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Meat quality of broiler chickens submitted to different times of pre-slaughter fasting

Qualidade da carne de frangos de corte submetidos a diferentes tempos de jejum pré-abate

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Highlights

Meat quality of the male/female chickens was evaluated at different fasting times.
Comparison of meat quality at slaughter, at 35 and 42 days of age.
Fasting times had noeffect on the pH, color and shear strength.
Lipid oxidation was higher after 12 hours of fasting, at slaughter on 42 days of age.
Fasting times were similar with respect to meat quality in both males and females.

Abstract

The influence exerted by different pre-slaughter fasting times on the meat quality of the male and female broilers, slaughtered at 35 and 42 days of age was evaluated, using 128, randomly selected birds from a larger batch, and rearing of the same management and diets. The treatments involved a diet of 4, 8, 12 and 16 h of feed and water restrictions, prior to slaughter. For each fasting time, eight birds of each sex were slaughtered. Meat quality was evaluated by assessing the pH, meat color using a CR400 Minolta Colorimeter, shear force using a Texture Analyzer device (model TA-XT2I) and lipid peroxidation, determined by the thiobarbituric acid-reactive substances method (TBARS). Fasting times and between males and females slaughtered at 35 and 42 days ofage showed no effect and hence no difference (P>0.05) in the pH, color and shear force. With respect to lipid oxidation, no difference was reported between fasting times at 35 days of age and between males and females; however, at 42 days a difference was evident between fasting times, in both males and females, and in 12 and 16 h it was higher whencompared to 4 and 8 h of fasting. The conclusion drawn was that the fasting timesexert no effect on the pH, color and, shear force of the broiler meat. However, the lipid oxidation values were higher after 12 h of fasting in the birds slaughtered at 42 days of age.

Key words: Meat coloring. Shear force. pH. Food withdrawal. Lipid oxidation.

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Resumo

Foi avaliada a influência de diferentes tempos de jejum pré-abate sobre a qualidade da carne de frangos de corte machos e fêmeas, abatidos aos 35 e 42 dias de idade utilizando 128 aves selecionadas aleatoriamente de um lote maior e criadas nas mesmas condições de manejo e dietas. Aves ficaram 4, 8, 12 e 16 horas com restrição alimentar e hídrica antes do abate. Para cada período de jejum foram abatidas oito aves de cada sexo. A qualidade da carne foi avaliada através do pH, cor da carne em aparelho Colorímetro CR400 Minolta, força de cisalhamento em aparelho Texture Analyzer (modelo TA-XT2I) e a peroxidação lipídica, determinada pelo método de substâncias reativas ao ácido tiobarbitúrico (TBARS). Os tempos de jejum entre machos e fêmeas abatidos aos 35 e 42 dias de idade não apresentaram diferença e não houve diferença (P>0,05) no pH, cor e força de cisalhamento. Com relação à oxidação lipídica, não foi encontrada diferença entre os tempos de jejum aos 35 dias de idade e entre machos e fêmeas; entretanto, aos 42 dias ocorreu diferença entre os tempos de jejum, tanto em machos como fêmeas, sendo que nas 12 e 16 horas foi maior quando comparado com 4 e 8 horas de jejum. Conclue-se que o tempo de jejum não exerceu efeito sobre o pH, cor e força de cisalhamento da carne de frango. Entretanto, os valores de oxidação lipídica foram maiores após 12 horas de jejum nas aves abatidas aos 42 dias de idade.

Palavras-chave: Coloração de carne. Força de cisalhamento. Jejum alimentar. Oxidação lipídica. pH.

Introduction

Pre-slaughter food fasting is at present controlled by ordinance 864-2023 (Ministério da Agricultura, Pecuária e Abastecimento [MAPA], 2023), recognized asa crucial stage in broiler chicken production, because it exerts a directeffect onthe meat quality (Castro et al., 2008). This practice has been adopted during the final process of raising broilers with variable times and employed to empty the contents of the digestive tract, thus preventing contamination in the slaughterhouse (Northcutt, 2005). However, this fasting time must not be too long, because the abstinence from food-inducedstress can precipitateundesirable alterations in the meat quality (Langer et al., 2010), which include quantitative and qualitative losses in the carcassesleading to economic losses (Garcia et al., 2008).

