kg 33,333.00). 2Level by kg of growth premix: Vitamin A (KUI/KG 3,000.00); Vitamin D3(KUI/KG 1,000.000); Vitamin E (UI/kg 8,333.33) Vitamin K3 (mg/kg (1,000); Vitamin B1-Thiamine (mg/kg 800.00); Vitamin B2 -Riboflavin (mg/kg 2,166.667); Vitamin B6 - Pyridoxine (mg/kg 1,400.00); vitamin B12-Cyanocobalamin (mg/kg 5,000.00); Pantathenic Acid (mg/kg 5,000.00) Niacin (mg/kg 11,666.667); Folic Acid (mg/kg 500.00); Manganese 70,000.00 33,333.00 (ppm); Zinc (ppm 26,666.00); Iron (20,000.00 ppm); Copper (ppm 2,666.67); Iodine (333.33 ppm); Selenium (ppm 80.00); Ethoxyquin (mg/Kg 22,200.00); Phytase Phyzyme (g/kg 16,667). 3Level by kg of slaughter premix: Vitamin A (KUI/KG 2,333.00); Vitamin D3(KUI/KG 834,000); Vitamin E (UI/kg 6,667.000) Vitamin K3 (mg/kg (1,000); Vitamin B1-Thiamine (mg/kg 600.00); Vitamin B2 -Riboflavin (mg/kg 1,667.000); Vitamin B6 - Pyridoxine (mg/kg 1,167.00); vitamin B12-Cyanocobalamin (mg/kg 4,000.00); Pantathenic Acid (mg/kg 4,000.00) Niacin (mg/kg 10,000.000); Folic Acid (mg/kg 334.00); Manganese 66,667.00 33,333.00 (ppm); Zinc (ppm 26,666.00); Iron (20,000.00 ppm); Copper (ppm 2,666.67); Iodine (333.33 ppm); Selenium (ppm 80.00); Ethoxyquin (mg/Kg 33,333.00); Phytase Phyzyme (g/kg 16,667). The inert product was replaced by Enramycin or Oleobiotec, according to the recommendations.

For the evaluation of drip loses, the methodology of Boccard *et al.* (1981) was followed. The right *Pectoralis minor* muscle was weighed, suspended by hooks of galvanized steel in polyethylene bags, kept under refrigeration for 24 hours, and then weighed to obtain the percentage of drip loses.

The water loss by pressure was performed using a sample of the cranial portion of the left *Pectoralis major* (breast fillet) of approximately two grams, with similar thickness (0.5 cm). The samples were placed between two filter papers and pressed by two acrylic plates, with a weight of 10 kg for five minutes. After pressing, samples were weighed again to obtain the percentage of water loss by pressure (Wilhelm *et al.*, 2010).

A sample of approximately 30 grams of the caudal portion of the *Pectoralis major* muscle was used to perform the test for water loss by freezing. The samples were weighed, frozen for 24 hours, thawed, and weighed (Galobart & Moran Jr, 2004).

For the analysis of cooking loses, approximately 90 grams of the median portion of the left *Pectoralis major* were subjected to cooking inside polyethylene bags through water bath for 60 minutes at 80°C. After cooking, the samples were chilled for 24 hours for later weighing and obtaining the percentage of cooking loses (López *et al.*, 2011).

For the analysis of color, the breast was refrigerated for 24 hours and the right *Pectoralis major* muscle was exposed for 30 minutes so that there was reaction of myoglobin with atmospheric oxygen. After this step, there were three readings per sample by means of the portable colorimeter apparatus (Konica Minolta, Color reader CR10, Mahwah, the USA) on the ventral surface of the right *Pectoralis major* muscle. The values of luminosity (L*) and indices of red (a*) and yellow (b*) were expressed in the CIELAB color system.

To measure the effect of plant extracts on the oxidative stability of chicken meat, fragments of breasts were removed for analysis of the thiobarbituric acid reactive substances (TBARS) resulting from lipid oxidation of the samples. The analyzes were performed immediately after slaughter and 60 days after freezing. The samples were stored in a falcon tube and packed in a freezer; according to an adaptation of the methodology described by Vyncke (1970). After the thawing of the sample, sub-samples of 10g were extracted, which were homogenized with 50 mL of trichloroacetic acid (TCA) 7.5%. The supernatant was filtered and aliquots of 4 ml were treated with 5 ml of solution of thiobarbituric acid (TBA) and placed in a boiling bath, cooled, and measured in a spectrophotometer at 538 nm. The result is expressed in milligrams of malondialdehyde (MDA) per kilogram of sample.

