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Meat quality and color of abdominal fat of broilers fed diets containing cashew nut meal treated with antioxidant

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ABSTRACT. This experiment aimed to assess the influence of diets containing cashew nut meal stored for 35 days and treated at different storage times with 500 ppm butylated hydroxytoluene on the characteristics of breast meat and abdominal fat. The experiment followed a completely randomized design. Treatments consisted of diets containing: untreated cashew nut meal; cashew nut meal treated with antioxidant on zero day of storage, and cashew nut meal treated with antioxidant on 21st day of storage. At 42 days old, broilers were slaughtered. Breast and abdominal fat of each bird were identified, weighed, frozen stored for subsequent analysis. The variables studied were: pH, water holding capacity, cooking losses and shear force, in the meat and color of the meat and of the abdominal fat. Treatments did not affect ($p > 0.05$) the evaluated parameters. However, the yellowness (component b*) of the abdominal fat was higher in birds fed the diet containing meal treated with antioxidant at storage day zero. In conclusion, the cashew nut meal can be stored for 35 days without antioxidant, but in order to achieve intense yellowness in abdominal fat of broilers 500 ppm antioxidant addition is required, at the beginning of storage.

Keywords: alternative food, BHT, physical and chemical characteristics.

Qualidade da carne e cor da gordura abdominal de frangos alimentados com farelo da castanha de caju tratado com antioxidante

RESUMO. O objetivo deste experimento foi avaliar o efeito de rações contendo farelo da castanha de caju com e sem adição de antioxidante butil hidroxitolueno durante 35 dias de armazenamento sobre as características da carne do peito e a cor da gordura abdominal de frangos de corte. O delineamento experimental foi o inteiramente casualizado e os tratamentos constaram de rações contendo: farelo da castanha de caju sem antioxidante, farelo adicionado de 500 ppm de antioxidante no dia zero de armazenamento e farelo adicionado de 500 ppm de antioxidante no 21º dia de armazenamento. Após o abate das aves com 42 dias de idade, o peito e a gordura abdominal foram retirados para análises de pH, capacidade de retenção de água, perdas por cocção e força de cisalhamento na carne e cor na carne e na gordura. Os tratamentos não afetaram os parâmetros avaliados ($p > 0,05$), exceto o valor de b* (intensidade do amarelo) da gordura, que foi maior nas aves alimentadas com farelo tratado com antioxidante no dia zero. O farelo da castanha de caju pode ser armazenado por 35 dias sem antioxidante, porém, para se obter gordura mais amarela o mesmo deve ser tratado com antioxidante no dia zero de armazenamento.

Palavras-chave: alimento alternativo, BHT, características físico-químicas.

Introduction

Brazil is a global reference in poultry agribusiness, highlighting in the production and export of chicken meat. However in order to continue being competitive in the poultry market, it is necessary to maintain the productivity of flocks through investments in health programs, management and nutrition, and provide diversified and practical products with stable quality standards.

Pavan et al. (2003) reported changes in the marketing of chicken meat in recent years, by increasing export and domestic consumption of chicken meat cuts (breast, thigh, drumstick and wing) and processed products (sausage, marinated steak, breaded etc) which add a greater commercial value to the final product.

The breast meat is used to prepare several products such as sausages, hams, etc, reason that justify the concern with its quality and yield (PAVAN et al., 2003). Nevertheless, quality standards of pectoral muscles frequently have undesirable variations (BRESSAN; BERAQUET, 2002) and may be irreversibly affected by biochemical and histological characteristics of muscle fibers (ZAPATA et al., 2006). These anomalies can be detected by means of parameters expressing the meat quality, such as color, pH, juiciness, tenderness, flavor and other hygiene-related (ALMEIDA et al., 2002; LAWRIE, 2005).

