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INFLUENCE OF SCREW SPEED VARIATION ON PROCESSING AND STRUCTURAL PARAMETERS OF BEEF HAMBURGERS

Lisa M. Berger[1*], Felix Adam[1], Monika Gibis[1], Jochen Weiss[1]

[1]Institute of Food Science and Biotechnology, Department of Food Material Science, University of Hohenheim, Germany

*Corresponding author email: lisa.berger@uni-hohenheim.de

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I. INTRODUCTION

Despite the growing popularity of meat alternatives, the consumer demand for meat products, especially hamburgers, remains high. Thus, maintaining and improving the quality of ground beef products is still of great interest. Manufacturing beef hamburgers consists of four main processing steps: pre-grinding, mixing, main grinding and forming. Berger et al. [1] previously identified grinding as the most critical step influencing the structural and functional properties of ground beef. Structural changes result from mechanical size reduction during grinding and can be quantified as the amount of non-intact cells (ANIC). However, the relationship between grinding screw speed and these structural changes has not yet been investigated in detail. This study aims to investigate the correlation between the grinding screw speed, the process parameters and the structural properties of the hamburgers to identify optimum processing conditions. It is assumed that an increased specific mechanical energy input (SME), caused by varying grinding speed screw combinations, would lead to altered structural properties of the hamburgers.

II. MATERIALS AND METHODS

Beef hamburgers were produced in pilot plant scale, as illustrated in Figure 1. Pre-cut, frozen and cooled beef was mixed (Paddle mixer type RC-40, Equipamientos Cárnicos, S.L., Mainca, Barcelona, Spain), pre-ground to 13 mm (Forschungsautomatenwolf Typ AE 130, Maschinenfabrik Seydelmann KG, Stuttgart, Germany), mixed again, main-ground while applying varying screw speed combinations and formed into hamburgers (Type MH-100 (modified), Mainca, Spain). The hamburgers were frozen and packed in PE bags directly after forming. Samples were taken for each screw speed variation, and the structure was histologically assessed according to the official German guidelines (§ 64 LFGB, L 06.00-13) using the point-count method. The specific mechanical energy input (SME) was calculated as previously described by Berger et al. [2]. The experiments were performed in duplicate, with a batch size of 10 kg per screw speed variation. An analysis of variance with the Games-Howell post hoc test was performed (p = 0.05).

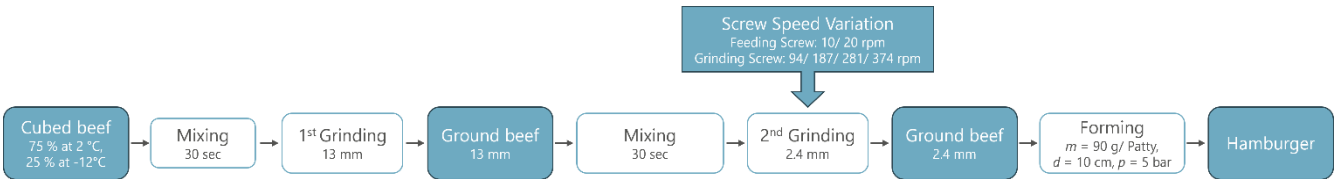


Figure 1: Production flowchart to produce beef hamburger with varying screw speeds.

III. RESULTS AND DISCUSSION

The hamburgers were composed of 61.63 ± 4.29 % water, 18.71 ± 4.23 % fat, and 18.30 ± 0.1 % protein. Figure 2 (A) shows the structural changes in the hamburgers, determined as the amount of non-intact cells (ANIC), as a function of the feeding (FSS) and grinding screw (GSS) speed variations. For both feeding screw settings, the ANIC increased with increasing grinding screw speed from 9.34 ± 0.42 Vol.% (10 rpm FSS/ 94 rpm GSS) and 10.80 ± 1.65 Vol.% (20 rpm FSS/94 rpm GSS) to 20.32 ± 7.78 Vol.% (10 rpm FSS/ 374 rpm GSS) and 17.20 ± 2.25 Vol% (20 rpm FSS/ 374 rpm GSS). Berger [3] showed that the material transportation in a meat grinder relied on the interaction of the meat, the grinder layout and the grinder settings. Next to the materials parameter, also the cutting set composition and the screw speeds were essential to maintain a constant drag flow towards the cutting set. Once one parameter was altered, the drag flow changed, too. Thus, by variating the screw speeds, the grinder settings are changes, thus altering drag flow conditions. Those changes directly impacted the ground meat properties, e.g. the meat structure as shown in Figure 2 (A). One reason for the increase in ANIC with increasing grinding screw speed is unbalanced mass flows resulting in either not completely loaded screws

