THE USE OF POWER ULTRASOUND FOR THE ACCELERATED CURING OF PORK

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Abstract – Meat curing is a time consuming and labor intensive process. Power ultrasound (US) induces cell disruption and increases mass transfer. This study aims to assess whether US can accelerate the transfer of brine into meat and to assess the effect of US on the meat quality parameters. Pork *M. longissimus thoracis et lumborum* samples were placed in a diffusion cell. Brine (6% NaCl) was placed on top of the sample allowing for unidirectional diffusion and an ultrasonic probe was placed in the brine. A 3 x 3 factorial design was applied with ultrasonic intensities of 44, 72 or 100 W/cm^2 and treatment times of 10, 25 or 40 min. A non-sonicated cured sample acted as the control. Samples were analyzed for changes in NaCl content, moisture content, weight, pH, color, texture profiles, cook loss and water holding capacity. NaCl content (%) was increased by all ultrasonic treatments ($p<0.001$) compared with the control. Moisture content (%) was significantly increased by 100 W/cm^2 for 10 or 25 min ($p<0.05$). Decreased cohesion force ($p<0.05$) and gumminess ($p<0.05$) were evident in sonicated samples. Ultrasonic curing can assist in brine transfer, thus reduce processing times without any detrimental impact on the quality of the end-product.

Key Words – brine, ham, processing

I. INTRODUCTION

Curing is an ancient preservation technique which involves the addition of brine to meat. Of the brine ingredients, NaCl is the most important for its preservation, flavor and quality enhancing properties. With the increased consumer demand for convenience meat products, the curing process has undergone many modifications and this has led to a wide range of cured meat products being available. For all the cure methods that can be applied, NaCl must diffuse into the complex meat matrix and this is a slow process. Several techniques have been investigated for the acceleration of meat curing such as vacuum tumbling [1], vacuum drying [2] and thaw salting operations [3]. Power ultrasound (US) is a novel processing technology which may accelerate mass transfer through several mechanisms such as cavitation, micro-stirring, micro-jetting and mechanical squeezing and releasing of the sample. The beneficial effect of US on mass transfer has been proven in apple [4], peppers [5], and cheese [6]. Studies on the ultrasonic curing of meat are limited. Of the few studies published, results are conflicting. Some authors suggest low-intensity US is effective for increased mass transfer [7], other authors suggest that a minimum ultrasonic threshold of 51 W/cm^2 is required for increased NaCl uptake [8] and some authors suggest there is no effect [9]. This study aims to assess a range of ultrasonic treatments on brine uptake by pork samples and to assess the quality of the cured meat.

II. MATERIALS AND METHODS

A. Meat Sampling and treatment

Pork *M. longissimus thoracis et lumborum* were excised from the carcass at 24 h post-mortem and vacuum packed. Muscles were stored at 4°C for 72 h prior to processing. Cylindrical samples (35 ϕ × 25 mm) of parallel fiber direction to the axis were cored from the muscles. Each sample was placed in an adapted jacketed vessel with an internal diffusion cell of 34 mm diameter. A glycol coolant (-2°C, 5L/min) was circulated through the jacketed beaker. A brine solution (65ml; 6% NaCl) was placed on top of the sample such that it came in contact with the one exposed surface of the meat. Ultrasonic treatments were applied by an XL2020 ultrasonic processor (Misonix, USA). The full power and frequency of the system were 550 W and 20 kHz, respectively. The entire ultrasonic head with an emitting surface of 12.6 mm

diameter was inserted into the brine. The distance from the US probe to the meat surface was 30 mm. Treatments were applied according to Table 1. Samples were kept at 4°C post-treatment until they had a total brine contact time (i.e. including US treatment time) of 2 h. A non-sonicated sample acted as the control.

Table 1. Experimental design treatments

Treatment	Time (min)	Ultrasonic Intensity (W/cm^2)
Control	0	0
1	10	44
2	10	72
3	10	100
4	25	44
5	25	72
6	25	100
7	40	44
8	40	72
9	40	100

B. Proximate analysis and pH

The sample pH was recorded by direct insertion of a glass pH electrode EC-2010-11 (Refex sensors Ltd., Westport, Co. Mayo, Ireland) into the meat. The top 10 g of the sample was removed for analysis. Moisture analysis was determined by weight loss after overnight oven drying at 103 ± 2°C. NaCl content was determined by standard titrametric Volhard method [10].

