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INFLUENCE OF PACKAGE INTEGRITY ON THE MICROBIOLOGY OF PORTION READY VEAL PACKED UNDER MODIFIED ATMOSPHERES

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INTRODUCTION

The distribution of red meats in centrally processed, retail-ready packs offers distinct and attractive advantages to processors, retailers and consumers alike. The extended shelf-life required to take full advantage of centralized processing can be achieved with modified atmosphere packaging (MAP). Oxygen containing atmospheres are often used in MAP for the retention of colour acceptable to consumers. Unfortunately, the use of oxygen limits the shelf-life of most meats to approximately one week (Taylor *et al.*, 1990). Microbiological growth is more severely restricted by storage under anaerobic conditions but the colour of meats packaged in this fashion is objectionable from a marketing standpoint. Veal is a relatively pale meat, however, and may be well suited for distribution in packs containing very low O_2 concentrations. The use MAP systems employing anoxic atmospheres could therefore be practical for the distribution of veal in portion ready packages.

A wide variety of packaging materials and systems for the preservation of meat under low oxygen tensions are available. All packaging systems are subject to failures that result in high O_2 concentrations around the product and, ultimately, in reduced shelf-life performance. Although the microbiological consequences of catastrophic failures resulting from improper package closure can be predicted, the consequences of gradual losses in package integrity are seldom considered. In this paper we present data on the bacteriological quality of stored veal both in intact and compromised packages sealed under 100% CO_2 and 100% N_2 atmospheres.

MATERIALS AND METHODS

Calves from a common origin were raised as described by Pommier *et al.* (1993) and were slaughtered at 200kg. The loins were removed from the carcasses within 48 hours of slaughter, boned, trimmed and cut into 1.5cm thick slices. The meat was packaged with a commercial MAP system using materials designed for this purpose by the manufacturer. Single slices were placed in 15x9x4cm preformed polyethylene trays that were evacuated, flushed with 100% CO_2 or 100% N_2 at atmospheric pressure and sealed under low O_2 permeability film with the MAP packaging machine. All the samples were placed in a walk-in cooler set at 4°C. Eighty samples from each treatment were analyzed after both 14 and 28 days in storage. The composition of the gas phase inside the trays (CO_2, O_2 and N_2) was determined by gas chromatography using a Porapak molecular sieve column (Supelco, Oakville, Canada). A sample of tissue (20cm^2) was removed from each slice using a sterile template and was blended in 0.1% peptone with a Stomacher. Suitable dilutions were spread plated onto the following media: plate count agar incubated at 25°C for 48 hours for the determination of total aerobic mesophilic plate counts (TPC); plate count agar incubated at 7°C for 10 days for the determination of total psychrophilic counts (PSY); brain heart infusion agar incubated under an H_2 + CO_2 atmosphere (GasPak, BBL, USA) at 25°C for 48 hours for the determination of total mesophilic anaerobic counts (ANA); violet red bile agar incubated

anaerobically at 37°C for 48 hours for the presumptive enumeration of Enterobacteriacae (ENT); MRS agar incubated anaerobically at 25°C for 72 hours for the presumptive enumeration of lactic acid bacteria (LAC); STAA agar incubated at 25°C for 48 hours for the presumptive enumeration of *Brocothrix thermosphacta* (BRT). Data were analyzed as a split plot design and analysis of variance was performed using the SAS analytical program (SAS Institute Inc., Cary, USA, 1990).

RESULTS AND DISCUSSION

Residual O_2 concentrations below 0.1% at the time of packaging were achieved consistently with the system used in these experiments (data not shown). Oxygen concentrations increased during storage however, and the number of trays containing various concentrations of O_2 are given in Table 1. Since most trays contained less than 0.5% O_2 it was assumed that samples containing higher concentrations had failed. The overall failure rate under CO_2 was 30.3% (48/158 samples), and 29.0% (45/150) under N_2. Eight of the trays (2.6%) had O_2 levels approaching 20.0% suggesting that catastrophic failures had occurred due to improper heat sealing or to film punctures during processing and storage. Because the number of failed samples increased between 14 and 28 days (from 12.6% to 17.7% under CO_2, 13.3% to 16.7% under N_2), slow leaks due to flaws in the film and defective seals were suspected as the main causes of package failure.

