SHORT COMUNICATION

IMPACT OF LOW TEMPERATURE, PROLONGED TIME TREATMENT AND VACUUM DEPTH ON THE PORCINE MUSCLE QUALITY AND SAFETY

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Abstract

The effect of low temperature (53 °C), long time heat treatment (Tc +5 h and Tc + 17 h – holding time, Tc – core temperature equal to the water bath temperature), and vacuum depth (0.3 and 0.6 -10^5 Pa) on texture and microbiological safety parameters in *M.longissimus dorsi* from slaughter pigs were studied. The study involved analysis of meat moisture, toughness, cooking loss and microflora parameters. Decreasing shear force and increasing cooking loss during low temperature and long time treatment was observed at 53 °C temperature along with the treatment duration (Tc +5 h and Tc +17 h). Positive shear force and vacuum depth correlation was oberved in the samples. No correlation between samples moisture content and shear force was found. Microbiological analysis revealed safety of the produced product within two weeks period storage at 4 °C temperature.

***Keywords*:** LTLT, vaccum depth, porcine quality and safety.

Introduction

Gentle treatment technologies have been improved during the last decade by cook-in-bag / container technology, which has been extensively adopted by catering services and food processing plants due to the possibility of increased consistency along the muscle as well as appealing texture and colour of the meat. Studies have shown that meat is more tender and has less cooking loss when heating temperatures are low. A range of heat-induced changes occurs at temperatures between 48 °C and 63 °C, and these events, alone or due to the presence of other proteins can be of significance to toughness, cooking loss and colour of LTLT treated meat (Christensen et al., 2011, Christensen et al., 2013). Clearly temperature, but also duration of cooking has a large effect on the physical properties of meat and the eating quality. But the effect on these physical properties when meat is heated at lower temperatures for a long period of time (LTLT) and different vacuum levels is not clearly understood. The aim of the study was to investigate the combined effect of heating temperature, time and vacuum depth on the physical properties and microbiological stability of LTLT treated *Longissimus dorsi* muscle from slaughter pigs.

Materials and Methods

Samples: Longissimus dorsi (LD) muscles were obtained from both sides of 10 slaughter pigs. Whole muscles were vacuum packed and stored at 4 °C for 2 days. After storage muscles were cut into samples, vacuum packed at different depth of vacuum (0.3×10^5 Pa and 0.6×10^5 Pa) and heat treated at 53 °C for Tc +5 h and Tc + 17 h – holding time (Tc – core temperature equal to the water bath temperature). After thermal treatment, samples were taken from the water bath and immersed in an ice-water bath until the temperature reached 26 °C. The samples were then stored in a storage room at 0–4.0 °C for 24 h up to 14 days before analysis. After storage, sample weights were recorded in order to calculate cooking weight losses, samples moisture analysis conducted (105 °C).

Warner–Bratzler shear force: blocks of 1×1×6 cm were cut from the heat treated samples. Each block was sheared 3 times by Lloyd TA1 Texture Analyzer equipped with a triangular Warner–Bratzler test cell. Mean maximum force required to shear through the samples, Warner–Bratzler Shear Force, was determined from each LTLT treatment.

Microbiological analysis: A surface area of 14.7 cm^2 and 0.3 cm depth was sampled in an aseptic manner from the surface of each muscle (raw, LTLT processed, stored for 7 and 14 days). Homogenates and suitable dilutions were prepared. Total plate count, mezophilic, thermophilic bacteria, *Enterobacteriaceae*, *Escherichia coli* counts, yeast and were performed according to standard procedures: LST EN ISO 4833:2003, LST ISO 21527-1:2008, LST ISO 21528-2:2009, LST ISO 16649-2:2002.

Statistical analysis was performed using the Statistical Analysis System (SAS, 1989). Variance was analyzed by using the general linear model procedure of SAS.

Results and Discussion

Effect of LTLT treatments in different vacuum depth on cooking weight loss, Warner–Bratzler shear force and water content. This study investigated the combined effect of heating duration of Tc + 5 h and Tc + 17 h and vacuum depth of 0.3 and 0.6×10^5 Pa of samples treated at 53 °C temperature evaluating in raw and LTLT treated samples moisture, cooking loss, shear force parameters.

