MECHANICAL AND STRUCTURAL CHARACTERIZATION OF INDUSTRIAL GROUND BEEF AND HAMBURGER PROCESSING LINE

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I. INTRODUCTION

The production of beef hamburgers involves four main processing steps: pre-grinding, mixing, main-grinding, and forming [1]. The amount of non-intact cells (ANIC) resulting from size reduction and disintegration of meat cells during processing is a measure for structural and morphological changes of the meat and determining product functionality and quality [1-3]. A previous study by Berger *et al.* [1] showed that grinding significantly influences structural changes in ground beef on a pilot plant scale while mixing and forming have less impact. This study aimed to characterize the mechanical processes and the resulting structural changes in the meat during each processing step on an industrial scale. It was assumed that grinding would induce the most significant structural changes due to the highest mechanical stress during this step.

II. MATERIALS AND METHODS

The beef was processed in an industry-scale process for hamburger production as illustrated in Figure 1. Lean (T = 0 °C, 13 mm), fatty (T = 0 °C, 13 mm) and frozen (T = - 10 °C, 16 mm) beef was separately pre-ground (pre-cutter – knife - hole plate 13 mm/ 16 mm), homogeneously mixed and ground to a final particle size of 2.4 mm (pendulum insert knives – hole plate). Hamburgers were formed by pressing the ground meat into defined molds. Samples were taken at each step and histologically assessed according to the official German guidelines (§ 64 LFGB, L 06.00-13) using the point-count method. An analysis of variance with the Tukey post hoc test was performed (p = 0.05).

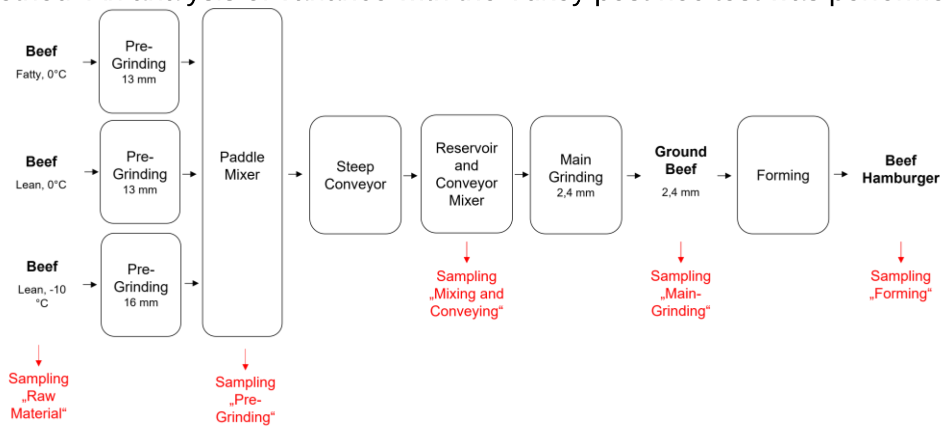

Figure 1. Flowchart of industrial hamburger production line and sampling.

III. RESULTS AND DISCUSSION

The hamburgers produced were composed of 60.68 ± 0.3 % water, 20.63 ± 0.04 % fat, 17.49 ± 0.21 % protein, and 1.42 ± 0.21 % collagen. The morphological changes in the meat, determined as the amount of non-intact cells (ANIC), are shown in Figure 2. The ANIC increased during processing from 5.18 ± 1.66 Vol% in the raw material to 29.04 ± 4.94 Vol% after the main griding, with pre-grinding and main-grinding causing the strongest significant increase. Mixing, conveying, and forming did not affect the ANIC and thus did not impact the structure.

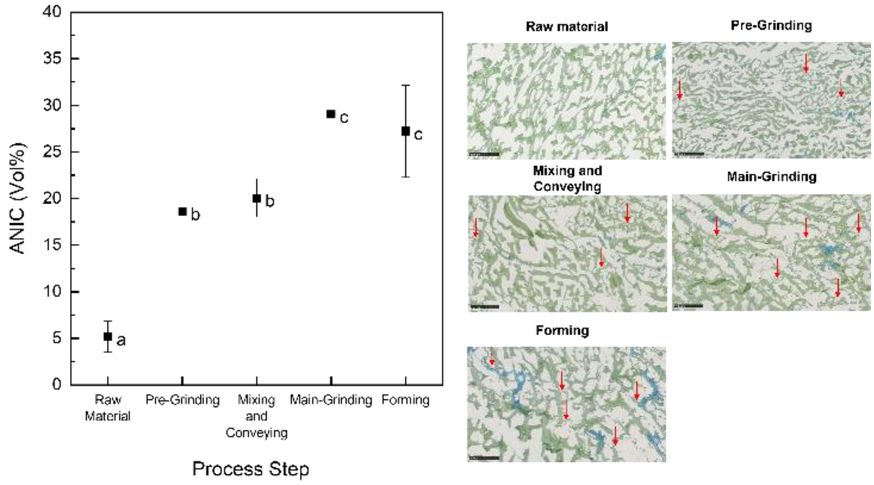

Figure 2. Amount of non-intact cells (ANIC) (left) and histological images (right) of beef at different processing stages. Red arrows exemplarily indicate non-intact cells. Data points with different letters are significantly different ($p < 0.05$).

Those findings are in accordance with the hypothesis and the results reported by Berger *et al.* [1] for analyses on a pilot plant scale. Grinding applies a combination of strong shear forces, friction, and pressure to the meat to reduce particle size. In mixing and conveying only weaker shear forces and friction and in forming mainly pressure is applied. The study suggests that the morphological changes in meat during grinding are caused by the combination of strong mechanical forces [1], which are responsible for the altered functional and quality attributes of the hamburger. Understanding these changes may help to improve the production process and product quality.

IV. CONCLUSION

The results indicate that morphological changes in ground beef on industrial-scale processing are only caused by the grinding steps while conveying, mixing, and forming are gentler and did not affect the structure. To optimize processes for gentler processing with less ANIC, the grinding should be optimized. The mechanical loads applied on an industrial scale were comparable to the pilot plant scale settings and thus comparable effects on the functional and quality properties of the products are assumed. This allows for better scale-up and a more sustainable and cost-effective approach to meat research.

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