EFFECT OF SPACE REDUCTION ON THE COOLING RATE OF PIG CARCASSES IN STATIC COOLING CHAMBERS

Maria Eduarda dos Santos[1,2], Jaqueline Back[2], Saulo Henrique Webber[1], Renata E. F. Macedo[1*]
[1] Graduate Program in Animal Science. Pontifícia Universidade Católica do Paraná (PUCPR). Brazil
[2] Frimesa Cooperativa Central, Brazil
*Corresponding author email: renata.macedo@pucpr.br

I. INTRODUCTION

The cooling of pig carcasses after slaughter is a fundamental process to maintain the microbiological quality of the product. For this purpose, the process must occur in a way that ensures the carcasses reach a maximum internal temperature of 7 °C within a period of 12 to 24 hours, to proceed to carcass cutting [1]. In industrial settings, carcasses are suspended in hangers for colling in cold chambers. The spacing between hangers must be at least 0.33 cm, allowing for three carcasses per linear meter, following the Brazilian regulations [1]. Cold chamber capacity stands as a limiting factor in increasing pig carcass processing at slaughterhouses. Hence, the increase of carcass density within chambers may enhance productivity. This study aimed to assess the impact of reducing the spacing between pig carcasses within static cooling chambers on cooling rate, pH and microbial counts of the carcasses.

II. MATERIALS AND METHODS

The study was conducted at a pork slaughterhouse located in the western region of the state of Paraná, Brazil. A total of 120 carcasses (average weight of 100 kg) were assessed in six cooling chambers (20 carcasses in each chamber). The carcasses underwent two treatments: TP, with a density of four carcasses per linear meter (0.25 cm spacing), and TC, with a standard density of three carcasses per linear meter (0.33 cm spacing). Within the chambers, the carcasses were uniformly positioned on the same track and region. The carcasses were monitored and temperature, measured hourly, pH, measured every two hours, and microbiological count, evaluated at 0, 4, and 12 hours, were assessed. The internal temperature was recorded using a thermometer (Hobo® U12, Massachusetts, USA), and pH was determined using a penetration pH meter (Testo 205, Titisee-Neustadt, Germany), both inserted at the geometric center of the ham. Microbiological samples were collected on ham by swabbing a disposable mold of 100 cm². The mesophilic aerobic count was conducted on PCA agar incubated at 30±1 °C for 72 h, and the Enterobacteriaceae count was performed on Enterobacteriaceae Count Plate incubated at 37 °C ± 1 °C for 24 h. Results were expressed in log CFU/cm². Data analysis utilized the statistical model $Y = aX + bY + \varepsilon$, where X represented treatments (0.25 cm and 0.33 cm spacing) and Y represented evaluation times (0 to 12). Mean comparisons were performed using GLM for linear models, employing two-way ANOVA in a factorial arrangement, followed by Tukey's test ($P<0.05$). To analyze the carcass temperature decrease over time, a modified Newton model was applied, according to the equation: $T = a(1+k)\ t+b$, where T represented the temperature as a function of time t, (a + b) denoted the initial temperature provided by the model, k indicated the decay rate, and b signified the temperature after a prolonged period.

III. RESULTS AND DISCUSSION

The mean temperatures for hot carcasses, measured inside the ham at the cooling chamber entrance, were 38.22 °C in TP and 38.25 °C in TC, within the typical range for hot carcasses after slaughter, which typically ranges from 38 °C to 41 °C [2]. There was no interaction between treatment and time for carcass temperature ($P > 0.05$). Treatment had no effect; only time exhibited a significant impact on temperature ($P < 0.05$). The mean temperature decrease rate (k) was -0.189 °C (TP) and -0.182 °C (TC). There was a notable reduction in temperature over time, with hams beginning to stabilize around t 9 in TC and t 10 in TP. By t 12, mean temperatures were 6.80 °C in TP and 6.84 °C in TC ($P > 0.05$). For pH, there was likewise no observed interaction between effects ($P > 0.05$), with only time exhibiting a significant effect, resulting in decreasing values over the evaluation period. Initial pH values (t0) stood at 6.47 in TP and 6.47 in TC, while final values (t12)

