

Opportunities and challenges for an automated, cell-based slaughtering-and-deboning of a pig carcass: time for a paradigm shift in meat processing

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Introduction: Traditional slaughter processing layouts are a continuous series of highly-specific operations that disassemble a pig carcass stepwise linearly. The operational failure of a single step within this series of operations will stop the entire process line. This linear processing has evolved to be efficient for processing a large number of animals, but in contrast, it is relatively inflexible and bottleneck operations can limit the speed of the entire line (de Medeiros Esper et al., 2021; Hinrichsen et al., 2022). In a cell-based modular concept like the MFC, most operations are carried out in a single manufacturing cell, and the capacity and speed of the process can be modulated by increasing/decreasing the number of manufacturing cells (Alvseike et al., 2020; Alvseike et al., 2018; de Medeiros Esper et al., 2021). The underdevelopment MFC is a ground-breaking autonomous robotic system coupled with the latest mechatronics, sensing and artificial intelligence. The cell is modifiable, and technologies can be added to it on demand. Feedback on performance and yields for each animal type (different size and anatomy) is paramount for the cell to improve itself over time by fine-tuning the integration between the vision system and the pivotal algorithms defining the cutting trajectories. This scientific communication compares the prevailing meat production system at processing plants with the MFC by outlining the opportunities and challenges for the uptake of this emerging cell-based modular meat processing toward a paradigm shift in the meat processing industry.

Objectives:

- To present the approach taken by the ongoing EU-funded R&D project, RoBUTCHER, which intends to develop and validate at TRL6 an autonomous robotic modular cell, the so-called Meat Factory Cell (MFC), for the disassembling of a pig carcass at the abattoir.
- To outline the main opportunities for such a cell-based slaughtering-and-deboning process.
- To describe the main challenges and adaptations required in current slaughter lines to adopt the MFC within a European context.

Materials and Methods: Conceptual ideation of the MFC's opportunities and challenges arise from the discussions among the consortium members and authors of this manuscript. A qualitative evaluation of key performance indicators will follow in the next stages of the project and is not yet available.

Results and Discussion: The following opportunities and challenges have been identified in the MFC processing:

Opportunities

- Reduction of the dependence on a shortage of skilled labour (butchers).
- Improved working conditions for operators.
- Customization of the chilling at abattoir with many potential impacts on meat safety and quality.
- New opportunities for new cuts and accelerated further processing of the carcass into meat products.
- Affordability from scalability for small producers and processors, as the MFC will require a lower investment than the current massive slaughter processing lines that target a high number of heads per hour. This implies that in the MFC, fewer animals need to be processed per day to get a return on investment, thereby enabling the use of robotic systems and automation in the decentralization of meat processing.
- Modernization of meat processing by uptaking sensing and digitalization technologies can benefit from digital transformation.

Challenges

- Adaptations of the traditional slaughter lines have been identified in three aspects: 1) validation of current grading might be required, 2) the veterinarian's post-mortem inspection, and 3) the carcass chilling regime.
- Resistance to change in the meat processing paradigm, from a fixed continuous slaughter line to a more flexible and modular meat processing. - Investment in these robotic solutions, especially at the stages when new meat processing plants are being designed and constructed.
- The replacement of human labour may not have a turning back, so skilled-labour workers, along with their mastering skills of meat handling, could be reduced.

Conclusions: The MFC will be tested at the pilot plant of the Max Rubner Institute (Kulmbach, Germany) from Autumn 2022 to validate the performance in the context of traditional line-based slaughter and cutting. Yields, meat safety indicators (microbiological counts), and quality parameters (primarily colour, tenderness and water-holding) will be evaluated to provide a quantitative basis for further developments, adaptations and adoption.

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