Influence of sonication on the oxidative stability of beef

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Abstract

Research in the last decade has shown the potential benefits of ultrasound treatment as an alternative technology for modifying properties of meat and meat products. The aim of research was to investigate the influence of ultrasound treatment on the oxidative stability of beef. Investigations were carried out on the *m. semimembranosus* excised at 24 hour post mortem and divided into eight blocks. Four of them were regarded as control samples (C). The other four were subjected to ultrasound treatment for 120 s with frequency of 45 kHz (sample S). Samples were then stored at 4°C until assessed. Directly after ultrasound treatment and then daily for a total of 4 days the following characteristics were tested: lipid oxidation by the TBARS method, carbonyl groups content, colour parameters CIE. By accounting for combined changes in L*a*b*, total colour change (ΔE) was assessed. Obtained results pointed out that colour of sonicated sample was slightly less stable as compared to the control sample of meat during ageing. The TBARS analysis revealed slight differences in the rate and extent of lipid oxidation between the samples during storage. No significant differences were observed between carbonyl compounds concentration in examined samples. This study shows that sonication in conjunction with chilled storage may be an effective method of formation technological properties of beef without compromising its oxidative stability.

Introduction

Safety and quality are of utmost importance to the meat industry. Treatments that have potential to ensure safe, consistent, high-quality products have been a major priority for recent research. Use of sonication as a processing technology appears to have excellent potential to achieve both safety and quality improvements. Applications of ultrasound to provoke changes in physical and chemical properties of meat and meat products have attracted the interest of research workers for the past few decades because it is a pure physical technique, providing an alternative to chemical or thermal means of processing (Dolatowski & Twarda, 2004; Dolatowski *et al*., 2007; Jayasooriya *et al*., 2004). Any method used for meat processing should not deteriorate its quality. Apart from microbial spoilage, oxidative deterioration of lipid and proteins is a major concern for food technologists due to the loss of quality associated with those processes.

The aim of this work was to evaluate the effect of sonication on the oxidative stability of lipids and proteins during a chilling storage of *semimembranosus* muscles from beef.

Materials and methods

Raw material

Investigations were carried out on young bulls (Lowland Black and White breed) slaughtered at a live weight of approximately 450 - 500 kg following standard procedure. The muscles (***M. semimembranosus***), free from quality defects, were excised at 24 hour *post mortem* from left half - carcasses of temperature 7°C. Muscle, free of external fat and connective tissue, was divided into eight blocks, (70 mm x 70 mm x 80 mm, length, width and height, respectively) of about 400 g. Four of the parts were regarded as control samples (C). The other four were subjected to ultrasound treatment with frequency of 45 kHz (sample S). In order to carry out ultrasound treatment samples packed in polyethylene bags were placed into an ultrasound bath (Polsonic, Warsaw, Poland) filled with cold water (4°C) and then sonicated. The low intensity ultrasonic field (2 W/cm^2) was applied perpendicularly to muscle fibers for 120 s. Meat samples were then stored at 4°C. Analyses were performed directly after ultrasound treatment and then daily for a total of 4 days.

Instrumental colour

Colour parameters were determined with an X - Rite Color® Premiere 8200 colorimeter (X-Rite Incorporated, Michigan, USA) with an illuminant D65, a 10° observer angle and a 3,32 inch diameter light surface. The instrument was calibrated against a white tile (L^* = 95,87, a^* = -0,49, b^* = 2,39) and a light trap. Samples for colour measurements were 5 cm thick and excided at the depth of 20 mm. An index ΔE describing the total colour change was calculated according to CIE equation (Commission Internationale de l`Eclairage (CIE), 1978):

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Lipid oxidation

Lipid oxidation was assessed by the 2-thiobarbituric acid (TBARS) method of Salih with some modifications (Pikul *et al*., 1989). The TBARS volumes were expressed as mg malondialdehyde/kg meat (mg MDA/kg meat).

Protein oxidation

Protein oxidation was measured by estimation of carbonyl groups formed during incubation of purified myofibrils (Cheng & Parrish, 1978) with 2,4-dinitrophenylhydrazine (DNPH) in 2 N HCL following the method described by Oliver *et al*. (1987). Carbonyl concentration was expressed as nanomoles of DNPH fixed per milligram of protein using an absorption coefficient of 21.0 $mM^{-1}cm^{-1}$ at 370 nm. Protein oxidation was expressed as nmol carbonyls/mg protein.

Three series of experiments and three replications of each experiment were conducted. Obtained results were subjected to statistical analysis (α=0.05). Error bars in all figures represent ± standard error.