which increases the dwell time of the meat in the screw or material blockage in the screw inlet, resulting in increased pressures and shear forces acting on the meat.

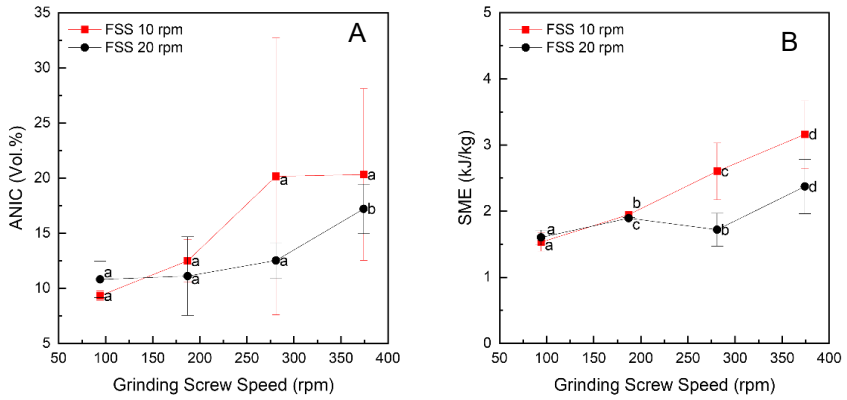


Figure 2: (A) Amount of non-intact cells (ANIC) of beef hamburgers produced with two feeding screw speeds (FSS; 10 rpm/ 20 rpm) as a function of variating grinding screw speed (94 rpm – 374 rpm). (B) Specific mechanical energy input (SME) during grinding of beef meat at two feeding screw speeds (10 rpm/ 20 rpm) as a function of variating grinding screw speed (94 rpm – 374 rpm). Data points with different letters are significantly different within one group ($p < 0.05$).

Figure 2 (B) shows the correlation between the specific mechanical energy input, characterizing the mechanical load on the meat during grinding, as a function of the screw speed variations. Figure 2 (B) shows that the SME increases with increasing GSS at both FSS, e.g. from 1.53 ± 0.14 kJ/kg (10 rpm FSS/ 94 rpm GSS) to 3.16 ± 0.51 kJ/kg (10 rpm FSS/ 374 rpm GSS) and 1.60 ± 0.11 kJ/kg (20 rpm FSS/ 94 rpm GSS) to 2.37 ± 0.41 kJ/kg (20 rpm FSS/ 374 rpm GSS), respectively. This underlines the hypothesis and the findings shown in Figure 2 (A) and highlights that more intense processing alters the structure of the ground meat. This is in accordance with the previous findings of Berger et al. [4], who found an increase in the ANIC when increasing the share of intensively processed meat batter in ground meat products, i.e. that the structural changes correlate with the mechanical energy input [4]. Those findings were in accordance with the hypothesis and the results reported by Berger et al. [1], who analyzed the main impact of the meat structure during ground beef processing and identified the grinding as the most important process step in terms of structural changes. The study stated that the structural changes in meat during grinding were caused by a combination of strong mechanical forces [1]. Thus, optimized grinding settings are essential for ground beef quality and functionality.

IV. CONCLUSION

The study showed that screw speed variations are a key parameter defining the ground meat structure. By changing screw speed settings, the mass flow and the drag flow, which is the basic mechanism of material transportation in the grinder, are altered. With increasing grinding screw speeds the specific mechanical energy input (SME) increased, resulting in increased amount of non-intact cells (ANIC). Based on previous findings of Berger et al [4] a correlation between the meat structure and the functionality of beef hamburgers exists. As a result, the optimum screw speed settings are crucial to maintain and optimize ground beef and hamburgers quality in industrial production.

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