C. Cook loss and WHC

The top 10g of the sample were weighed and placed in adapted tubes [11]. Samples were cooked (90°C, 10min), reweighed, centrifuged (1000 rpm, 4°C, 10 min) and weighed a final time. The cook loss was recorded and the percentage weight change before and after cooking. The WHC was calculated as the percentage weight change before cooking and after centrifugation.

D. Color measurement

Color measurements were recorded on each sample before entry into the diffusion cell and directly after the curing period. Values of lightness (L*), redness (a*) and yellowness (b*) were recorded by the CIE Lab system on a dual beam spectrophotometer (Ultra Scan Pro, Hunter Lab, Virginia, USA). The total color difference (ΔE) was calculated according to equation 1. An average of three readings was taken per sample.

$$\Delta E^* = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \right]^{1/2} \qquad (1)$$

E. Texture profile analysis

Texture profile analysis (TPA) was performed on samples after cooking in a water bath (77°C, 10 min). Analyses were performed on a cylindrical core (16 ϕ x 20 mm) taken from the centre of the sample. A total of seven replicates were completed. Readings of hardness (N), chewiness (N), cohesiveness, gumminess (N) and springiness (mm) were recorded using an Instron Universal testing machine (Model no. 5543, Instron, UK).

F. Statistical analysis

Two separate statistical analyses were performed using Genstat software (Genstat, 14th Edition, VSN international Ltd, UK). Firstly, a two-way analysis of variance (ANOVA) with factors of treatment time and ultrasonic intensity was used to assess differences between ultrasonic treatments (i.e. excluding the control). Secondly the control was included in a randomized block analysis with ten treatments with muscle set as a random effect. This allowed for a test between individual treatment means including the control. Where a significant difference was detected, means were compared using a least significant difference test (LSD).

III. RESULTS AND DISCUSSION

A. pH, NaCl and Moisture

US treatments did not have an effect on the pH of samples ($p>0.05$). There was a significant effect of US intensity on moisture content whereby samples subjected to 100 W/cm^2 ($p<0.05$) showed higher moisture content than other US intensities. The treatment which caused the greatest increase in moisture content was 100 W/cm^2 for 10 min but

this was not significantly different from the 25 min treatment at 100 W/cm^2 and 72 W/cm^2 (Fig. 1).

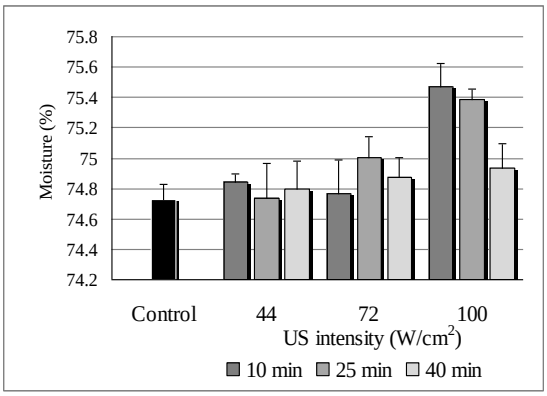

Fig 1. Mean moisture content (%) for each treatment. Error bars show the standard deviations.

NaCl content increased as a function of US treatment time ($p<0.05$) and US intensity ($p<0.001$). All US treatments resulted in increased NaCl content in comparison with the control ($p<0.001$) (Fig. 2). The treatment with the highest NaCl content was 100 W/cm^2 for 25 min, though this was not significantly different from the 40 min treatments at 72 and 100 W/cm^2.

