INFLUENCE OF MINCING SPEED ON THE STRUCTURE OF MINCED MEAT

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I. OBJECTIVES

During minced meat production, muscle cells are destroyed due to a combination of unit operations (comminution, mixing, forming). Therefore, to maintain a high-value product, the amount of destroyed muscle cells should be as low as possible. In order to prove alternative analyses to time- and resource-consuming histology, minced meat was produced at varying mincer speed and analyzed for, e.g., water-holding capacity (WHC), heat capacity with differential scanning calorimetry (DSC), and overall structure scanning electron microscopy (SEM). The working hypothesis to prove is that a higher energy input leads to more destroyed muscle cells.

II. MATERIALS AND METHODS

Pork shoulder was diced (3 cm^3), minced to first 12 mm and then at a knife rotational speed of 100 or 400 rpm to 2.8 mm. Volume flow rate was constant at 25 L/min. For WHC, 10 or 5 g was placed on filter paper for 2 h or 2 min with 2 kg for extra- or extra- and intercellular water, respectively ($n = 3$). Cooking loss was calculated after separation of solid and liquid phase after steam heating of 200 g at 145°C for 30 min in a plastic beaker ($n = 3$). Compression and adhesiveness were measured with texture analyzer with a stamp (r = 1 mm), driven 1 mm/s in and out in samples beaker ($n = 6$). Elasticity was analyzed frequency-dependent with oscillation rheometer at 20°C ($n = 2$). Heat flow was measured with DSC from −40°C to +40°C ($n = 2$). Rancidity was analyzed from extracted fat (fat extraction with petroleum ether at 40°C) ($n = 3$). SEM images were produced to illustrate structural differences ($n = 1$). Histological analysis was conducted based on §64 LFGB (Lebensmittel und Futtermittelgesetzbuch) L06.00-13 with a calculation of threshold at confidence intervals of 98% ($n = 8$). Significant differences were determined with paired *t* test using Sigma Plot 14.0 (Systat Software Inc., San Jose, CA).

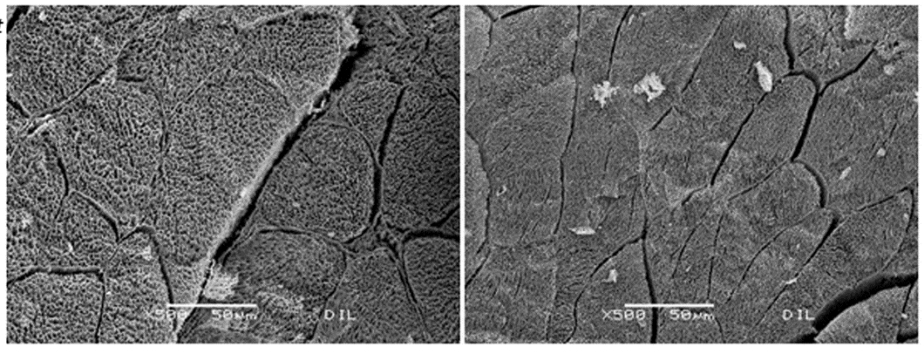
III. RESULTS

Results and *P* values of analyses (Table 1) show that the higher the energy input, respectively, knife rotational speed, the higher the water loss, the earlier the occurrence of rancidity, the more destroyed the structure, and the more cells are destroyed. SEM images support structural results through a finer network. The WHC of minced meat depends on the state of myofibrillar proteins and their coagulation ability, and moreover, the structural strength depends on the amount of proteins that pass from cellular to continuous phase. Since in our approach, differences can only be caused by the knife rotational speed, the higher water loss, lower cooking loss, compression, adhesiveness, and elasticity, as well as the higher heat capacity in 400-rpm sample, might be due to more coagulated proteins.

Table 1: Mean ± standard error of the mean and p-values for water losses (filter press, cooking loss), compression, adhesiveness (texture analysis), elasticity (rheology), heat capacity (DSC), rancidity and amount of destroyed cells (histology) of raw minced meat samples produced at 100 and 400 rpm mincer speed.

Analysis for	Filter press	Cooking loss	Texture analysis		Rheology	DSC	Rancidity	Histology
	Extra- + inter-cellular water loss (%)	Water loss (%)	Compression (kPa)	Adhesiveness (kPa)	Elasticity/G' from 0.1 to 9.997 Hz (kPa)	Heat capacity (J/g)	Induction time of fats rancidity (h)	Amount of destroyed cells (%)
100 rpm	12.4 ± 0.5	23.4 ± 0.1	45.8 ± 4.5	-3.14 ± 0.2	13.1 – 30.0	196 ± 0.3	7.65 ± 0.09	13.1
400 rpm	17.1 ± 0.7	21.9 ± 0.4	27.6 ± 3.4	-2.01 ± 0.1	13.5 – 29.7	203 ± 7.4	6.62 ± 0.06	24.1
p-value	< 0.005	< 0.05	< 0.05	< 0.05	< 0.01	< 0.001	< 0.001	CI of 98 %

SEM: 500x enlargement of samples produced at 100 (left) and 400 rpm (right) mincer speed. The length of the bar is 50 µm.



IV. CONCLUSION

Hypotheses have been proven successfully as analyses show high significant differences between samples, as does histology, and a higher energy input destroys more cells. Since especially DSC and rancidity measurement show high significant differences between the samples, these analyses might correlate to histology. Nevertheless, correlations need to be proven by further experiments on a larger scale.

Keywords: histology, differential scanning calorimetry, minced meat, rancidity, scanning electron microscopy