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Glycolysis Rate Delay in Turkey Breast *Pectoralis major m.* in a Commercial Air Chilling Processing Line and Meat Qualities

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Abstract: The development of *Rigor mortis* (RM) in turkey *Pectoralis major* under routine commercial plant conditions was described. Carcass samples (n = 40) were refrigerated by air chill (AC) in a processing line and the final temperature (T) of 4°C was reached after 7 h *Postmortem* (PM) and the ultimate pH (pHu) of 5.68 was achieved after 24 h PM. For results comparison, carcasses were kept at ambient temperature (AT), averaging 20±2°C and the pHu of 5.67 was reached after 5 h PM. The AC samples presented darker and higher water holding capacity values compared to AT samples after 10 h PM while at 24 h PM these results did not differ between delay and fast glycolysis. Finally, the rate of glycolysis was directly affected by air refrigeration and the fillet samples should be processed at 24 h PM to ensure complete RM onset thus preventing the decrease of meat qualities.

Key words: Meat color, pH curve, temperature, water holding capacity

INTRODUCTION

Cooling is a critical step in animal carcass processing at commercial slaughterhouses, with important effects on meat quality and cost (Jacob *et al*., 2012). In refrigeration systems, the carcasses are cooled rapidly to reduce microbiological proliferation and food safety risks (Honikel, 1998; Mor-Mur and Yuste, 2010). The Brazilian Ministry of Agriculture requires that poultry carcasses be chilled to 4°C or lower for subsequent commercialization of poultry products and meat derived products (Brasil, 1998).

Three technologies are currently commercially available for chilling: immersion chill (IC), air chill (AC) and combi in-line air chill (CIAC) (Demirok *et al*., 2013). The cooling rate affects the biochemical processes within the muscle and influences the meat visual appearance (Ledward, 1985; Rosenvold and Wiklund, 2011), flavor characteristics (Thompson *et al*., 2005), tenderness, water holding capacity (WHC) and color (Zamora *et al*., 1996; Savell *et al*., 2005). Several studies have compared the meat quality obtained under these three refrigeration systems (Davey and Garnett, 1980; Jaime *et al*., 1992; Aalhus *et al*., 2002; James *et al*., 2006; Jacob *et al*., 2012; Demirok *et al*., 2013). A chilling rate either too slow or too fast can result in a lower quality of meat (Joseph, 1996).

Thus, the diverse technologies applied to chill carcasses during postmortem processes can promote different pH values during *Rigor mortis* onset (Jacob *et al*., 2012). Few suggestions have been implied that under AC system there was a production of meat at the quality level similar to that obtained by the other chilling methods (Bowling *et al*., 1987; Van Moeseke *et al*., 2001; Jacob *et al*., 2012; Demirok *et al*., 2013). Therefore, this work aimed to evaluate the development of *rigor mortis* in turkey *pectoralis major* obtained directly from commercial processing lines refrigerated by AC systems by measuring the pH, color and water holding capacity of the resulting meat.

MATERIALS AND METHODS

Sampling and refrigeration systems: The experiment was conducted in a commercial turkey slaughterhouse in Santa Catarina State, Brazil, in the summer of 2013. Eighty carcass samples of BUT-9 lineage turkeys, with a weight of 18.00±0.5 kg were divided equally into two treatments: (1) treatment by Air Chill (AC) and (2) treatment at ambient temperature (AT). Both treatments followed the routine process of the commercial slaughter line, which consisted in sequence of hanging, electrical stunning, bleeding, scalding, defeathering and evisceration (45±3 min) (Carvalho *et al*., 2014).

Air chilling (AC) treatment: Carcasses were held by the hocks on shackles in the commercial AC room for approximately 360 min. The air velocity in the room was

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1.5 m/s with a temperature of -6±2°C and an RH of 75%, as measured by a Kestrel 4000 Instrument (Nielsen-Kellerman, Boothwyn, PA, USA). After cooling, the carcasses were deboned and samples from the AC treatment were stored at 4°C according to Brazilian legal requirements (Brasil, 1998) for up to 26 h for further analysis.