The growing industrialization process of chicken meat has raised concerns regarding the effect that fasting exerts on the characteristics of meat quality, particularly in terms of pH, tenderness, cooking loss and its chemical composition (Ali et al., 1999; Beraquet, 1999; Berri, 2000). This finding has kindled interest to the degree thatmore studies have been do neon pre-slaughter stress and changes in the production systems by the food companies, whose sole goal is to prevent any negative public perception of their products (Pereira et al., 2013).

Food restriction in the pre-slaughter fasting phase has primarily resulted in conditions of chronic stress, which cause depletion in the muscle glycogen reserves (Guàrdia et al., 2005). From some studies it appears that there is a relationship between the appearance of changes in meat quality and fasting-induced stress prior to slaughter,

during which the muscle glycogen stores are consumed (Xing et al., 2015). Stress triggers the muscle to enter an anaerobic state, starting metabolism in the absence of oxygen and the outcome of this metabolism is the accumulation of lactic acid, and denaturing proteins, thus lowering the meat quality (Abdalla et al., 1999).

Several changes occur in the meat due to pre-slaughter handling, induced by the denaturation of the myofibrillar and sarcoplasmic proteins in response to sharp drop in pH while the animal carcass remains hot (Olivo et al., 2001; Soares et al., 2002). Due to the stress experienced by the birds, the muscle glycogen stores are depleted and with no reserves at the time of slaughter, which prevents the formation of lactic acid. Consequently, the pH depletion gradually slows down and rigor mortis also develops at as lower rate, resulting in the depreciation of meat quality (Miller, 2002). Pre-slaughter management thus influences the drop in the pH during the post-mortem cycle for the stabilization and transformation of the muscle into meat (Olivo & Shimokomaki, 2002). Thus, pH is an important indicator for evaluating meat quality, and where any alteration in the pH can lower the quality of the processed chicken meat products (Komiyama, 2006).

Meat color can exhibit negative consequences because of the stress the bird is subjected to during pre-slaughter fasting (Castillo, 2001) and this has been the first attribute that the consumer observes. A customer equates meat color to the characteristics of freshness and a healthy product (Troy & Kerry, 2010). The selective absorption of light wavelengths by the meat fibers and their natural pigments, based on the internal and external conditions, and specifically the quantity and chemical state of the pigments, give the meat color its healthy look (Cornforth, 1994).

With regards to the sensory attributes, tenderness and juiciness are the chief factors that consumers of fresh or processed meat desire (Xiong, 2005). Meat tenderness is normally evaluated using instruments that involve driving a blade through a piece of meat, either raw or cooked, of standardized dimensions. The maximum force required to shear the sample is assessed and used as a measure of the tenderness of the meat (Ramos & Gomide, 2009).

Lipids are a crucial ingredient of meat products because of their relationship with the organoleptic qualities, which directly influence the acceptability of the product (Pino, 2005). Lipid oxidation is a process the meat undergoes in which the quality decreases, raising its susceptibility to bacterial deterioration, and inducing organoleptic changes in the aroma, flavor and tenderness. The hydroperoxides formed during this process, aldehydes in particular, are the main one responsible for the loss of the natural aroma in meat frozen for a certain periods of time (Gray et al., 1996).

The aim of this work was to assess the effect of pre-slaughter fasting times on the meat quality of both male and female broilers chickens, slaughtered at 35 and 42 days of age.

Material and Methods

This study was conducted in the Poultry Sector of the Agroveterinary Sciences Center of the State University of Santa Catarina (CAV/UDESC) in Lages/

SC, with the approval of the UDESC Ethics Committee on the use of animals, under Protocol No. 6957021219.