The results obtained in the experiment were tabulated and analyzed using analysis of variance (ANOVA) of the procedure General Linear Model (GLM) with the aid of the statistical program SAS (2002, SAS Institute Inc., Cary, NC) and when significant, the averages between the treatments were compared by the Tukey test.

RESULTS AND DISCUSSIONS

Growth performance

The use of an additive based on plant and spice extracts in the diet didn't show significant difference (p>0.05) for average weight, weight gain, ration intake, and feed conversion of broiler chickens when compared with a conventional growth enhancer and with the control diet, in none of the periods of growth assessed (Table 2).

The research was carried out in an experimental poultry house, with new poultry litter and prior disinfection of all equipment and the facility; therefore presenting low immune challenge and low microbial load. The use of alternative additive growth promoters such as plant extracts must be evaluated according to the sanitary conditions of birds and facilities. In situations of sanitary control, the use of such products may be dispensable; on the other hand, in challenging sanitary situations, different doses and combinations of these plant extracts should be studied because of their various advantages for the productive chain.

Upon testing a mixture of plant extracts composed of cloves, thyme, cinnamon, pepper, and oregano, Rizzo *et al.* (2010) also found a similar performance to that related to the diet with AGP. Ramos *et al.* (2014) supplemented the rations for broilers with additives as an alternative to the conventional use of antimicrobials and found no significant differences in productive performance.

Plant extracts represent a new class of additives in poultry feed. Their uses are still limited in relation to their mode of action and aspects of application. According to Alloui *et al.* (2014), complications may be encountered due to various changes in botanical origins, transformations, and compositions of plants

Table 2 – Effect of supplementation of plant extracts based additive in broiler chicken diets on the productive performance for 42 days.

		1-7 days		
Diets	Live weight, g	Weight gain, g	Feed intake, g	Feed conversion
Control diet	177.08	133.67	154.08	1.163
Control diet + AGP	175.64	132.04	151.92	1.151
Control diet + VE (100g/t)	174.96	131.79	154.39	1.172
Control diet + VE (150g/t)	171.97	128.82	152.49	1.186
CV, %	2.970	3.720	3.320	3.220
p value	0.577	0.581	0.886	0.619
		1-21 days		
Control diet	920.90	870.36	1186.43	1.363
Control diet + AGP	913.09	863.97	1174.49	1.360
Control diet + VE (100g/t)	920.54	880.31	1189.07	1.352
Control diet + VE (150g/t)	863.31	818.81	1134.13	1.385
CV, %	3.37	3.63	3.49	2.12
p value	0.06	0.07	0.25	0.44
		1-35 days		
Control diet	2232.73	3360.46	2176.44	1.544
Control diet + AGP	2131.65	3262.24	2082.53	1.567
Control diet + VE (100g/t)	2163.19	3300.13	2122.96	1.555
Control diet + VE (150g/t)	2076.43	3179.48	2031.93	1.565
CV, %	4.630	4.840	3.940	2.130
p value	0.218	0.278	0.190	0.813
		1-42 days		
Control diet	2876.10	2819.81	4576.00	1.622
Control diet + AGP	2780.11	2730.99	4455.17	1.631
Control diet + VE (100g/t)	2820.62	2780.39	4502.42	1.619
Control diet + VE (150g/t)	2734.57	2690.06	4401.69	1.636
CV,%	3.670	3.770	4.430	1.740
p value	0.301	0.356	0.656	0.816

CV: coefficient of variation, AGP: antibiotic growth promoter, VE: vegetable extracts.

and their extracts. Most commercial products are comprise various active compounds, and their physiological impacts and effects on production performance can be different. Phytogenic compounds can improve digestive enzyme activity, nutrient absorption, and antioxidant and antimicrobial activities (Raza *et al.*, 2019). Additionally, other effects such as anti-inflammatory, anti-fungal, anti-infectious, and antitoxigenic have been confirmed in some researches (Young *et al.* 2003, Rizzo *et al.* 2010, Hong *et al.* 2012, Alloui *et al.* 2014, Yang *et al.* 2018, Raza *et al.*, 2019).

The carvacrol extracted from oregano has a high capacity to degrade the membrane of Gram-negative bacteria by affect its permeability, allowing the migration of ions and other compounds and resulting in a homeostatic imbalance that leads to the death of the bacteria (Bajpai *et al.* 2013).