Table 1 shows the results obtained for cooking weight loss (CL), Warner–Bratzler shear force (WB) and moisture.

Table 1

Physical properties analysis of LTLT *Longissimus dorsi* muscle (mean values)

Treatment / Properties	Raw meat sample	T_c+5h, 0.3 10^5 Pa	T_c+5h, 0.6 10^5 Pa	TT_c+17h, 0.3 10^5 Pa	TT_c+17h, 0.6 10^5 Pa
Moisture, %	664.24	667.76	667.88	667.99	557.76
Share force, N	552.43	449.90	884.24	559.38	772.34
Cooking loss, %	NA*	88.72	99.02	116.66	115.12

*NA-not applicable

Among alterations in the meat occurring during cooking are toughness and juiciness changes, both of them being important when assessing eating quality of meat.

As expected, cooking loss increased when thermal treatment time was prolonged from Tc+5 h to Tc+17 h in both samples groups: by 91% for LTLT samples treated in 0.3×10^5 Pa vacuum depth, and 68% for samples treated in 0.6×10^5 Pa vacuum depth. However no significant differences were found ($p>0.05$) within the LTLT samples treated the same time but different vacuum depth. The results are in line with those reported for *Semitendinosus* (ST) muscle from young bulls (Christensen et al., 2013), although controvercial result of the same authors was found for *Longissimus dorsi* muscle from slaughter pigs where increasing time did not affect the cooking loss at any temperature (Christensen et al., 2011).

Moisture content did not differ significantly, except for LTLT samples treated for Tc + 17 h at 0.6×10^5 Pa vacuum depth, where moisture was 11% lower than the avarge of LTLT treated samples. Cristensen et al. (2012) found that juiciness decreased with increasing heating temperature and time in all species, and cooking loss increased with increasing temperature.

Shear force (WB) mean values increased as the vacuum depth increased, significant differences ($p<0.05$) being observed between the mean values obtained in samples treated for 5 h in 0.3 and $0{,}6\times10^5$ Pa vacuum depth where shear force increased by 69 % and by 23 % in samples treated of 0.3 and $0{,}6\times10^5$ Pa for 17 h. Both heating time and vacuum depth significantly affected shear force for LTLT porcine samples treated for 5 h at 53 °C temperature, the linear relationship was found for the experiment, although for 17 hours treated LTLT samples there was inverse effect registered between vacuum depth and shear force parameters (table 1). Mortensen et al. (2012) performed sensory analysis of eating quality and found increased tenderness of ST from young bulls with increasing heating times from 3 to 12 h at 56 °C, 58 °C and 60 °C, although in contrast to the results of the current decreased shear force with increasing heating time was found in cows, where WB-PF of ST decreased with increasing temperature and only minor decreases of WB-PF were observed with increased heating time, except at 55 °C where a significant decrease in WB-PF was observed with increasing temperature from 2.5 h to 19.5 h (Christensen et al., 2013).

Effect of LTLT treatments on product microbiological quality

The temperature and treatment duration primarily defines the sensory quality, microbial safety and shelf-life of LTLT products. A number of national and international recommendations exist, such as good manufacturing practice (GMP). Significant process parameter differences are evident among the various GMP recommendations; nevertheless, all of them, invariably, focus upon microbiological safety (Vaudagna et. al., 2002). The results from the current microbiological investigation of the raw meat (LD) and LTLT treated LD from pigs are presented and the effect of 53 °C treatment for 5 and 17 h regime on samples safety discussed below.