Ambient temperature (AT) treatment: Carcasses were randomly collected after deboning and stored at 20±2°C for 26 h and the pH changes were monitored throughout the experiment. This treatment was set for comparative purpose in relation to AC samples.

Temperature and pH determination: pH and temperature were measured (in duplicate) by inserting electrodes into the *pectoralis major* (pH meter system, Testo 205, Lenzkirch, Germany) as described in Olivo *et al.* (2001). The measurements were performed on samples at 0.06, 1, 4, 5, 6, 7, 9, 10, 22, 24 and 26 h *postmortem* (PM).

Color determination: This evaluation was carried out using a Minolta CR-400 colorimeter, taking five different reading points per sample for color determination (L*, a*, b*), as described by Soares *et al.* (2003) for broiler breast meat. Analyzes were performed at 10 and 24 h PM.

Water-holding capacity (WHC): The WHC was determined based on the technique reported originally by Hamm (1998) and described in Wilhelm *et al.* (2010). A total of 80 samples divided into two treatment (n = 40) was collected from the cranial side of the breast fillets, cut into 2.0 g (±0.10) cubes and analyzed in triplicate. They were first carefully placed between two filter papers placed in acrylic plates and then left under a 10 kg weight for 5 min. The samples were weighed and the WHC was determined by the exudate water weight through the following formula:

$$WHC\ (\%) = 100 - \left[\left(\frac{Wi - Wf}{Wi}\right) x\ 100\right]$$

where, Wi and Wf are the initial and final sample weights, respectively. Analyzes were performed at 10 and 24 h PM, similarly to the previous item.

Statistical analysis: The results were analyzed by the program Statistica for Windows 7.0. The Student t-test at 5% probability ($p \leq 0.05$) was used to determine significant difference between the two treatments AT and AC at the same PM time. The Tukey's test at 5% probability ($p \leq 0.05$) was used to determine significant difference among PM time for temperature and pH of AT or AC meat samples.

RESULTS AND DISCUSSION

The effect of carcasses chilling on the *Pectoralis major m.* temperature decline is shown in Fig. 1. At 0.06 h PM and there was no temperature difference relative to both treatments. At 1.0 h PM, the carcasses temperature in the AT samples conditions was 39°C, while that of the carcasses kept under AC conditions was not significantly different. However, a dramatic change was observed at 4.0 h PM as the temperature of the carcasses in AC was significantly lower than that of observed in samples kept in the AT conditions. The final temperatures of 24.7 and 2.3°C were reached after 22 and 9 h PM, respectively, in the AC and AT treatments, with chilling rates of 0.69 and 4.19°C/h, respectively. The results reported by McKee and Sams (1998) and Khan (1971) indicated that high temperature PM (10-40°C) in poultry accelerated depletion (exhaustion) of ATP within the muscle samples influencing the final meat characteristics. Femery and Pool (1960) also observed high temperatures PM provided the increase in the rate of glycogen degradation in broiler muscle. In turkey breast under higher temperatures there was an accelerated PM metabolism as reported by Rathgeber *et al.* (1999).

In relation to the pH values, no difference within the treatments at 0.06 and 1.0 h PM was observed (Fig. 2). However, after 5 h PM, the carcasses from AT conditions reached their ultimate pH (pHu) value of 5.67, while those from AC reached a pHu value of 5.67 after 24 h PM and the chilling rates were 0.151 and 0.031 un/h, respectively. These results corroborated that there was a close relationship between both temperature and pH as at higher T values a quicker glycolysis onset occurred thus the pHu was reached approximately 5-fold faster than in the samples stored under chilling conditions. This fact indicated that a fast muscle metabolism occurred under higher temperatures as reported previously (Alvarado and Sams, 2002, 2004; Zhu *et al.*, 2013).