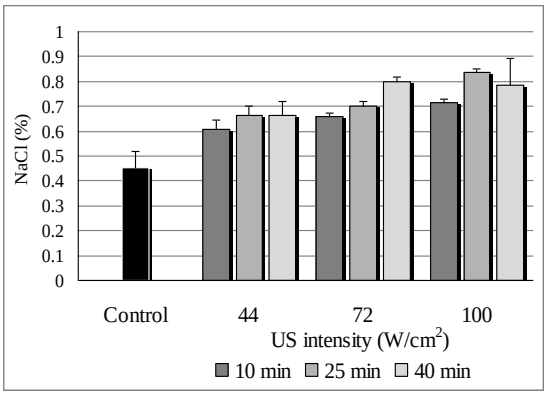

Fig. 2. Mean NaCl content for each treatment. Error bars show the standard deviations

B. Cook loss and WHC

There was no significant effect ($p>0.05$) of ultrasonic curing on cook loss and WHC.

C. Color

US curing had no effect ($p>0.05$) on the total color difference (ΔE) of samples.

D. TPA

There was no difference ($p>0.05$) in the hardness (N), chewiness (N) or springiness (mm) of samples. Cohesiveness of samples was decreased ($p<0.05$) by all ultrasonic treatments in comparison to the control (Fig. 3), though the overall difference was quite small (up to 5.6%). However, there was a large decrease ($p<0.05$) in gumminess of samples when using ultrasonic curing. All US treatments resulted in lower gumminess than the control ($p<0.05$) with the exception of 72 W/cm^2 for 10 min. The lowest gumminess with a 36% reduction compared to the control was achieved by 72 W/cm^2 for 40 min (Fig. 4).

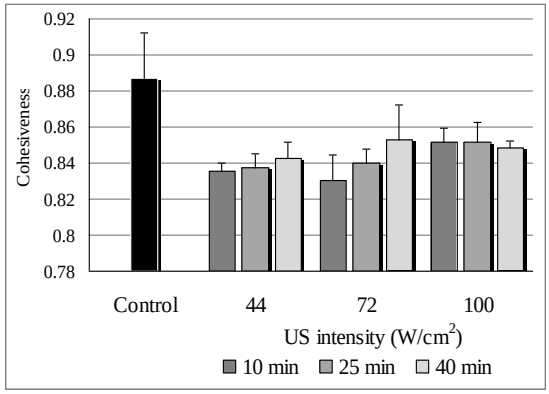

Fig. 3. Mean cohesiveness for each treatment. Error bars show the standard deviation.

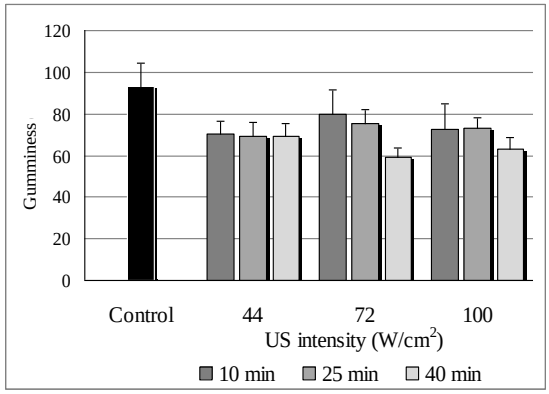

Fig. 4. Mean gumminess for each treatment. Error bars show the standard deviations.

For all parameters where significant effects of US treatments were found, the US treatment with the greatest total energy input (100 W/cm^2 for 40 min) was not found to give the greatest effect. It may be that prolonged exposure of meat to high ultrasonic intensities results in protein denaturation [7] which may partially offset some of the effects found with shorter exposure times thereby explaining the results presented in this study.

IV. CONCLUSION

Ultrasonic curing can increase brine uptake during meat curing. NaCl content increased as a function of US intensity and treatment time, with the greatest increase in NaCl content being achieved by a treatment of 100 W/cm^2 for 25 min. For increased moisture gain, a treatment of 100 W/cm^2 for 10 or 25 min was required. Ultrasonic treatments had a potentially positive effect on meat texture by decreasing the cohesiveness and gumminess, without any detrimental effects on other quality parameters. Ultrasonic curing exhibits excellent potential for the acceleration of processing in the meat industry.

ACKNOWLEDGEMENTS

The authors wish to thank the Department of Agriculture, Fisheries and Food for their financial support through the Food Research Institutional Measure (FIRM).

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