Microbial and physical changes in marinated beef of high and normal pH during storage in different atmospheres

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Introduction

In DFD (Dark, Firm, and Dry) meat, the concentration of muscle glycogen and available glucose is low, ultimate pH is high, and therefore the meat is more susceptible to microbial spoilage (Gardner et al., 2001; Apple et al., 2005; Mounier et al., 2006). The food industry at present is using different marinades (Björkroth et al., 2005; Friedman et al., 2006), and modified atmosphere packaging (Phillips, 1996; Ercolini et al., 2006) to modify the meat ecosystem and these changes may influence the shelf life of meat including the microbial spoilage. Although there is some knowledge on the effect of different modified atmosphere packaging (MAP) and some marinade treatments on the microbial growth on meat, there is a lack of information concerning the effect of the interaction of these strategies on meat microflora development and on meat quality attributes. The objective of this study was to evaluate and compare the effect of marinating beef with high and normal pH, respectively, in red wine under different MAP conditions with respect to meat quality characteristics and microbial spoilage.

Materials and Methods

Two DFD *Longissimus dorsi* (LD) and 2 Normal LD from the 11th to 16th vertebra were removed from beef carcasses at 7-10 days postmortem. Twenty-four steaks of 1 cm of thickness were cut from each LD and randomly assigned to 1 of 24 treatments following a 2 x 2 x 2 x 6 factorial experimental design. The main factors ultimate meat pH (below 5.8; normal, or above 6.5, DFD), marination (non- marinated vs. marinated with red wine), MAP conditions (70% O_2/ 30% CO_2, MAP-O; vs. 70% N/30% CO_2, MAP-N), and days of storage (0, 3, 7, 11, 15, and 19). Steaks assigned to marination treatment were covered during 36 h with organic red wine (12.5% of alcohol and pH of 3.40). All samples were packaged into trays (13 x 18 x 4 cm) covered with transparent film, O_2 permeability of 10 cm^3 per m^2 day, and stored in the refrigerator at a constant temperature of 4ºC. At each sampling time meat quality attributes: pH, drip losses, water holding capacity, and meat color parameters: L* (lightness), a* (redness), b*(yellowness), were determined, and mesophilic aerobic bacteria, *Pseudomonas*, *Enterobacteriaceae*, *Brochothrix thermosphacta*, and lactic acid bacteria (LAB) were monitored. Furthermore, the DNA of each sample was extracted to analyze the microbiota by Denaturing Gradient Gel Electrophoresis (DGGE), as described by Nielsen et al. (2005).

Results and Discussion

In DFD meat, water-holding capacity (WHC) tended (P = 0.07) to be higher than normal meat in accordance to Apple et al. (2005), and Zhang et al. (2005). The other meat quality attributes were not significantly affected. However, the growth rate of bacteria was greater (P < 0.05) in DFD meat than in normal meat, as previously reported by Silva et al. (1999) and Gardner et al. (2001). Marination resulted in greater (P < 0.05) WHC, drip losses, and lower (P < 0.05) meat pH due to the effect of acidity and organic acid content of red wine (Friedman et al., 2006). Furthermore, the L*(lightness), a*(redness), and b*(yellowness) meat surface color parameters were significantly affected (P < 0.05) by marination with red wine indicating that the marinated meat was darker, less red and less yellow. Moreover, the interaction (P < 0.001) between marination treatment and storage time indicated that while there was a pronounced increase in bacterial counts in non-marinated meat during storage, the aerobic, mesophilic counts remained under 10^3 CFU/g in the marinated meat, i.e. too low a level to cause microbial spoilage. The effect of marination on the microbial counts was slightly higher (P < 0.05) in normal meat compared with DFD meat. The *Pseudomonas*, *Enterobacteriaceae*, and, in particular, LAB were the least affected bacteria while large reductions were observed in *B. thermosphacta*.

In terms of MAP, meat quality attributes were not significantly affected, in contrast to those results reported by Phillips (1996), and Ercolini et al. (2006). However, in meat packaged under MAP-O, the mesophilic aerobic bacteria, the *Enterobacteriaceae*, *Pseudomonas* and *B. thermosphacta* increased their initial number to about 10^5 or 10^6 CFU/g, in 3 days, whereas the development in the meat packaged under MAP-N was slower.

Using DGGE, twelve different strong bands were clearly identified, indicating a wide diversity of bacteria. The number of bands identified was affected by ultimate meat pH marinated treatment (P < 0.05), and MAP conditions (P < 0.01). For example, the number of bands identified was lower (P < 0.001) in normal meat (4.25±0.47) than in DFD meat (7.29 ±0.46).

Conclusions

Marination with red wine has a marked antibacterial effect and increases the microbiological shelf life stability. It also counteracts the differences between normal and DFD beef and marination should be considered as one way of enhancing the value of DFD meat. However, modifications are necessary to optimize some of the meat quality attributes.

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