71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

ASSESSMENT OF BACTERIOLOGICAL CONTAMINATION IN THE INTERNAL ABDOMINAL CAVITY OF PIG CARCASSES AFTER EXTENDED EVISCERATION IN THE CONTEXT OF THE MEAT FACTORY CELL (MFC) ROBOTIC PROTOTYPE

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I. INTRODUCTION

Artificial intelligence (AI) and robotics offer strategic capabilities for future meat production, and the MFC prototype system developed within the EU-funded RoBUTCHER project is an innovation for automating pig carcass cutting at abattoirs (Fig 1A-B). The MFC process cuts the cleaned hot carcass into seven primal cuts (i.e. two forelimbs, two hindlimbs, saddle, belly (with ribs) and entire organ set, Fig 1C) rather than the regular two halves [1]. In contrast to the conventional process, evisceration happens at the MFC's final process step [2]. Therefore, it took an extended time of up to 290 minutes with a mean time of 183 minutes before MFC evisceration, as the robot operation and AI training for cutting trajectory required considerably longer at this very early stage of development, allowing the experimental observation of such prolonged evisceration times in a very significant number of pig carcasses (n=52). The robotic MFC process is anticipated to be significantly faster as the system operational tasks progress [1]. Our study aims to provide information on the microbiological consequences of extending the evisceration time.

II. MATERIALS AND METHODS

Samples were collected from the internal abdominal cavity of pigs after evisceration at the belly flare (Fig 1D) from the conventional line (n=23) and the MFC process (n=52). Aerobic Plate Count (APC) and *Enterobacterales* (E) were quantified according to ISO methods [3-4]. Data analyses were carried out using JMP software (SAS Institute Inc., US). Datasets were tested for normality using the Shapiro-Wilk test. Microbial data did not follow a normal distribution, so median (quantile 50%) and quantiles are reported. Non-parametric comparisons using the Wilcoxon / Krustal-Wallis test were calculated to determine significant differences.

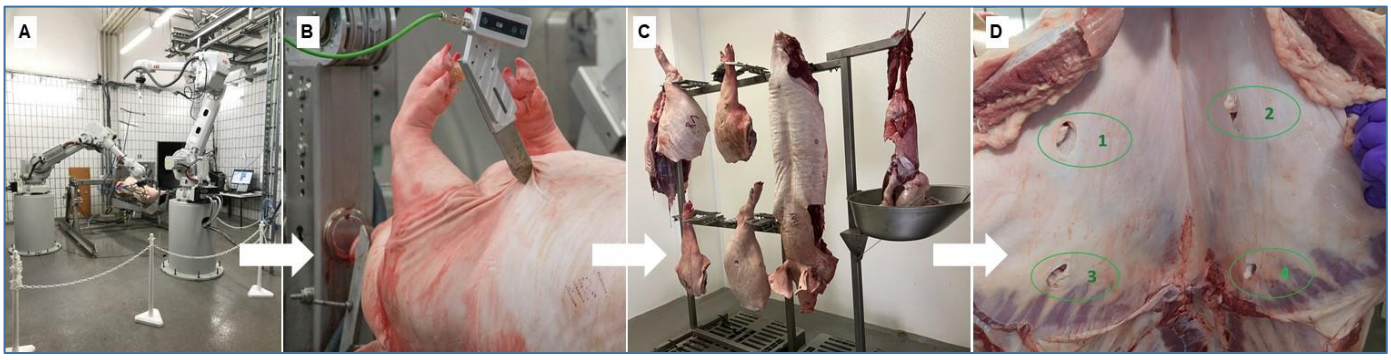


Figure 1. Photos of the Meat Factory Cell (MFC) prototype system developed within the EU-funded RoBUTCHER project (A), robot-guided knife with incorporated camera performing a cut (B), output of the MFC presented on a rack for veterinarian inspection (C) and sampling points for microbial analysis at the internal abdominal cavity of a pig carcass (D).

III. RESULTS AND DISCUSSION

The conventional line and MFC had comparable internal abdominal cavity microbial counts of approx. 2.5-3 and 1-2.0 log CFU/cm^2 for APC and E, respectively ($P > 0.05$) (Fig 2). Indeed, the percentage of samples with E below the detection limit in the MFC process (56%) was more than double that in the conventional line (23%). Despite this delayed evisceration, this suggested no microbial contamination via migration/ leaking from the gastro-intestinal gut barrier. There exists minimal evidence-based literature regarding the microbiological status

of meat after extended evisceration. Early work reported no microbiological contamination in domestic sheep carcasses subjected to delayed evisceration (24 h at 20 °C) [5]. In another study, on-farm slaughter of five Holstein dairy cattle with evisceration occurring up to 4 h postmortem does not pose increased microbiological risks [6].

