Effect of pulsed magnetic field on microbiological quality and lipid oxidation of minced beef meat during refrigerated storage

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Abstract—**This study was conducted to investigate the effect of pulsed magnetic field (PMF) on the microbiological quality and lipid oxidation of minced beef meat during refrigerated storage at 4°C. Fresh minced samples (*Supraspinatus* muscles) were exposed to 1 Hz PMF with intensity about 10 mT for 2 hours at 4°C. Treated and non treated (control) samples were stored at refrigeration temperature (4±1) °C during 12 days. Their microbiological quality was assessed before the exposure and at 6ht and 12th day of storage by counting the number of total aerobic mesophilic bacteria. The lipid oxidation was determined by thiobarbituric acid reactive substances (TBARS) every 2 days of storage. Five experiments were conducted and data were evaluated by Student's *t*-test. Analysis of variance (ANOVA) and Duncan´s Multiple Range Tests, at the 0.05 level of significance, were used for comparing the means to find out the effect of storage period. The mesophilic count did not change until the 6th day of storage for both groups. But at the 12th day the mesophilic count significantly increased by 2 logs and 0.7 logs for control and treated samples, respectively. The TBARS number of both groups increased during 12 days of refrigerated storage. However, PMF treatment had no significant effect on the TBARS number of samples at any particular storage time. PMF can be a potential technology for meat preservation since the exposure of minced beef meat to PMF in this study conditions reduced the microbial growth and did not affect the lipid oxidation stability.**

Keywords—**Meat quality, preservation, meat stability.**

I. INTRODUCTION

Studies observed affects of magnetic fields on biological material such as enzyme activity [1], cell metabolism [2], and especially in the development of microorganisms [3,4]. Based on these effects, some authors proposed the use of magnetic fields as a potential alternative for food preservation [5,6].

Application of magnetic fields to process food products is being considering a novel nonthermal processing method like irradiation and high hydrostatic process, but very limited studies have been carried out on this topic.

However, in the specific case of fresh meat, the application of some nonthermal preservation technologies can produce undesirable changes like an increase in lipid oxidation [7,8] and consequently off-odors and flavors [9].

This study was undertaken to evaluate the effect of pulsed magnetic field with intensity about 10 mT at 1Hz of frequency on the microbiological quality and lipid oxidation of minced beef during refrigerated storage at 4°C.

II. MATERIALS AND METHODS

A. Sample preparation and exposure to PMF

Five *Supraspinatus* muscles (chuck tender) were obtained at 48 hours post slaughter from female Angus cattle weighing 429 to 462 lbs and aged between 18 and 24 months. Each muscle was minced and aerobically packaged in polypropylene trays (0.09m x 0.065 m x 0.04m) covered with polyvinyl chloride film.

The magnetic field was produced inside a cylindrical coil by an electric current supplied to the coil, similar to described by Novák et al. [4]. Packed minced samples were placed in the centre of the coil and exposed to a 1 Hz PMF with intensity about 10 mT for 2 hours at (4±1) °C. Control samples were not exposed to PMF. Treated and control samples were stored in the dark at (4±1) °C for 12 days and evaluated during the refrigerated storage.

B. Microbiological analysis

Microbiological quality was assessed before the exposure to PMF and at the 6th and 12th day of refrigerated storage through total aerobic mesophilic bacteria count. A 25 g sample of minced meat was homogenized at 4000 rpm for 2 minutes with 225 mL of 0.1% saline peptone (Oxoid) in an aseptic homogenizer (Tecnal, TE-645 model). The homogenate was serially diluted and the different dilutions were placed, in duplicate, on Plate Count Agar (PCA) medium. The total aerobic mesophilic bacteria count was determined after incubation for 48 hours at (36±1) ^{o}C. Results were expressed as the number of colony-forming units (CFU) per g of meat.

C. Lipid oxidation

Lipid oxidation was measured before the exposure to PMF and every 2 days of refrigerated storage. The lipid oxidation was determined as 2-thiobarbituric acid reactive substances (TBARS) [10] and the results were expressed as mg of malondialdehyde (MDA) per kg of meat from the standard curve. TBARS determinations were carried out in two replications for each sample.

D. Experimental design and statistical analysis

Five muscles were used and each muscle composed one tray with control sample and one tray with treated sample. Data from the two different treatments were evaluated statistically by Student's *t*-test. Analysis of variance (ANOVA) and Duncan´s Multiple Range Tests, at the 0.05 level of significance, were used for comparing the means to find out the effect of storage period.

III. RESULTS

A. Microbiological analysis

Total aerobic mesophilic bacteria counts in treated and non treated control samples during refrigerated storage are shown in Fig. 1. Initial mean counts were 3.3 $\log_{10}$CFU/g. In both cases there were no significant changes in microbial counts until the 6th day of refrigerated storage.

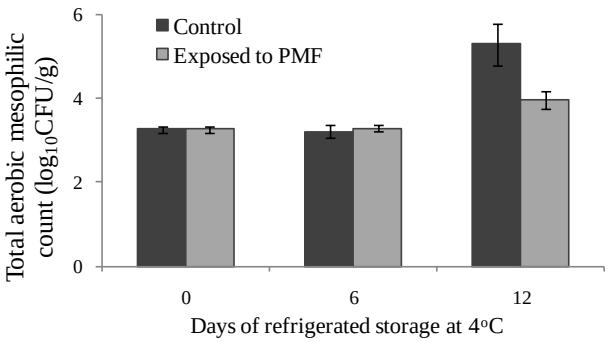

Fig. 1 Effect of exposure to pulsed magnetic field on total aerobic mesophilic counts of minced beef during refrigerated storage at 4^{o}C.
Vertical bars represent the standard error.

