EFFECTS OF MODIFIED ATMOSPHERE PACKAGING ON THE SHELF-LIFE OF HAMBURGERS FROM CULL COW BEEF

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Abstract - Microbiological changes of hamburger patties from cull cow beef packaged in over wrapped or modified atmosphere (20:80/CO_2:O_2) packaging were evaluated. Total viable count (TVC), psychrotrophic aerobic count (PVC), *Enterobacteriaceae*, pseudomonads and lactic acid bacteria (LAB) were enumerated during storage at 4ºC. High initial counts (~ 6 log cfu/g) were found for TVC, PVC and *Enterobacteriaceae*. The method of packaging only had significant effects on counts of TVC (P<0.001), *Enterobacteriaceae* (P<0.01) and pseudomonads (P<0.001) at the end of storage. Based on TVC, the shelf-life of hamburger patties stored under MAP would be 7 days, whereas in over wrapped packaging, it would be 3 days.

Keywords - Hamburgers, Cull cow, modified atmosphere packaging, Shelf-life

I. INTRODUCTION

The finishing of cull cows from the dairy herds can be an important activity to raise the profits of a cattle farm. The productive life of these cows is about five years. Over 50% are culled for various reasons, none of which prevent them from being used for butchering. Finishing these animals increases their weight with a subsequent rise in price.

Modified atmosphere packaging (MAP) is a technique, which is widely used to extend the shelf-life and to improve the quality of perishable foods including meat and meat products stored at refrigeration temperatures. The use of MAP gives other advantages like ease of storage, distribution, sale and utilization [1,2,3,4].

The most important factor in controlling meat spoilage is microbial contamination and growth, which affects safety and color [5]. Oxidative effects on myoglobin cause color deterioration, and lipid oxidation can cause rancidity and contribute to off-flavors and off-odors [6,7]. Such parameters can be controlled by MAP with low concentrations of O_2.

MAP is the removal and/or replacement of the atmosphere surrounding the product before sealing in gas-barrier materials, and can involve evacuation, which removes most of the air before the product is enclosed in barrier materials, or forms of gas replacement, where air is removed by vacuum and replaced with another gas mixture before packages are sealed in barrier materials [8]. The three gases commonly used for MAP are oxygen (O_2), carbon dioxide (CO_2) and nitrogen (N_2); each gas plays a specific role in extending shelf-life or maintaining good appearance.

To date, several studies have been carried out to evaluate the effectiveness of MAP on the preservation of fresh and minced beef [9,10,11] but not hamburger patties, which involves numerous operations, such compressing by hand and moulding, that could affect the microbiological quality of the product. Thus, the principal objective of this study was to determine the shelf-life of hamburger patties produced from Holstein Friesian cull cows stored in two different packaging types: over wrapped or 20:80 CO_2:O_2 packaging.

II. MATERIALS AND METHODS

II.1. Animals and hamburger patty production

Six cows of the Holstein Friesian breed from the experimental herd of Agricultural Research Centre of Mabegondo, were used for this study. Animals were finished with commercial concentrate. Immediately after slaughter, carcasses were weighed and chilled at 4°C in a cold chamber for 24 h.

Hamburger patties of 100 g were manufactured using the primal cut of neck. Meat was ground using a 6 mm plate in a refrigerated grinding

machine. The meat was mixed and compressed by hand; 12.5 g of NaCl per kg of meat was added and the meat was held under refrigeration for 20 h. The hamburgers were produced in moulds with a diameter of 10 cm and a height of 1 cm in a patty-maker.

II.2. Packaging parameters

Hamburger patties were placed on polystyrene (PS) trays (300 mm of thickness) and the trays were packed by one of the following methods:

Over wrapped (OWP): trays were sealed with a polyamide-polyethylene (PA/PE) film with an oxygen transmission rate of 40 cm^3/m^2/24 h/bar and 100 mm of thickness.

Modified atmosphere: trays were evacuated and flushed with a gas mixture of 20% CO_2 + 80% O_2, (Carburos metálicos S.A., Barcelona, Spain). Packages were heat sealed with an oxygen-permeable polyethylene (PE) film (<2 ml/m^2/24 h/bar, 74 mm of thickness).

All samples were stored at 4°C. Hamburger patties were analyzed for microbiological quality after 0, 3, 5 and 7 d of storage.

II.3. Microbiological analysis

Two packages per treatment were analyzed on each sampling day. A total of 32 hamburger patties were analyzed.

Ten g of each sample was diluted in 90 mL sterile bacteriological peptone water (0.1%) and homogenized in a Masticator blender (IUL Instruments, Barcelona, Spain) for 2 min. Serial 10-fold dilution series were prepared in sterile bacteriological peptone water (0.1%).

Total viable counts (TVC) and psychrotrophic aerobic count (PVC) were determined on Plate Count Agar (PCA; Oxoid, Unipath Ltd., Basingstoke, UK) incubated at 30ºC for 48 h and 7°C for 10 d, respectively; pseudomonads were determined by plating onto *Pseudomonas* Selective Agar (Merck, Darmstadt, Germany) with CFC supplement (Merck), and incubated at 25ºC for 48 h. *Enterobacteriaceae* were determined on double-layer Violet Red Bile Glucose Agar (Merck) at 37ºC for 24 h and Lactic acid bacteria (LAB) were determined on double-layer de Man Rogosa Sharpe medium Agar (Oxoid) (pH 5.6), after incubation at 30ºC for 5 days. After incubation, plates with 30-300 colonies were counted. Microbiological data were transformed to logarithms of the number of colony forming units (cfu/g).