The cashew nut meal (CNM) used in animal nutrition is a fat-rich ingredient (35.97%), in which 81.5% correspond to unsaturated fatty acids. In birds, the intake of polyunsaturated fats associated with lypogenesis favors the formation of unsaturated fats, raising the level of these acids in the organism (BONDI, 1988). This increase in polyunsaturated lipids besides changing the consistency of carcass fat (SANZ et al., 1999) also favors the development of oxidative rancidity in meat, reducing its quality (MORRISSEY et al., 1997).

In this context, this study aimed at evaluating the influence of diets containing CNM, treated or not with antioxidant for 35 days of storage, on physical and chemical characteristics of breast meat and color of abdominal fat of broilers.

Material and methods

Analyses on meat quality and color of abdominal fat were conducted at the Laboratory of Food Technology of CCA/UFC and at Embrapa – Tropical Agribusiness between January and March 2006.

Ross broilers were reared in experimental warehouses, and distributed into a completely randomized design with three treatments and eight repetitions of 12 broilers each.

The CNM was acquired from a local industry and separated into three lots to be stored in polyethylene bags under local environmental conditions (28°C mean temperature 75% mean RH). The first lot was stored without adding antioxidant; to the second was added 500 ppm BHT at the beginning of storage; and to the third was added 500 ppm BHT after 21 days of storage. After 35 days of storage, the CNM was analyzed for acidity index (AI) and peroxide index (PI) before being used to prepare the diets.

Broilers fed isonutrients diets based on corn, soybean meal and CNM (15%), according to nutritional requirements relative to each rearing phase. Treatments consisted of diets containing: CNM without addition of BHT (s/BHT); CNM with addition of BHT (500 ppm) on the day zero (BHT/0); and CNM with addition of BHT (500 ppm) on the 21st day of storage (BHT/21).

At 42 days old, after fasting for 6h, eight broilers per treatment, with weights corresponding to the mean of the group ± 100 g, were identified and killed by cervical dislocation followed by exsanguination, scalding (water at 60°C for 3 min.), plucking and evisceration.

Then it was removed the whole breast with bones (muscles *Pectoralis major* and *Pectoralis minor*) and the abdominal fat of each broiler. Abdominal fat was considered all adipose tissue around the cloaca and that attached to the gizzard.

Samples of breast meat and abdominal fat were identified, weighed, packed individually in polyethylene bags and freezer stored (-20°C) until analysis.

Breast samples were removed from the freezer, allowed to partially thaw in refrigerator at 2°C and then the skin of each breast was removed. The color of the samples was determined according to CIE system (L* a* b*), where: L* = lightness; a* = redness and b* = yellowness (BRESSAN et al., 2001).

Pectoral muscles were then hand deboned, being the left muscles collected for analysis of pH and water holding capacity (WHC), and the right muscles, to measure the cooking losses (CL) and shear force (SF) of the meat.

The reading of pH of the meat were performed with a digital potentiometer, with electrode previously calibrated and inserted into three points on the widest portion of the meat (ALLEN et al., 1997).

After determined pH, the breast meat of each broiler was ground in a food processor. Samples were taken from the mass to estimate the WHC of the meat, according to Warriss (2003).

The right breasts were weighed, packed in polyethylene bags and water bath cooked. Through the difference between the weight pre- and post-cooking, it was determined the CL (WATTANACHANT et al., 2004).

SF was determined with small cylinders (1.27 cm diameter) of cooked meat, according to Liu et al. (2004).

The color of the abdominal fat was directly determined on the fat mass, as described above for the breast meat.

Statistical analyses were run with the software Statistical Analysis System (SAS, 2000) using ANOVA and the means were compared by the Dunnett's test (5% probability), considering the diet with CNM without antioxidant during storage as the control treatment.

Results and discussion

Values of acidity (AI) and peroxide (PI) indices determined according to AOAC (1990), in the untreated CNM (s/BHT) and in the CNM treated with antioxidant on the day zero (BHT/0) and on the day 21 (BHT/21), at 35 days of storage, were 6.469 meq 100 g^{-1} and 2.255 meq kg^{-1}; 6.370 meq 100 g^{-1} and 1.956 meq kg^{-1}; and 6.377 meq 100 g^{-1} and 2.013 meq kg^{-1}, respectively.

