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SURFACE MICROBIAL LOAD OF PORK FRESH MEAT THROUGHOUT THE CARCASS COOLING AND CUTTING PROCESS UNTIL PACKAGING

N. Rodríguez-Cánovas[1], E. Orcajada-Hermosilla[1], L. Casas[2], A. Serrano[2], G.B. Martínez-Hernández[1], A. López-Gómez[1*]

[1] Refrigeration and Food Safety Engineering Group, Universidad Politécnica de Cartagena, Spain

[2]R&D Department, La Comarca Food Group, Lorca, Spain

*Corresponding author email: antonio.lopez@upct.es

I. INTRODUCTION

After the death of the animal (24 hours post-mortem), biochemical and structural changes occur that will determine the final quality and palatability of the meat [1]. These changes are influenced by the cooling process to which the carcass is subjected after slaughtering. Regulation (EC) 2073/2005 establishes microbiological criteria applicable to food products in the European Union, including specific requirements for fresh meat and pork carcasses. It applies to food products throughout all stages of production, processing, and distribution.
To achieve good product quality, maximum hygiene must be maintained during the fresh meat production process. This includes controlling the microbial load on the surface of fresh meat when it undergoes the various cutting processes and moves along the production line until packaging [2]. The microbial contamination of fresh meat is directly related to its shelf life. Approximately one-third of the bacteria in fresh meat are not associated with the origin animals but are transmitted during handling and cutting from personnel, equipment surfaces, or the air surrounding the machinery in rooms where fresh meat circulates [3].

II. MATERIALS AND METHODS

A sampling of the surface of the carcass and fresh meat was carried out to analyse the microbial load from the stabilization cooling process to the products packaging in different distribution formats.
For the surface of the carcass, a study was conducted once the carcass entered stabilization, where it was placed in a refrigeration chamber at 0 °C for 16-24 hours, finally reaching a temperature below 7 °C before entering the cutting room. The sampling points were referenced according to ISO 17604:2015 standards.
In the study of the surface microbial load of the fresh meat, the loin was chosen as the reference. Loin samples were taken before (start of the cutting line) and after (end of the cutting line) handling. After sampling at the end of the line, the loins were marked with strings for later identification and stored in different plastic box. To simulate real conditions, the plastic box with the loins were sent to the main storage chamber for fresh meat, where they remained for about an hour and a half at a temperature of 4 °C. Finally, the three plastic boxes were sent to each of the meat expedition for distribution points: fresh packaging, fresh shipment, and frozen shipment, to analyse the microbial load on the surface of the fresh meat at the end of the packaging line. The studies were conducted in triplicate over three weeks, analysing different days. The microbial quality at the different analysis points was evaluated.
For the hygienic analysis, the excision method was used. A homogeneous amount from each of the different study points was collected. Under sterile conditions, 25 g of a representative sample from all points were weighed, and a volume of peptone water was added in a 1:9 ratio. The mixture was homogenized using a Stomacher. Subsequently, the appropriate serial dilutions were prepared with peptone water, followed by plating on selective media suitable for each microorganism.
The experimental data were analyzed using the Statgraphics program (version 5.1 Plus, Statgraphics Technologies; Virginia, United States). The mean values were subjected to the Least Significant Difference (LSD) test with $p<0.05$. The data represented in the graphs and figures are expressed as the mean ± standard deviation (SD).

III. RESULTS AND DISCUSSION

The results obtained reflect the influence of the stabilization, cutting, and storage processes on the microbial load of the meat and the surface of the carcass (Table 1).
In general terms, it was observed that the initial refrigeration of the carcasses contributes to a slight reduction in the mesophilic aerobic bacteria load but does not prevent a slight increase in the presence of enterobacteria. This could be related to the condensation of moisture on the surface of the carcass during stabilization, which favors the survival of certain bacteria, as noted in previous studies on carcass refrigeration in the meat industry [1].

In the case of fresh meat, the variability in microbial load along the cutting line suggests that handling and contact with surfaces and utensils play a crucial role in cross-contamination. Although mesophilic aerobes show a progressive reduction until packaging, the subsequent elevation of these microorganisms after this process could be linked to exposure to external agents or the lack of sterility in the materials used for packaging. These findings are consistent with studies that have shown that packaging can be a critical stage in maintaining the microbiological quality of meat [2].

Table 1. Surface microbial load of fresh meat along production process. Different lowercase letters represent significant differences ($p<0.05$) between stages and production rooms.

	Carcasses		Fresh meat					
	Entry into stabilization	Exit from stabilization	Start of the butchering line	End of the butchering line	Before packaging	After packaging	Fresh shipment room	Freezer room
Total mesophilic aerobes (log CFU/g)	4,26 ± 0,34^{a}	4,19 ± 0,40^{ab}	4,17 ± 0,20^{ab}	4,02 ± 0,16^{ab}	3,54 ± 0,42^{ab}	3,85 ± 0,03^{b}	4,11 ± 0,15^{ab}	4,07 ± 0,03^{ab}
Enterobacteria (log CFU/g)	2,89 ± 0,18^{ab}	3,11 ± 0,95^{a}	1,43 ± 0,22^{c}	2,10 ± 0,25^{bc}	2,24 ± 0,90^{c}	1,96 ± 0,19^{c}	2,00 ± 0,24^{c}	1,86 ± 0,25^{bc}

On the other hand, enterobacteria exhibit fluctuating behavior throughout the process, with an increase in the final cutting phase and just before packaging, which suggests the need to strengthen hygiene measures at these stages. The reduction in their load after packaging and storage in freezing demonstrates the effect of these processes in reducing potentially pathogenic bacteria [3].

IV. CONCLUSION

These results highlight the importance of implementing more effective control strategies throughout the production chain, including the optimization of hygiene protocols, improvements in packaging conditions, and continuous monitoring of microbial load at different stages of the process. The application of emerging technologies, such as the use of plasma-activated water or additional antimicrobial treatments, could represent a viable alternative to reduce contamination at critical points and improve the microbiological safety of fresh meat intended for human consumption.

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