There was no significant difference (p>0.05) in the absolute weights of carcass, commercial cuts, and abdominal fat at 42 days of age (Table 3). This result, associated with that obtained for productive performance, demonstrates that the removal of AGP can have a smaller negative impact than expected.

The addition and natural compounds added to the broiler diet can potentially contribute to improving growth performance, since they can contribute to improving digestive function through many modes of action, such as reducing intestinal pH, promoting beneficial bacterial growth, or inhibiting the growth of pathogenic microbes that can be harmful to the health of the animal (Yang *et al.* 2018).

Similar results were found by Rizzo *et al.* (2010), who tested different complexes of plant extracts in increasing levels and also found no difference in carcass characteristics when compared to a control diet without addition of growth promoters. Hong *et al.* (2012) highlight the relevance of the dosage of essential oil, the type of basal diet, the health status, the stress factors, and supply conditions for the responses of performance in studies with plant extracts.

Fascina *et al.* (2012) also reported higher carcass yields when using a mixture of plant extracts composed of turmeric extract, citrus and grape seed extract, essential oil of Chinese cinnamon, boldo do chile leaves, fenugreek seeds, and a mixture of organic acids in the diet of broiler chickens. Despite not having observed differences in carcass yield, Isabel & Santos (2009) reported that the breast yield was significantly higher in chickens that received 100 ppm of mixture of cloves and cinnamon, in comparison to the use of organic acids. Lara *et al.* (2010) found no significant difference for the carcass yields of broilers receiving treatments with plant extracts and positive control with flavomycin.

There is great interest and expectation that alternative additives maintain the zootechnical indexes obtained with the use of AGP and can replace them. However, when the animal is raised in an environment with good sanitary conditions, combined with a balanced diet that meets its nutritional requirements, the necessary conditions for expressing its protein deposition genetics to the maximum are present, and it is therefore questionable whether the use of any additive growth promoter is needed.

Meat quality

There was no significant effect of the diets on improving meat quality. The effects on meat quality of

Table 3 – Effect of supplementation of plant extracts based additive in broiler chicken diets on the absolute weight and relative weight commercial cuts and abdominal fat of broilers.

Diets	Carcass	Breast	Legs	Wings	Fat
			Absolut weight (g)		
Control diet	2412.21	975.75	726.42	233.33	32.73
Control diet + AGP	2353.13	960.08	698.96	229.67	30.65
Control diet + VE (100g/t)	2368.91	981.13	695.13	233.43	32.77
Control diet + VE (150g/t)	2329.29	957.00	689.88	227.71	32.91
CV, %	6.53	10.26	6.03	7.60	29.22
p value	0.2978	0.7758	0.2065	0.5050	0.9993
Diets			Relative weight (%)		
Control diet	78.21	40.39	30.14	9.68	1.35
Control diet + AGP	78.41	40.76	29.73	9.76	1.30
Control diet + VE (100g/t)	77.87	41.37	29.37	9.86	1.39
Control diet + VE (150g/t)	78.36	40.97	29.67	9.78	1.42
CV, %	1.71	5.09	4.19	6.20	31.44
p value	0.5854	0.7493	0.2007	0.7226	0.7986

CV: coefficient of variation, AGP: antibiotic growth promoter, VE: vegetable extracts.

the supplementation of plants extracts based additive in broiler diets are shown in Table 4.

The addition of natural extracts to the diet can have a positive influence on meat quality. In such circumstances, supplementation with extracts rich in compounds with bioactive potential could inhibit the negative effects on performance and partially alleviate oxidative stress, consequently improving meat quality (Leskovec *et al.* 2019).

The pH is one of the most important factors in the transformation of muscle in meat and has a decisive effect on the quality of fresh meat and derived products (Petracci & Cavani, 2012). However, in this study, the technological properties, pH, drip loses, Pressure, Cooking loses, and freezing loses were not influenced (p>0.05) by the experimental diets.

This is not in accordance with studies that report that the addition of bioactive compounds to the diet can improve the resistance of the technological properties of meat, such as color, texture, and water holding capacity (Ognik *et al.*, 2016).

Young *et al.* (2003) tested a combination of ascorbic acid (1000 ppm) and α-17tocopherol (200 ppm) or oregano (3%) on stressed and not stressed broiler chickens and verified that the activities of antioxidant enzymes (catalase, superoxide dismutase, and glutathione peroxidase) in the breast muscles and liver were positively affected by the supplementation, reducing the oxidant activities generated by stress. On the other hand, similarly to the results of the present study, Park & Kim (2019) observed no effect of dietary *Achyranthes japonica* extract supplementation on the pH, cooking loss, WHC, or drip loss of breast meat.