The birds were raised in a conventional positive pressure aviary, under wood shavings, abiding by the recommendations put forward by the breeding management, according to the lineage manual. Water and food were provided *ad libitum,* formulated with corn and soybean meal, in accordance with the recommendations of Rostagno et al. (2017) for the respective phases. All animals during the pre-experimental period were raised in the same environment and received similar management.

The treatments consisted of different pre-slaughter fasting times, with the birds remaining without access to feed and water for 4, 8, 12 and 16 hours. The treatments were evaluated differently in males and females slaughtered at 35 and 42 days of age, using a total of 128 animals and studying eight birds at each fasting period and of each sex. In the 24 hours prior to the slaughter, dividers were placed to separate the treatments from the replicates. At the beginning of the fasting period, the birds were weighed and placed in appropriate transport boxes and, in due time, transported to the slaughter site, located near the aviary where the birds were raised. At the beginning of the fasting period, after 35 days, the males showed average weight of 2.22 kg while the females were at 1.99 kg. At 42 days, the malesweighed 2.92 kg whie the females were around 2.67 kg. Weight reduction was linear, depending upon the duration of fasting, for males at 35 days (y=0.224x+0.996) and 42 days (y=0.247+0.328) and for females at 35 days (y=0.189x+ 1.679) and 42 days (y=0.226x+0.66).

The chickens were euthanized by cervical dislocation according to the recommendations of the Humane Slaughter Guide of the Federal Council of Veterinary Medicine [CFMV] (2013). After scarificing the birds by cutting the jugular artery with a knife, bleeding was performed and then the breasts were removed of the birds, where the pH was measured using the Phâmetro Sentron 1001 device, introducing the penetration electrode directly into the breast of the sample bird; this was then refrigerated, and evaluated 24 hours post the sacrifice, according to the methodology described by Olivo et al. (2001).

To determine the meat color, a Minolta CR400 colorimeter was used, evaluating L* (brightness), a* and b* (CIELAB color system) on the pectoral muscle face, following the methodology described by Olivo et al. (2001), where the CIELAB coloring functions by measuring the intensity of colors in three axes, with L* from black to white, a* from green to red and b* from blue to yellow.

Rectangular blocks of the pectoral muscle samples, each having a cross section and dimensions of 4-5 cm, were sectioned to determine the shear force (Ramos & Gomide, 2009), evaluated on the Texture Analyzer device (model TA-XT2I) which makes the cut using a specific blade for chicken meat at a speed of 20 mm/s, descending until it touches the sample. After the blade was lowered at 2 mm/s, the cut was made perpendicular to the fiber and the force to cut this fiber was measured, and expressed in kgF/cm².

Lipid peroxidation was determined using the method of substances reactive to thiobarbituric acid, as indicated by Vyncke (1970). First, 3 g of the homogenized sample was mixed with 25 mL of trichloroacetic

acid (TCA) solution (37.5g of TCA, 0.5g of EDTA), homogenized for two minutes and filtered. Next, 5 mL of the filtrate was added to the test tube and mixed with 5 mL of 0.02 M TBARS 31 solution (thiobarbituric acid, Milli-Q water). The tubes containing the solution were boiled in a water bath at 90ºC temperature for 40 min, together with the white solution (TBARS solution + trichloroacetic acid solution), cooled under water and brought to optical density (OD) in a spectrophotometer at 532 nm. This analysis quantifies substances reactive to TBA (thiobarbituric acid) formed during lipid peroxidation, mainly malonaldehyde, and is determined by a standard curve (y= 54.134x + 0.0008) constructed from 1,1,3,3 tetramethoxypropane (TMP) and the results are expressed in mgTMP.kg^{-1}.