Results and discussion

The TBARS analysis (Figure 1) revealed slight differences in the rate and extent of lipid oxidation between samples during storage. At the start of the experiment sample of meat subjected to ultrasound treatment (S) was characterized by the higher TBARS values than the control sample. The passage of time after slaughter was coupled with the decrease of the difference between samples.

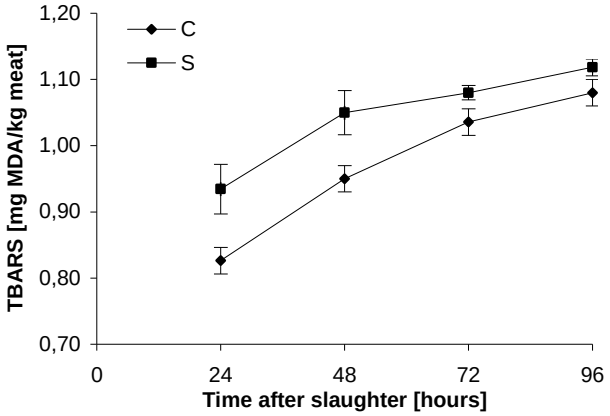

Figure 1. Lipid oxidation (mg MDA/kg meat) of *M. semimembranosus* during storage.

Analysis of total colour change ΔE (Table 1) showed a slight influence of ultrasound treatment on meat colour stability. Colour of sonicated meat sample (S) was less stable as compared to the control sample (C) sample. The most noticeable differences between samples were observed 72 hours *post mortem*. The total colour change of both examined samples tended to increase during storage.

Table 1. Influence of sonication on meat colour (mean ± standard error)

		Time after slaughter (hours)		
		48	72	96
C	ΔE	1.87±0.03	1.73±0.03	2.39±0.02
S		2.08±0.02	2.57±0.03	2.62±0.01

Protein carbonyl content was increasing during meat aging (Figure 2). No clear effect of sonication was noted on carbonyl content. Comparison of result obtained for samples C and S at the end of the experiment showed that the former had slightly lower concentration of carbonyl groups than the latter. These results showed that during beef meat storage protein oxidation as measured by carbonyl content is linked to lipid oxidation as measured by TBARS values. These results are in agreement with those previously found by Mercier et al. (1995).

For a few days after animal death antioxidant protection of muscle remains active, certainly contributing to limit carbonyl formation. After 10 day of *M. longissimus lumborum* and *M. diaphragma pedialis,* Martinaud *et al*. (1997) measured carbonyl values of 5.1 nmol/mg and 6.9 nmol/mg protein in myofibrils, respectively. In meat, amino acids with reactive side chains, for example, amino and sulfhydryl groups, are especially susceptible to oxidation. Formation of carbonyls is one of the most important changes in oxidized proteins. Protein oxidation is responsible for many biological modifications,

as protein fragmentation or aggregation and decrease in protein solubility, affect the quality of meat and meat products (Decker *et al*., 1993; Estévez & Cava, 2004).

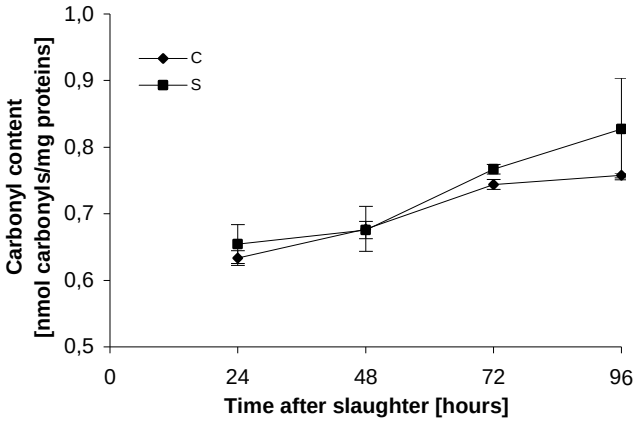

Figure 2. Protein oxidation (nmol carbonyls/mg proteins) of *M. semimembranosus* during storage.

Oxidation might also play a role in controlling proteolytic activity of enzymes and could be linked to meat tenderness (Mercier *et al*., 2004; Starke-Reed & Oliver, 1989). In meat, protein oxidation may lead to decreased eating quality such as reduced tenderness and juiciness, flavour deterioration and discoloration.

Conclusions

This study shows that sonication in conjunction with chilled storage may be an effective method of formation of technological properties of beef without compromising its oxidative stability.

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