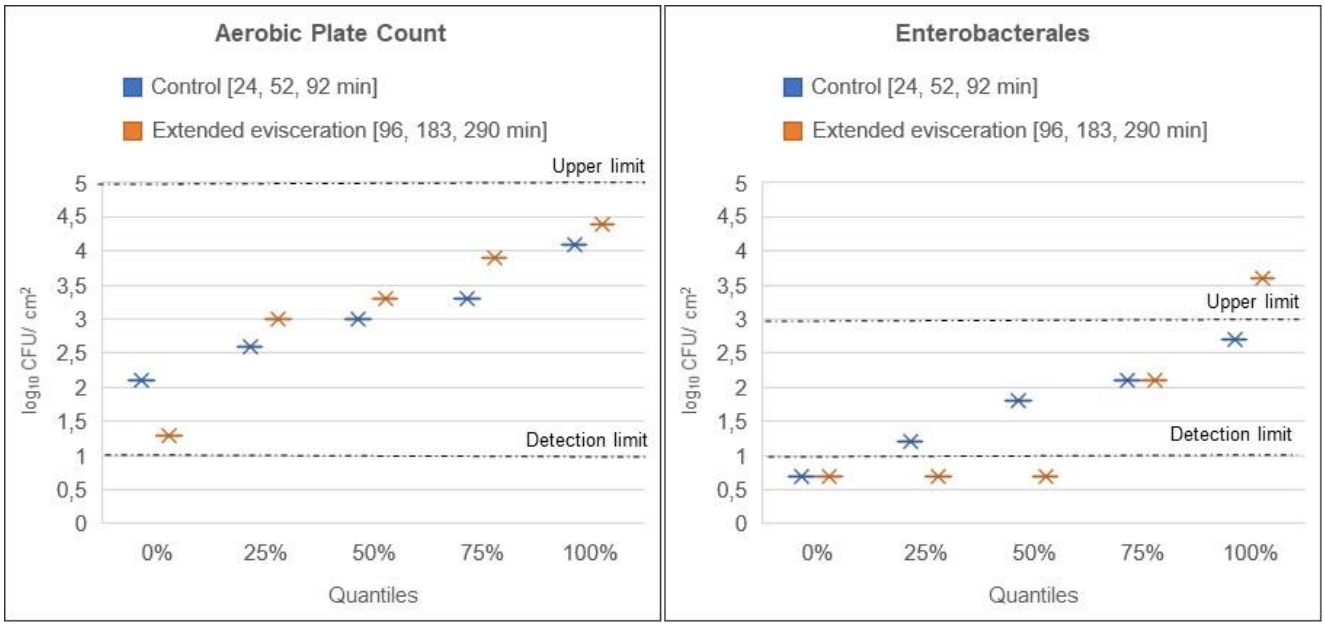


Figure 2. Microbial counts (log_{10} CFU/ cm^2) for Aerobic Plate Count (APC) and *Enterobacterales* (E) in the internal abdominal cavity (i.e. belly flare) of pig carcasses processed through the conventional line (control) compared to the Meat Factory Cell (MFC) robotic prototype that corresponds to the extended evisceration.

[#]: Dash lines indicate the detection limit and acceptable upper limit according to the EU regulation [7].
[##]: Postmortem sampling times are expressed in the legend of the graphs, given the range [minimum, median, maximum] in minutes (min).
[###]: It should be noted that evisceration in the conventional line took place ~15 min postmortem, but the samples were taken afterwards, at that precise time postmortem indicated.

IV. CONCLUSION

These results are of substantial evidence for 1) the positive practical feasibility of the MFC with the evisceration at the process end and 2) the revisit of the timeframe allowed in legislation for performing the evisceration ("without undue delay") [8]. As a precaution, European Member States often impose more stringent time limits, for instance, 45 min in the case of Bavaria (Germany), which are not always justified. The principle of eviscerating an animal as soon as possible should apply, but in exceptional cases, a longer permitted interval for evisceration could give abattoirs room in case of a line stoppage. The topic requires further experimental validation and, eventually, a regulatory revision to optimise condemnation numbers while assuring the highest safety standards.

ACKNOWLEDGEMENTS

The European Commission has funded this work under the project 'RoBUTCHER, A Robust, Flexible and Scalable Cognitive Robotics Platform' (Grant Agreement: 871631, https://robutcher.eu).

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