A completely randomized design was adopted having eight replications in each treatment (fasting time of 4, 8, 12 and 16 h) and each sex, where a sample from each bird was considered an experimental unit. The results were subjected to the analysis of variance and when differences were found, the *Tukey* test (5%) was applied, using the SAS statistical program (Statistical Analysis System Institute [SAS Institute], 1998).

Results and Discussion

No difference (P>0.05) was observed in the pH of the meat between the fasting times in males and females, both at 35 and 42 days of age. No differences (P>0.05) were observed between males and females at the respective ages at the time of slaughter (Table 1).

No difference was observed in the meat color due to fasting times and between males and females (Table 2) at both 35 and 42 days of age. However, Komiyama et al. (2008) observed that the luminosity value (L*) of the birds subjected to a four-hour fast was greater than those who experienced 8, 12 and 16 h of pre-slaughter fasting, emphasizing that very short periods of fasting causes the L value to worsen. Then, Castro et al. (2008) evaluated the effect of different fasting times (3, 6, 9, 12, 15 or 18h) observed that L* values decreased as thefasting time increased, although no statistical difference was evident.

Table 1
PH average at different fasting times (hours) of male and female broilers slaughtered at 35 and 42 days of age

Sex	Fasting times (h)	pH at 35 days	pH at 42 days
Male	4	5,92	5,83
	8	6,08	5,93
	12	5,96	5,93
	16	5,96	5,80
	Probability	0,2471	0,1970
	SEM	0,14	0,08
Female	4	6,03	5,85
	8	5,94	5,90
	12	5,97	5,87
	16	5,99	5,91
	Probability	0,2098	0,3934
	SEM	0,14	0,09
Male x Female	Male	5,98	5,88
	Female	5,95	5,88
	Probability	0.4491	0,9296
	SEM	0,16	010

SEM: Standard error of the mean.

Table 2
Meat color assessed by luminosity (L*, a* and b*) at different fasting times (hours) of male and female broiler chickens slaughtered at 35 and 42 days of age

Sex	Fasting times (h)	L*	a*	b*	L*	a*	b*
		35 days			42 days		
Male	4	55,1	0,28	10,7	57,2	-0,80	13,1
	8	56,1	-0,04	12,2	54,0	0,29	11,6
	12	53,4	0,31	10,2	52,1	-0,54	11,5
	16	52,1	1,63	11,6	54,0	-1,15	11,8
	Probability	0,2179	0,2583	0,3225	0,1395	0,8940	0,3758
	SEM	3,36	1,51	1,96	3,17	1,03	1,49
Female	4	54,1	0,18	12,1	56,6	-0,67	13,8
	8	53,7	1,38	11,2	52,3	0,51	12,7
	12	51,9	0,74	11,0	55,1	-0,51	12,3
	16	52,7	0,51	11,5	53,8	-0,74	12,0
	Probability	0,3666	0,0865	0,5328	0,0880	0,0658	0,1746
	SEM	2,20	0,92	1,61	3,08	1,05	1,94
Male x Female	Male	54,2	0,54	11,2	54,4	-0,47	12,0
	Female	53,1	0,71	11,4	54,7	-0,40	12,7
	Probability	0,1861	0,5908	0,5630	0,7009	0,8315	0,1418
	SEM	3,11	1,25	1,76	3,30	1,12	1,68

SEM: Standard error of the mean.

The L* value is the main parameter that determines the color of the poultry meat. The ideal light range for chicken and turkey fillets is around 49-50 (Barbut et al., 2008). Higher values indicate a lighter color, indicating that the fillets have a low pH (pH<5.6), while values below this range mean that the fillets are darker and have a high pH (pH>5.9). Color is one of the main indicators of the quality of most foods. This sensorial quality strongly influencesthe decision to purchase meat and its acceptance by the consumers. In most cases, color can be considered a good indicator of these properties, which together, will affect consumer choice and determine the handling characteristics, tenderness, juiciness, appearance, yield and cost of the meat products (Garcia et al., 2010).