Results of microbiological analyses performed on veal from trays containing <0.5% O_2 are given in Table 2. Counts on meat stored under CO_2 were always lower due to the bacteriostatic effect of the gas (Clark and Lentz, 1972; Gill and Tan, 1980), although differences were statistically significant ($P \leq 0.05$) only for psychrophilic and anaerobic counts. Lactobacilli dominated the microflora of veal under both storage conditions in agreement with the observations of Lee *et al.* (1983). Enterobacteriaceae counts increased from an average of 1.8×10^4CFU/cm^2 after 14 days to 3.2×10^5CFU/cm^2 at 28 days of storage under N_2, but were only detected in a few samples after 28 days under CO_2 (average count = 1.5×10^4CFU/cm^2). *Brocothrix thermosphacta* was also recovered in small numbers (<10^4) from a few samples containing <0.5% O_2.

Average microbiological counts for failed samples containing various oxygen concentrations are presented in Figures 1 and 2. Oxygen concentrations between 0.5 and 1.0% did not have a major impact on aerobic, anaerobic, psychrophilic or lactic acid bacteria counts in veal stored under either gas for 14 days. Lactic acid bacteria dominated the microflora and total aerobic counts, which are associated with the presence of aerobic microorganisms with a high spoilage potential, were similar to those determined in intact samples (Table 1). Enterobacteriaceae counts on meat stored under N_2 for 14 days were lower than those observed on meat from intact trays. The apparent inhibition of enteric bacteria in these samples was unexplained but may have been due to antagonism by the lactic acid bacteria (Schillinger and Lucke, 1987). This could also account for the absence of *Brocothrix thermosphacta* which was expected to grow in the presence of O_2, particularly on meat stored under N_2. Large increases in all counts, including *Brocothrix thermosphacta*, were only observed in highly compromised packs (>1.0% O_2) after 28 days in storage. Elevated O_2 concentrations in these samples probably favoured faster growth of aerobes at the expense of the lactic acid bacteria, thereby limiting their inhibitory potential. Visual evidence of spoilage and strong putrefactive odours were detected in trays containing >1.0% O_2 but meat from trays with concentrations between 0.5 and 1.0% never appeared spoiled.

CONCLUSIONS

The microbiological stability of portion ready veal packed in rigid trays overlaid with gas impermeable film was better under CO_2 than N_2 atmospheres. Package failure resulting in O_2 concentrations up to 1.0% did not severely alter the spoilage association of the meat. Catastrophic failures resulting in O_2 concentrations between 1.0 to 20.0% led to the outgrowth of bacterial groups normally found on aerobically spoiled meat.

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Table 1. Number of samples containing various levels of oxygen upon sampling. Each count represents one tray of veal.

O_2 level %	C02 14 days	C02 28 days	C02 total	N2 14 days	N2 28 days	N2 total
0.0-0.4	39	31	70	21	23	44
0.4-0.5	19	19	38	33	28	61
0.5-0.6	3	3	6	6	5	11
0.6-0.7	4	0	4	2	3	5
0.7-0.8	2	4	6	3	0	3
0.8-0.9	4	2	6	2	3	5
0.9-1.0	2	0	2	0	3	3
1.0-2.0	2	9	11	1	7	8
2.0-20	5	10	15	6	4	10
Total	80	78	158	74	76	150

Table 2. Microbiological counts on veal slices stored for 14 and 28 days at 4°C under 100% CO_2 and 100% N_2. Values are the means of samples with residual O_2 concentrations <0.5%. The standard error of the mean is given in parentheses.

	14 days	28 days
TPC		
CO2	4.642^{a} (0.135)	5.533^{b} (0.136)
N2	4.964^{a} (0.137)	5.867^{b} (0.131)
PSY		
CO2	5.793^{c} (0.084)	6.548^{e} (0.084)
N2	6.163^{d} (0.0.84)	6.885^{f} (0.080)
ANA		
CO2	5.754^{g} (0.167)	6.329^{gh} (0.167)
N2	6.281^{h} (0.160)	6.685^{h} (0.162)
MRS		
CO2	5.789^{i} (0.124)	6.306^{j} (0.125)
N2	6.233^{ij} (0.119)	6.629^{j} (0.121)

* Means followed by the same letter are not significantly different (P>0.05).