Results of pH, WHC, CL, and SF of the breast meat of broilers are listed in the Table 1. Diets containing CNM treated with antioxidant at different storage periods had no significant influence ($p > 0.05$) on these variables.

Several studies have proven the muscle pH is strongly associated with animal species, genetic factors, management techniques before, during and after slaughtering and conditions of meat storage, but no report showed the influence of nutritional levels of diets on this characteristic.

Table 1. Mean pH, water holding capacity (WHC), cooking losses (CL) and shear force (SF) in the breast meat of broilers fed diet containing CNM treated or not with 500 ppm BHT during storage period.

Treatments	Breast			
	pH	WHC (mL 100 g^{-1})	CL (%)	SF (kgf-g)
CNM without BHT	6.18	70.93	22.71	1.38
CNM with BHT added at day zero	6.32	89.36	23.03	0.80
CNM with BHT added at day 21	6.28	72.41	21.27	1.01
Mean	6.26	77.57	22.34	1.06
CV (%)	1.96	35.83	7.65	41.39

Several studies have proven the muscle pH is strongly associated with animal species, genetic factors, management techniques before, during and after slaughtering and conditions of meat storage, but no report showed the influence of nutritional levels of diets on this characteristic.

In this experiment, the final pH measured in the meat after 45 days of storage under freezing (-20ºC) varied between 6.1 and 6.3. Lower pH values, 5.91 and 5.98 were obtained by Moreira et al. (2003) and Liu et al. (2004), respectively in broiler breast kept under refrigeration (2 - 4ºC) after slaughtering. These results agree with Zapata et al. (2006) who analyzed pectoral muscle of broilers on the slaughter day and after 30 days of storage, and observed an increase in pH from 5.9 to 6.1 over time of storage.

Although WHC had not been different ($p > 0.05$) between treatments, the highest value (89.36 mL 100 g^{-1}) was found in breast meat of broilers fed diet containing CNM treated with BHT at the beginning of storage period and the lowest value (70.93 mL 100 g^{-1}) in the group whose diet was not treated (Table 1).

The WHC is the capacity of muscle and meat products to keep the water bound under specific processing conditions (ALMEIDA et al., 2002). This property is essential both in meat sold fresh and that intended for industrialization. The reduction in the WHC of meat results in increased exudate released (LAWRIE, 2005), implies losses in cooking yield and in obtaining a meat drier, less tender, less juicy and less tasty (OWENS et al., 2000).

The extent and rate of pH fall post mortem affect the WHC (LAWRIE, 2005), with a positive correlation between these attributes registered in several studies (ALLEN et al., 1997; ZAPATA et al., 2006).

In the present study, data were not submitted to correlation analysis, but it was possible to observe that values of WHC and pH have been directly proportional.

The chicken breast meat presented values of CL within a normal range, according to reports in literature (ALMEIDA et al., 2002; WATTANACHANT et al., 2004; ZAPATA et al., 2006), from 21.27 to 23.03%.

The rapid drop in pH, usually lower than 5.8 in the first 15 min. after slaughter when the carcass is still hot around 35ºC, leads to protein denaturation, giving a pale color to the meat, reduced WHC, and higher CL, characterizing the PSE meat (pale, soft and exudative) (ALLEN et al., 1997). In the meat considered PSE, the content of water lost in cooking is greater than in normal meat (OWENS et al., 2000), which can cause serious damage for companies selling fresh meat or processed meat products.

Sheldon et al. (1997) reported that the supplementation of diets for turkeys with vitamin E inhibited the PSE conditions, due to the antioxidant action of the vitamin in preserving the cell membrane integrity of muscle tissue of the breast.