The pH and temperature parameters influenced the meat qualities, in particular the color parameter (Alvarado and Sams, 2002). Color is an important attribute for customer satisfaction at the time of the purchase (Fletcher, 1999; Droval *et al.*, 2012). The L* value of the meat depends on the amount of light that is scattered. Swatland (1993, 2008) reported that an increased scattering of light due to denaturation of the sarcoplasmic proteins and an increase in extracellular water were responsible for paler meat. The effects of chilling after 10 and 24 h PM on the turkey breast meat color and WHC are shown in Table 1.

In fillets at 10 h PM, the samples chilled (AC) had significantly lower L* values than those from AT, probably as the consequence of lower T (Fig. 1) and higher pH (Fig. 2) observed for AC fillets. Several researches have reported color changes in meat turkey

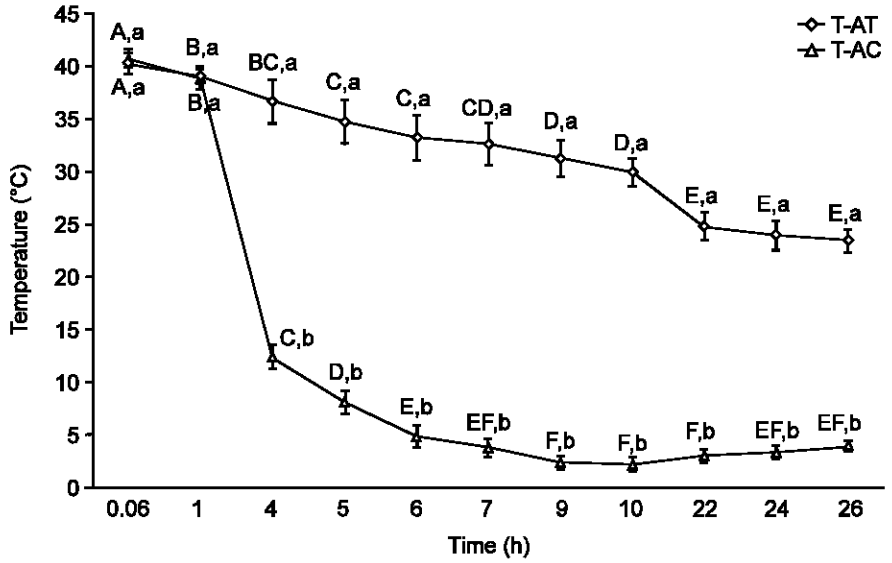

Fig. 1: Temperatures (T) values of turkey carcass measured at postmortem times of 0.06, 1, 4, 5, 6, 7, 9, 10, 22, 24 and 26 h for the following treatments: Ambient temperature (AT) and Air Chill System (AC). Standard deviation bars are indicated (n = 40 per treatment group). Means followed by different uppercase letters in the same treatment differ by Tukey test at 5% significance ($p \leq 0.05$) among postmortem time. Means followed by different lowercase letters in the same time differ by Student's t test at 5% significance ($p \leq 0.05$) between treatments