The color of the meat directly impacts the sensorial quality of meat and stands out as a major factor for consideration at the time of purchase, ranging from gray shading to pale (Costa *et al.*, 2011). Color is usually expressed by three components: brightness, L * luminosity; redness, a *; and yellowing, b *. The results of the analyzes of color 24 hours after slaughter on broiler breast did not present significant effects on the parameters evaluated.

Chouliara *et al.* (2007) found no difference in the color of fresh meat of chicken breast after supplementation with plant extracts. Similarly Mirshekar *et al.* (2009), upon evaluating the effect of supplementation of 1000 ppm of extracts of rosemary, equinacea, green tea, and ascorbic acid on the quality of the meat, did not detect differences in the spectra of color a* and b*. Once again, this matches the results of the present study.

The supplementation of plant extracts based additive in broiler diets had effect (p<0.06) on lipid peroxidation. The *in natura* breast meat of broilers supplemented with plant extracts presented higher levels of MDA (nmol/mg protein) than broilers with diets supplemented with AGP. However, this effect was not observed on the meat after freezing (Table 4). As MDA, the thiobarbituric acid reactive substances (TBARS) is an indicator of meat oxidation status (Raza *et al.* 2019). The plant extracts used in the present study considerably inhibited MDA production and can be used to reduce lipid peroxidation and adverse free radical effects on *in natura* meat of broilers. Associated to loss of nutritional quality, as well as taste changes, lipid oxidation is a major reason for consumer rejection and loss of meat quality during storage (Guyon *et al.*, 2016).

According to Grau *et al.* (2001), to the extent that the temperature is reduced, the physical and biochemical reactions that lead to the sensory changes begin to occur at reduced speed. Freitas *et al.* (2012) tested ethanolic extract from mango pits in dosages of 200 and 400 ppm and showed that there was a delay of lipid oxidation of meat of chickens, the level of 400 ppm being more efficient. Belenli *et al.* (2016) found decreased lipid oxidation in broiler chicken thighs through the measurement of MDA when they were

Table 4 – Effect of supplementation of plant extracts based additive in broiler chicken diets on TBARS (MDA nmol/mg protein) values and meat quality parameters.

Diets	pH	Pressure (%)	Cooking (%)	Drip (%)	Freezing (%)	L*	a*	b*	MDA *in nature*	MDA freezing
Control diet	5.90	9.37	49.76	1.11	4.22	57.46	1.84	9.16	0.104^{ab}	0.088
AGP	5.88	8.69	51.04	1.22	4.12	59.11	2.00	8.85	0.138^{a}	0.078
VE (100g/t)	5.95	9.01	50.48	1.24	3.92	59.40	1.50	9.19	0.078^{b}	0.089
VE (150g/t)	5.92	10.92	49.92	1.09	3.94	57.94	1.96	7.86	0.088^{b}	0.094
CV %	4.15	27.53	4.87	19.28	39.40	5.97	56.92	21.08	39.18	28.57
p value	0.9389	0.3633	0.6006	0.2633	0.9684	0.2168	0.4247	0.1389	0.0600	0.3581

CV: coefficient of variation, AGP: antibiotic growth promoters, VE: vegetable extracts.

Means followed by distinct letters in the column differ from each other by the 5% Tukey test.

supplemented with an additive based on watercress seed.

New studies with plant extracts on diets of broilers reared under conditions of environmental stress may show satisfactory results due to the antioxidant potential of these additives for the improved oxidative stability of chicken meat (Placha *et al.* 2014).

The results obtained in several studies about supplementation of plants extracts can be inconsistent. The content of active substances in phytogenic feed additives may vary widely, depending on the plant part used, harvesting season, and geographical origin. The technique for processing (such as cold expression, steam distillation, extraction with nonaqueous solvents or no) modifies the active substances and associated compounds within the final product (Windisch *et al.*, 2008; Alloui *et al.*, 2014).

The phytogenic feed additives may add to the set of nonantibiotic growth promoters for use in broilers diet, such as organic acids and probiotics. However, good management practices, nutrition, and biosecurity can be the best tools to maintain maximum performance and meat quality of broiler chickens.

CONCLUSION

The supplementation of vegetal extracts based on carvacrol, cinnamaldehyde and eugenol associated did not affect the broiler chickens' productive performance, the characteristics of carcass, and meat quality.

The plants extracts used in the present study considerably inhibited MDA production in the *in natura* meat of broilers.

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