On the 12th day, there was an increase of 2 $\log_{10}$ cycles and 0.7 $\log_{10}$ cycles in relation to the initial counts for control and treated samples, respectively. So, the exposure to a 1Hz PMF for 2 hours reduced the total aerobic mesophilic count on the 12th of refrigerated storage comparing to the non exposed sample.

B. Lipid oxidation

Lipid oxidation of treated and non treated control samples during refrigerated storage are shown in Fig. 2. TBARS values from treated and control samples showed a similar behavior during the storage at 4^{o}C. Initial TBARS mean values were 0.10 mg MDA/Kg meat.

A significant increase in TBARS values was noticed on the 4th day for both the samples. On the 6th day and on the 8th day there was a decrease in the TBARS values for treated and control samples, respectively and on the 10th day the TBARS values increased for both treatments. But differences in TBARS number for treated and control samples were not significant at any storage time.

The exposure to a 1Hz PMF for 2 hours did not affect the lipid oxidation of minced samples during 12 days of refrigerated storage.

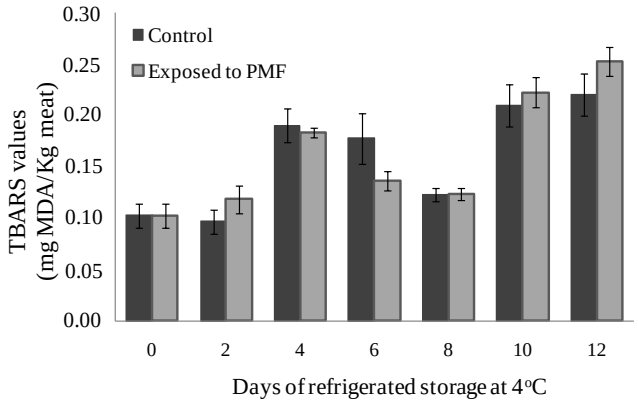

Fig. 2 Effect of exposure to pulsed magnetic field on TBARS values of minced beef during storage at 4°C. Vertical bars represent the standard error.

IV. DISCUSSION

A. Microbiological analysis

The low initial microbial counts indicate that the samples were obtained in good hygienic conditions in terms of mesophilic aerobic microorganisms.

Skrökki [11] analyzed 37 minced meat samples and verified that, in terms of mesophilic aerobic microorganisms, 80% of the samples showed good hygienic quality (<7 $\log_{10}$CFU/g of meat), 20% had tolerable quality (from 7 to 8 $\log_{10}$CFU/g of meat) and only one sample showed poor quality (>8 $\log_{10}$CFU/g of meat). Based on these parameters, samples in the present study showed good hygienic quality during 12 days of refrigerated storage.

The behavior observed in Fig. 1 is consistent with verified by Novák et al. [4] that the magnetic field kills a part of the microorganisms, maybe the most sensible to external fields, and the rest of them continue to develop without any disturbance.

Effects of magnetic fields on microorganisms, as well as in the present study, have also been observed by other authors [4, 12] who obtained different results, since the effects of magnetic fields depend on the type and strain of microorganism. The microbiological analysis assessed in the present study is a general analysis and do not identify which specific microorganisms are present in the samples.

In vitro reduction of yeast *Sacharomyces cerevisiae* treated with 50 Hz magnetic field with intensity of 10 mT was observed by Novák et al. [4] comparing to non treated samples, with no difference when using different exposure times to the magnetic field (12 or 24 minutes).

Some authors reported that magnetic fields, in general, alter the growth and reproduction of microorganisms, causing changes in DNA synthesis, change the orientation of biomolecules and biomembranes to a parallel or perpendicular direction to the applied magnetic field and change the ionic movement across the plasma membrane [13]. And also, other authors observed effects of magnetic fields of 55 and 80 mT on the synthesis *in vitro* of ATP which may also explain the inactivation of microorganisms [14].

B. Lipid oxidation

Changes in TBARS values over the time of refrigerated storage were expected, since the aerobically packaging favors the lipid oxidation.

The exposure to 1 Hz PMF of about 10 mT for 2 hours did not affect TBARS values of minced beef during 12 days of refrigerated storage.

In general other methods used for fresh meat preservation as ionizing radiation and high hydrostatic pressure, although very effective in inactivating microorganisms, can cause sensory changes as an increase in lipid oxidation [15], which was not observed in the present study with pulsed magnetic field.

Some authors observed that irradiation of fresh minced beef with 5 or 10 kGy increases TBARS values during the refrigerated storage at 4°C and the addition of antioxidants as α-tocopherol can delay the lipid oxidation during the refrigerated storage [16].

V. CONCLUSIONS

In conclusion, pulsed magnetic field with intensity about 10 mT at 1Hz of frequency improves the microbiological quality, in terms of mesophilic aerobic counts and did not affect the lipid oxidation of fresh meat during refrigerated storage. The use of PMF has the potential to be used as innovative technology in combination with refrigeration in the preservation of fresh meat, however more studies are needed to

understand the mechanisms of action of the magnetic fields.

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