Microbiological analysis of raw *M.Longissimus dorsi* revealed the pollution status of the raw material ready to use for LTLT treatment. Total plate count varied within the limits of 2.6×10^6 to 1.1×10^7 CFU g^{-1}, mesophilic bacterial count – 2.0×10^6 to 0.8×10^7 CFU g^{-1}, thermophilic bacteria count – 1.0×10^4 to 5.1×10^4 CFU g^{-1}, yeast and mold count within the limits of 3.8×10^2 to 6.0×10^2 CFU g^{-1}, spores of thermophilic microorganisms, *Enterobacteriaceae* and *E. coli* have not been identified in the samples. Microbiological data suggested that the initial contamination of the raw material was high enough, but no defects and deterioration of the samples were observed. Bacterial spores that can survive heat treatment have not been found.

Treatment of 53 °C temperature for 8 h (Tc +5 h) and vacuum depth of 0.3×10^5 Pa and 0.6×10^5 Pa significantly diminished microbiological contamination in the LTLT treated samples within the 1st shelf life day compared to those of raw meat samples. Samples treated with different vacuum depth of 0.3×10^5 Pa and 0.6×10^5 Pa revealed that total plate count varied within the limits of 1.6×10^2 and 2.0×10^1 CFU g^{-1}, mesophilic bacteria count – 1.1×10^2 and 1.4×10^1 CFU g^{-1} thermophilic bacteria count within the limits of 7.5×10^1 and 4.3×10^1 CFU g^{-1} respectively. Yeast and molds, mesophilic and thermophilic bacteria spores, *Enterobacteriaceae* and *E. coli* have been identified in the LTLT samples.

LTLT samples (treatment of 53 °C temperature for 8 h (Tc +5 h) and vacuum depth of 0.3×10^5 Pa and 0.6×10^5 Pa) were kept for 14 days and analysed for microbiological contamination on the 7th and 14th day of the storage. A minor growth of micro-organisms in the samples stored for 7 days was registered; however

significant microorganisms' increase (with no threat to human safety) in the samples kept for 14 days was identified. Samples treated with different vacuum depth of 0.3×10^5 Pa and 0.6×10^5 Pa revealed that total plate count varied within the limits of 3.2×10^4 and 3.0×10^4 CFU g^{-1}, mesophilic bacterial count – 2.7×10^4 and 1.4×10^4 CFU g^{-1}, thermophilic bacteria count - $1.1x10^4$ and 0.8×10^4 CFU/g respectively. Yeast and molds, mesophilic and thermophilic bacteria spores, Enterobacteriaceae and E. coli have not been identified in the LTLT samples within the 14 days of storage.

Treatment of 53 °C temperature for 20 h (Tc +17 h) and vacuum depth of 0.3×10^5 Pa and 0.6×10^5 Pa significantly diminished (by 10 times) microbiological pollution in LTLT samples compared those of raw meat samples within 7 days of storage. The results revealed that microbiological indicators level was similar to those of 8 h (Tc + 5 h) treatment within the whole storage period (14 days).

Both LTLT treatments for 8 and 20 h duration with different vacuum depth enabled to reduce the marginal pollution of raw meat samples from 2.6×10^6–1.1×10^7 CFU g^{-1} to 2.0×10^1–3.5×10^2 CFU g^{-1} in LTLT samples already at the 1st day of storage, with inactivation of yeast and molds.

Conclusions

Application of low temperature and long time treatment (53 °C, Tc +5 h and Tc + 17 h – holding time, Tc – core temperature equal to the water bath temperature, and vacuum depth of 0.3 and 0.6 -10^5 Pa) revealed that:

- cooking loss increased due to low temperature treatment prolongation from Tc +5 h to Tc + 17 h in LTLT *M.Longissimus dorsi* samples;
- shear force (WB) mean values increased as the vacuum depth increased, significant differences ($p<0.05$) being observed between the mean values obtained in samples treated for 5 h in 0.3 and $0{,}6\times10^5$ Pa vacuum depth where shear force increased by 69% and in samples treated of 0.3 and 0.6×10^5 Pa for 17 h by 23%.

Analyzing the obtained microbiological analysis results it can be concluded that employing LTLT treatment and different depth of the vacuum (0.3×10^5 Pa and 0.6×10^5 Pa) the microbiological safety of the LTLT product was ensured for a maximum period of 14 days, as longer storage times would increase the risk of mesophilic and thermophilic bacteria development.

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