were 5.94 in TP and 5.99 in TC (P > 0.05). Correspondingly, like other parameters, only time displayed an effect on both mesophilic aerobic and enterobacteria counts, showing a decline in treatments throughout the cooling period (Table 1). Mesophilic aerobic counts in pig carcasses exhibit variability across studies, with reported values ranging between 2.40 and 4.95 log CFU/cm² [3, 4, 5]. The recorded values generally align with the lower end of this range, but below the thresholds established by Brazilian legislation and the European Union (5 log CFU/cm²) [6, 7]. Enterobacteria counts were initially below 0.23 log CFU/cm² at t0, experiencing a significant reduction to 0.04-0.05 log CFU/cm² at t12, values below the standards set by Brazilian legislation (3 log CFU/cm²) and the European Union (5 CFU/cm²) for pig carcasses [6, 7].

Table 1 - Mesophilic aerobic and enterobacteria counts in ham of pig carcasses during cooling in static cold chamber.

Time (h)	Mesophilic aerobic (log UFC/cm²)		Enterobacteria (log UFC/cm²)	
	TP	TC	TP	TC
0	2,75 ± 0,95 ^{aA}	2,79 ± 0,86 ^{aA}	0,21 ± 0,40 ^{aA}	0,23 ± 0,43 ^{aA}
4	2,26 ± 0,80 ^{bA}	2,33 ± 0,66 ^{bA}	0,07 ± 0,23 ^{bA}	0,08 ± 0,22 ^{bA}
12	2,37 ± 0,93 ^{abA}	2,26 ± 0,64 ^{bA}	0,04 ± 0,15 ^{bA}	0,05 ± 0,16 ^{bA}

Means followed by the same lowercase letters in the same column do not present significant differences between times (P <0.05); means followed by the same uppercase letters in the same row do not present significant differences between treatments (P < 0.05). TP = protocol treatment; TC = control treatment. Mean ± standard deviation.

IV. CONCLUSION

Optimizing the occupancy rate to four pig carcasses per linear meter in the cooling chambers has demonstrated efficacy in lowering internal carcass temperature and managing microbial proliferation. Consequently, narrowing the spacing between pig carcasses, as observed in this study, can be adopted without adverse effects on cooling efficiency or carcass microbiological quality. This adaptation enables increased cooling capacity and higher pig carcass production volume.

REFERENCES

1. BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Portaria 711, de 1 de novembro de 1995. Aprova as normas técnicas de instalações e equipamentos para abate e industrialização de suínos. Brasília, 1995.
2. Ludtke, C.; Peloso, J. V.; Dalla Costa, O. A.; Rohr, S. A.; Dalla Costa, F. A. (2016) Bem-estar animal na produção de suínos: frigorífico. Brasília, DF: ABCS/Sebrae. 46 p.
3. Cê, E. R.; Giombelli, A.; Kich, J. D.; Moresco, K. S.; Miranda, A.; Pedrão, M. R.; Johann, G.; Badaró, A. C. L.; Hashimoto, E. H.; Machado-Lunkes, A. (2022) Monitoring of pig slaughter stages and correlation in the prevalence of pathogens and levels of microorganisms that indicate microbiological quality and hygiene using a predictive model. Journal of Food Protection 86 1: 100034.
4. Zweifel, C.; Fischer, R.; Stephan, R. (2008) Microbiological contamination of pig and cattle carcasses in different small-scale Swiss abattoirs. Meat Science 78 3: 225-231.
5. Delhalle, L.; Sadeleer, L.; Bollaerts, K.; Farnir, F.; Saegerman, C.; Korsak, N.; Dewulf. J.; Zutter, L.; Daube, G. (2008) Risk factors for *Salmonella* and hygiene indicators in the 10 largest Belgian pig slaughterhouses. Journal of Food Protection 71 7:1320-1329.
6. EC. EUROPEAN COMMISSION. Regulamento (CE) nº 2073/2005 da Comissão, de 15 de Novembro de 2005. Relativo a critérios microbiológicos aplicáveis aos gêneros alimentícios. Jornal Oficial da União Europeia. 2005.
7. BRASIL. Ministério da Agricultura, Pecuária e do Abastecimento. Institui a exportação de carne suínas para os estados-membros da União Europeia. Brasília, 2007. Circular nº 130/2007/CGPE/DIPOA.