Based on this assertion, it is possible that the BHT used to protect the CNM against the oxidative rancidity could also act on oxidative stability of cell structures. However this could not be detected in the present study, once no significant difference ($p > 0.05$) was observed between the parameters of meat quality evaluated in broiler breast fed diet containing CNM treated with 500 ppm BHT on the day zero and of animals fed diet with untreated CNM.

The texture or tenderness of meat is the most important quality criterion (LYON et al., 2004; LAWRIE, 2005), perceived by the consumer during chewing, and can be instrumentally measured by the shear force.

According to the literature, factors affecting the texture of meat can be related to the living animal (age, sex, nutrition, exercise, stress before slaughtering, presence of connective tissue, thickness and sarcomere length) and to the conditions during and after slaughtering (electrical stimulation, rigor mortis, carcass cooling rate, maturation, methods and temperature of cooking and final pH).

The SF of the breast of broilers fed diets with CNM treated or not with BHT during the storage varied from 0.81 to 1.39 kgf-g (Table 1), without significant differences ($p > 0.05$).

There is some disagreement in literature relative to limit values of SF to identify the breast meat as tender. Lyon et al. (1985) have used as reference the value of 7.5 kgf-g, above which the meat is considered tough. The great variation in SF values for the pectoral muscle in studies on poultry (ALMEIDA et al., 2002; PAVAN et al., 2003; ZAPATA et al., 2006) indicates the metabolic heterogeneity of muscle tissue after the animal death (DUTAUD et al., 2006).

The softening of the muscle is achieved from structural changes involving pH and action of proteolytic enzymes (LAWRIE, 2005), being required chilling (0°C) of the meat for at least 24h for weakening of muscle fibers (ZAPATA et al., 2006).

Low values of SF found can be related to conditions of meat storage, where the period between slaughtering and freezing (slow process) consists of a reasonable maturation time for chicken meat (ZAPATA et al., 2006).

Diets containing CNM treated or not with BHT in different periods of storage did not affect ($p > 0.05$) the components L*, a* and b* of breast meat color and color components L* and a* of the abdominal fat. However, the component b* of the fat was higher ($p < 0.05$) in broilers fed diets whose BHT was added to the meal on the day zero of storage (Table 2).

Table 2. Color (L*, a* and b*) in the breast meat and in the abdominal fat of broilers fed diets containing CNM treated or not with 500 ppm BHT during the storage period.

Treatments	Color					
	Breast			Abdominal fat		
	L*	a*	b*	L*	a*	b*
CNM without BHT	50.88	3.22	0.61	71.51	5.27	13.84
CNM with BHT added at day zero	50.97	2.56	1.14	70.52	7.05	15.85*
CNM with BHT added at day 21	49.98	3.44	0.89	70.80	6.40	14.20
Mean	50.61	3.07	0.88	70.90	6.24	14.63
CV (%)	5.05	29.70	169.71	2.68	33.15	5.77

L* lightness, a* redness and b* yellowness. *Different from the control by Dunnet's test ($p < 0.05$).

In birds, dietary lipids affect the composition of fatty acids of the body, especially abdominal and intramuscular fats (SANZ et al., 1999; LEESON; SUMMERS, 2001). In agreement with Esteve-Garcia et al. (1999) the types of lipid in the carcass influence the color of the intramuscular fat. Nevertheless, no studies have shown if changes in pigmentation of intramuscular fat do modify the appearance of the breast meat of broilers.

On the other hand, the increase in polyunsaturated fatty acids in fat makes the meat more susceptible to develop oxidative rancidity (CRESPO; ESTEVE-GARCIA, 2001, 2002; SANZ et al., 1999). Free radicals formed during the oxidation process attack new lipids or lipid-soluble substances such as pigments (ENGBERG et al., 1996), affecting the color of the fat of tissues.

Apparently, the composition of the lipid fraction of muscle tissue has a higher proportion of structural lipids, which are less susceptible to the influence of the diet, reason why the color of the breast meat of broilers was not different ($p > 0.05$) between broilers fed diets containing CNM treated or not with BHT (Table 2).