II.4. Statistical analysis

Results were expressed as means ± standard error. Comparison of means was performed by one-way analysis of variance (ANOVA). Tukey HSD was used to determine the differences among the mean values ($P<0.05$). Data were analyzed using the general linear model of SPSS (SPSS 19.0, Chicago, IL, USA) software package.

III. RESULTS AND DISCUSSION

Changes in microbial populations of hamburger patties packaged under different conditions are shown in Table 1.

Counts at day 0 were comparable with to those reported by Mastromatteo et al. [12] in poultry patties and higher than that found by Bañón et al. [13] for beef patties. The high initial values for TVC, PVC and *Enterobacteriaceae* suggested either poor quality raw meat, inappropriate working conditions or a high temperature during processing [12].

The evolution of TVC throughout storage depended on packaging conditions. In OWP samples, TVC increased significantly ($P<0.05$) during storage, reaching an average value of >7 log cfu/g after 5 d; considered as the upper limit for good quality fresh meat [14]. The TVC remained constant in MAP packed patties and never reached the limit of >7 log cfu/g during storage. A concentration of 20-30% CO_2 is sufficient to inhibit the growth of aerobic spoilage bacteria [15,16] in ground beef patties. Therefore, the shelf-life of hamburger patties stored under OWP would be 3 days, while under MAP conditions it would be 7 days.

The evolution on PVC through the storage period was similar ($P>0.05$) among packing conditions. For all samples, counts of psychrotrophic remained stable during the first 5 d and increased

significantly (P<0.05), reaching an average value of 8.5 log cfu/g at the end of storage (7 d). These data are in agreement with Bañón et al. [12] and with Rubio et al. [17], which observed that packaging conditions did not affect the growth of PVC and demonstrated that 20% CO_2 was insufficient to slow down the growth of psychrotrophic organisms [15].

growth, showing an average value of 5.41 log cfu/g at the end of the storage for both packs, which is similar to the results found by Mastromatteo et al. [12] in poultry patties. This could be explained because LAB are facultative anaerobic bacteria and are able to grow in the presence or absence of oxygen.

Table 1. Microbial populations (log cfu/g) of hamburger patties packaged in different atmospheres and stored at 4ºC.

Microbial group	Packaging	Days of storage				SEM	Significance
		0	3	5	7		
TVC	OWP	5.96±0.97^{a}	6.50±0.10^{ab}	7.06±0.31^{b}	7.95±0.41^{c}	0.19	***
	20:80/CO_2:O_2	5.96±0.97	5.99±0.40	6.29±0.60	6.83±0.38	0.14	ns
	SEM		0.11	0.18	0.20		
	Significance		*	*	***		
PVC	OWP	5.98±0.87^{a}	6.55±0.67^{a}	6.71±0.82^{a}	9.02±1.18^{b}	0.30	***
	20:80/CO_2:O_2	5.98±0.87^{a}	5.90±1.03^{a}	6.16±0.98^{a}	8.14±1.51^{b}	0.29	*
	SEM		0.26	0.26	0.40		
	Significance		ns	ns	ns		
Enterobacteriaceae	OWP	5.29±0.47	5.49±0.42	5.24±0.22	5.53±0.36	0.08	ns
	20:80/CO_2:O_2	5.29±0.47	5.13±0.27	4.99±0.39	4.71±0.40	0.09	ns
	SEM		0.11	0.10	0.16		
	Significance		ns	ns	**		
Pseudomonads spp.	OWP	3.28±0.35^{a}	4.51±0.72^{b}	4.35±0.54^{b}	5.46±0.32^{c}	0.19	***
	20:80/CO_2:O_2	3.28±0.35	3.55±0.61	3.47±0.85	3.38±1.10	0.15	ns
	SEM		0.23	0.24	0.38		
	Significance		*	ns	***		
Lactic acid bacteria	OWP	4.49±0.71^{a}	4.78±0.27^{ab}	5.14±0.43^{b}	5.76±0.74^{c}	0.15	*
	20:80/CO_2:O_2	4.49±0.71	4.64±0.14	4.52±0.41	5.06±0.96	0.13	ns
	SEM		0.06	0.15	0.26		
	Significance		ns	*	ns		

The application of MAP delayed the growth of *Enterobacteriaceae* and *Pseudomonads* spp. Counts of *Enterobacteriaceae* and *Pseudomonads* spp. on OWP samples were significantly higher (P<0.01) than those packaged under MAP, particularly after 7 d of storage, confirming that the presence of CO_2 limited the growth of these organisms. Our results are similar to those of several others who determined that MAP applications could limit or inhibit the growth of *Enterobacteriaceae* and *Pseudomonads* spp. [11, 18,19].

Counts of LAB increased significantly during storage (P<0.05) in OWP samples while they remained stable under MAP. Moreover, the packaging conditions did not affect (P>0.05) their

IV. CONCLUSIONS

The high initial microbial loads found in this study suggest that an improvement of the microbiological quality of raw meat and better hygienic working conditions are necessary.

The results of the present study indicated that atmospheres containing 20% CO_2 could be effective in extending the shelf-life of hamburger patties up to 7 days in refrigerated storage. Further studies are necessary to evaluate the use of other gas combinations to prolong the shelf-life and preserve the quality of hamburger patties.

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