In the present study, all the L* values fel well within the range considered normal in the literature, according to the classification of chicken meat by Allen et al. (1998) in light (L*>50.0) or dark (L*<45.0) or by Quiao et al. (2001), in light (L*>53), dark (L*<46), or normal (46>L*<53).

Shear strength emained unaffected by fasting times in males and females, with no change between the male and female chickens at either 35 or 42 days of age (Table 3). It was Allen et al. (1998), Bressan and Beraquet (2002), and Fletcher (1991)

who also reported no difference in the shear force related to the fasting times. However, Komiyama et al. (2008) reported a different finidng which indicated a worsening in the shear strength, with four hours of fasting compared to 8, 12 and 16 h of pre-slaughter fasting. According to Mendes and Komiyama (2011), during very short periods of fasting (up to 4 h) the shear force shows a propensity to worsen.

Table 3
Shear strength and TBARS (thiobarbituric acid) at different fasting times (hours) of male and female broilers slaughtered at 35 and 42 days of age

Sex	Fasting times (h)	35 days	42 days	35 days	42 days
Male	4	2,55	1,84	0,44	0,21 b
	8	2,19	2,03	0,42	0,39 b
	12	2,73	2,76	0,32	0,65 a
	16	2,6	2,85	0,52	0,70 a
	Probability	0,1094	0,0898	0,1674	0,001
	SEM	0,77	1,12	0,20	0,11
Female	4	2,51	2,01	0,33	0,22 b
	8	2,89	1,66	0,38	0,37 b
	12	2,55	2,33	0,32	0,58 a
	16	2,87	2,93	0,49	0,65 a
	Probability	0,4970	0,1049	0,2119	0,0001
	SEM	0,61	1,01	0,19	0,16
Male x Female	Male	2,68	2,31	0,41	0,48
	Female	2,53	2,26	0,42	0,46
	Probability	0,2850	0,8464	0,8700	0,7628
	SEM	0,55	0,96	0,24	0,23

*Means with unequal letters on the columns differ statistically by tukey test (5%).
SEM: Standard error of the mean.

Differences were noted in the results of the TBARs analysis between fasting times at 42 days for both males and females; however, no difference was observed between the males and females at the time of slaughter at 35 and 42 days. At 12 and 16 hours, the results were greater compared to the values noted at 4 and 8 hours. In the study by Mahmoud and Edens (2003) it was indicated that oxidative changes in lipids can a rise from stressful conditions.

The difference found between fasting times on day 42 and but not seen on day 35 can be attributed to the greater amount of fat present in the poultry meat, depending on age (Novello et al., 2006), where it is known that as age increases the fat deposited in the

carcasses of the birds also increases and this situation with the presence of greater fat quantity affects the oxidation, with the fasting period observed in this study. Chicken meat is highly susceptible to oxidation because of its composition, which has high levels of unsaturated fatty acids (Vasconcelos et al., 2007) and is the main non-microbial factor responsible for the deterioration of the meat products (Pradhan et al., 2000).

Lipid oxidation is one of the major reasons that causea deterioration in the meat quality, which contributes to degradation in the flavorand the reduced shelf life of the products due to the initiation of peroxidation (Vercellotti et al., 1992). The studies by Brossi et al. (2007) after subjecting the chickens to a situation of heat stress induced in a climatic chamber for two hours at approximately 35°C and relative humidity of 75%, revealed no chemical changes that could be detected by TBARS analysis in the thigh muscle, refrigerated for 1, 7 or 14 days of storage. These results suggest that the TBARS analysis performed on fresh meat may not possess the same sensitivity to the effects of heat stress (Brossi et al., 2009).

Conclusion

Fasting times do not change the pH, color and shear strength of broiler meat. However, lipid oxidation shows a definite rise after 12 hours of fasting, in the broiler chikens slaughtered at 42 days of age; however, no lipid oxidation is observed in birds slaughtered at 35 days of age. The effects of fasting time on meat qualityare similar in both males and female chickens.

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