The color is an important attribute of meat quality that influences the consumer acceptance (ALLEN et al., 1998), being a parameter frequently used as indicative of anomalies (LAWRIE, 2005). Defects of color in chicken meat have been a problem to the poultry industry for many years.

Currently, the pH and the value of L* are the main tools used to identify PSE and DFD meat (dark, firm and dry).

Allen et al. (1998) examined the color of chicken meat soon after slaughtering and based on the values of L*, have classified into: dark (L* < 45), normal (45 < L* < 50) and clear (L* > 50). Qiao et al. (2002) determined the component L* of breast meat of broilers, 24h after slaughtering, dividing into: dark (L* < 46), normal (48 < L* < 53) and clear (L* > 53).

In this experiment, the values of L* were within the range of meats characterized as normal (49.98 < L* < 50.88), meaning that diets used had no effect on the color of breast meat of broilers.

Using scores of color to verify the effect of supplementing the diet with vitamin E on the oxidative and sensorial stability of refrigerated (1 and 7 days) or frozen turkey breast meat (30, 90 and 150 days), Sheldon et al. (1997) observed higher amounts of vitamin E in the diet, and therefore in the muscle, may reduce the incidence of PSE defect and improve the meat oxidative stability, regardless of freezing time.

Possibly the BHT used in the treatment of the CNM may have antioxidant effect similar to observed in vitamin E, which incorporated to the cell membrane of the muscle tissue protects cells from the lipid peroxidation.

In relation to the color components a* and b*, values obtained in the present study (Table 2), for breast meat of Ross broilers stored at -20ºC were higher than found by Zapata et al. (2006) for breast meat of poultry of the same breed.

The color component a* is associated with the amount and chemical state of myoglobin, the main pigment of muscle tissue (GENOT, 2003; LAWRIE, 2005). Increases in the values of a* are due to the oxidation of myoglobin during the storage, resulting in browning of the meat (GENOT, 2003).

Antioxidants may prevent the peroxidation of lipids and fat-soluble nutrients, such as carotenoids (LEESON; SUMMERS, 2001), but this effect could not be detected by determining the parameter b* (yellowness), probably by the low content of pigments present in the chicken meat.

Regarding the color component L* of the abdominal fat, the lack of effect of diets containing CNM treated or not with BHT, on the lower intensity of yellow color in broiler fat, has indicated that the oxidative process did not affect the degree of light scattering on the surface of fat (Table 2).

Similarly, the redness (a*) of the abdominal fat of broilers was not influenced by the intake of diets containing CNM treated or not with antioxidant.

On the other hand, the color component b* was higher in the abdominal fat of broilers fed diets containing CNM treated with BHT on the day zero of storage than in those of the control group. This can be related to the action of the antioxidant to block the propagation of free radicals, preserving the pigments and giving a yellower color to the abdominal fat.

Toxic metabolites or fatty acid free radicals formed in the CNM stored for 35 days without antioxidant, seem to have degraded some of these pigments, justifying the lower value of b* (yellowness) found in the fat of broilers of this group (Table 2).

However the efficiency of antioxidants mostly depends on the incorporation of this additive into the food or diet before the start of the oxidation process (LEESON; SUMMERS, 2001). Thus the treatment of CNM with BHT after 21 days of storage had no effect on the preservation of pigments since the component b* of the fat was similar to obtained with the untreated CNM.

Esteve-Garcia et al. (1999) verified a lower yellowness (b*) in the intramuscular fat of broilers fed diets containing greater amount of PUFA compared with the fat of broilers fed diets with predominance of SFA and MUFA. Meantime, increased concentration of vitamin E (natural antioxidant) in the diet has reduced the fat rancidity and increased the amount of β-carotene.

Conclusion

Diets containing 15% of CNM stored for 35 days without antioxidant have no influence on pH, water holding capacity, cooking losses, and shear force of the breast meat of broilers. However, these diets allowed the achievement of abdominal fat with lower intensity of yellow color.

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