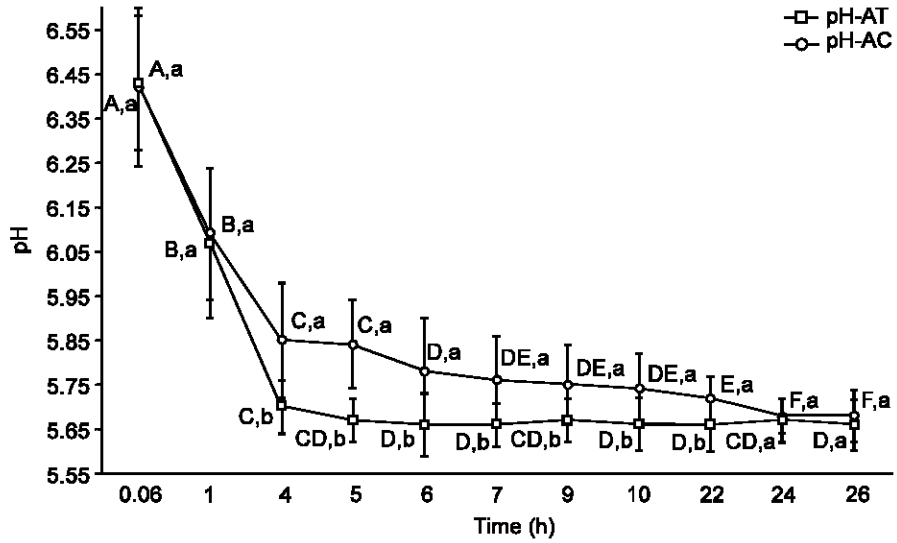

Fig. 2: pH values of turkey carcass measured at postmortem times of 0.06, 1, 4, 5, 6, 7, 9, 10, 22, 24 and 26 h for the following treatments: Ambient temperature (AT) and Air Chill System (AC). Standard deviation bars are indicated (n = 40 per treatment group). Means followed by different uppercase letters in the same treatment differ by Tukey test at 5% significance ($p \leq 0.05$) among postmortem time. Means followed by different lowercase letters in the same time differ by Student's t test at 5% significance ($p \leq 0.05$) between treatments

breast that were submitted to accelerated rate of glycolysis PM (Froning *et al*., 1978; Pietrzak *et al*., 1997; McKee and Sams, 1998). McKee and Sams (1998) also observed high values of L*4 h PM in turkey breasts submitted between 20-40°C when compared with those submitted at 0°C, immediately after evisceration. The same authors also suggested that carcasses stored at higher temperatures resulted in acceleration of *rigor mortis* as the consequence of quicker biochemical changes in muscle. The incidence of pale soft and exudative (PSE) meat was not detected in this particular experiment probably because of amount sampling as its

Table 1: Values of L*, a*, b* and the water holding capacity (WHC) of turkey fillet measured at 10 and 24 h postmortem under the following treatments: Ambient temperature (AT) and Air Chill System (AC)

Time (PM)	AT	AC
L* 10 h	52.26±2.55^{A,a}	49.01±2.49^{B,b}
L* 24 h	52.89±2.79^{A,a}	52.72±2.30^{A,a}
a* 10 h	4.89±1.45^{A,a}	4.74±1.37^{A,a}
a* 24 h	5.26±1.51^{A,a}	4.20±1.58^{A,a}
b* 10 h	3.78±1.31^{A,a}	4.09±1.53^{A,a}
b* 24 h	4.08±1.40^{A,a}	4.61±1.76^{A,a}
WHC (%) 10 h	74.72±1.77^{A,b}	77.89±1.91^{A,a}
WHC (%) 24 h	74.37±1.70^{A,b}	74.57±1.63^{B,b}

Means followed by different uppercase letters in the same column for each parameter differ by Student's t-test at a 5% significance level ($p \leq 0.05$). Means followed by different lowercase letters in the same row differ by Student's t test at the 5% significance level ($p \leq 0.05$). PM: postmortem

number was not sufficient although as reported elsewhere this phenomenon occurred (Carvalho *et al*., 2014).

In relation to the WHC, samples from the AT treatment after 10 h PM were significantly lower in comparison to those from the AC treatment, although at 24 h PM they were not different from each other as the pH values were quite similar and finally the a*, b* values were not significantly different in any treatment (Table 1).

Conclusion: In conclusion, the rate of muscle pH decline is directly affected by the chilling temperature. Complete *rigor mortis* was reached up to 24 h PM under the air chilling commercial conditions, indicating that turkey fillets should be handled by the processors after this length of time in order to keep its myofibrillar proteins functionalities.

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