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THE EFFECT OF CENTRALISED PRE-PACKAGING ON THE MICROBIAL, ODOUR, COLOUR AND ACCEPTABILITY ATTRIBUTES OF PVC-OVERWRAPPED PORK LOIN CHOPS

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Please refer to Folio 62A.

INTRODUCTION

During a previous trial (Scholtz *et al.*, 1992) it was concluded that pork retail cuts could be bulk stored in a 100% CO_2 at 0°C for 21 days, with a subsequent retail shelf life of four days (0°C). The commercial storage life of the 100% CO_2 bulk stored pork chops was, however, limited owing to a loss in the colour of the pork chops. According to Taylor (1990) a system which successfully combines bulk pre-packaging with the high O_2:CO_2 of modified atmosphere packaging (MAP) and low meat temperature conditions could provide colour stability of bulk pre-packaged samples. The present study was designed to evaluate a laboratory bulk pre-packaging technique (utilising various approximate gas mixtures, i.e. 80% O_2:20% CO_2 and 25% CO_2:50% N_2:25% O_2) in terms of quality attributes such as microbiology, colour, odour and consumer acceptability.

MATERIALS AND METHODS

Six pig carcasses were selected according to muscle pHi(>6) and mass (c.65kg). The 12 loins represented three repetitions. Both loins of each carcass were randomly allocated to a specific bulk pack treatment (c. 80% O_2:20% CO_2 and c. 25% CO_2:50% N_2:25% O_2) and each loin cut into 18 chops. Each chop was placed in a shallow styrofoam tray and overwrapped with PVC (OTR - c. 5 000ml/m²/24h/ 1atm at 22°C 75% RH).

Bulk Packaging (Mother bag)

Twelve of the PVC-overwrapped chops from each loin were bulk packed with a laboratory method, six per bulk pack (BB4L Cryovac barrier bag, OTR - 39ml/m²/24h/atm at 23°C 75% RH) (Scholtz *et al.*, 1992). Twelve bulk packs, representing three repetitions, were subsequently filled with ca. 100% CO_2 and the other 12 bulk packs were filled with c. 25% CO_2:50% N_2:25% O_2.

Foamtray/PVC overwrap controls

In order to evaluate the validity of the comparison of the different bulk packaging treatments (c. 80% O_2:20% CO_2 vs. c. 25% CO_2:50% N_2:25% O_2) over the different pork carcasses, the other six PVC-overwrapped chops from each loin served as PVC-control samples.

Storage and Shelf life study

Bulk Packaging (Mother bag)

Three replicate bulk packs from each treatment (c. 80% O_2:20% CO_2 and c. 25% CO_2:50% N_2:25% O_2) were opened after c. one hour of saturation with the specific gas mixture. One set (2) of PVC-overwrapped samples from each bulk pack was assessed 30 minutes after opening the bulk pack. The remaining four samples were displayed in an open deck

retail display cabinet (c. 0°C) for two or four days. The remainder of the bulk packs (18) were stored at 0°C for either 7, 14 or 21 days. After each relevant storage period, three replicate bulk packs from each treatment were opened and assessed as noted above.

Foamtray/PVC overwrap controls
The Day 0 PVC-overwrapped control samples were assessed without a display period, while the rest of the samples were displayed in an open deck retail display cabinet (c. 0°C) for two or four days.

Quality Attributes

Microbiological analysis
A measured area of c. 12cm^2 was removed aseptically to a depth of c. 5mm from the upper surface of the sample (Nortjé *et al.*, 1982). This was homogenised in a Stomacher 400 (DHK (Pty) LTD) with a 100ml of 1/4-strength Ringer's (Merck) diluent. Counts were obtained as follows: Total aerobic counts (Standard 1 nutrient agar, 3 days at 25°C); lactic acid bacteria (5 days at 30°C) on MRS agar (de Man, Rogosa and Sharpe, 1960); Pseudomonas spp. (Kielwein agar, 3 days at 25°C) (Kielwein, 1971) and Enterobacteriaceae (2 days, 37°C, DHL agar) (Sakazaki *et al.*, 1960).

Colour
The colour of each unopened sample was assessed by a trained panel (10 people) 30 minutes after each pack was opened. The colour was scored on a 5 point scale ranging from 1=`Extremely pale' to 5=`Extremely dark' (Anon, 1981).

Odour
Samples were assessed by a trained panel (10 people) 30 minutes after each pack was opened. Odour was scored on a 6 point scale which ranged from 1=`No odour' to 6=`completely off'.

Acceptability
Acceptability of each unopened sample was assessed by an untrained panel (8 people) to give an indication of the consumer acceptability of the PVC-overwrapped sample. This was done 30 minutes after each pack was opened, according to an 8 point scale ranging from 1=`Extremely unacceptable' to 8=`Extremely acceptable'.

Statistical analysis

The data was analyzed by analysis of variance and levels of $P \leq 0.05$ were taken to be significant.

RESULTS AND DISCUSSION

PVC-Overwrapped Control Samples

The mean total counts of the control groups did not differ significantly over the whole retail shelf life period (Days 0, 2 and 4) (P=0.6867). Both control groups followed a similar trend regarding the initial total count, therefore PVC-overwrapped control samples could serve as a general control to compare the results of the packaging treatments that were assessed (Table 1).

Bulk Packaging

Mean Total count
The mean total counts were influenced significantly by the different bulk storage days (P=0.0134) and retail shelf life days (P=0.0001). The total counts obtained from the retail cuts from both applications after 0 days bulk storage were

initially (Day 0) at low levels, log 2 cm^{-2} (Table 2), but increased to reach significantly higher levels after a subsequent 4 days retail display. The initial total counts (0 days display) after 14 and 21 days bulk storage were still at acceptable levels for both bulk packaging treatments (log 5 cm^{-2}).

Mean Anaerobe and Lactic Acid Bacteria counts

The statistical analyses for the main effects of the lactic acid bacteria counts were similar to that noted for the total counts. According to the packaging treatments X storage days interaction (P=0.0140) of the lactic acid bacteria counts, the samples stored in c. 25% CO_2:50% N_2:25% O_2 for 0 days had lower mean counts (log 2 cm^{-2}) after display (Day 0, 2 and 4) than the samples from the other treatment (log 3 cm^{-2}). After 14 and 21 days storage and subsequent display the latter, however, had lower mean counts (log 4 cm^{-2}) than those stored in c. 25% CO_2:50% N_2:25% O_2 (log 5 cm^{-2})(Table 2).

Mean Pseudomonad count

Only the display period (P=0.0001) main effect had a significant influence on the mean pseudomonad counts. The mean pseudomonad counts followed the same increasing trend as the mean total counts after 0 days bulk storage for both packaging treatments (Table 2).

Mean Enterobacteriaceae count

The statistical analysis of the mean Enterobacteriaceae counts was similar to that recorded for the mean total counts. The mean Enterobacteriaceae counts of the samples from both packaging treatments following 0 days bulk storage were initially (Day 0) low (log 1 cm^{-2}) (Table 2). Even after 21 days bulk storage the retail cuts from all the treatments still had low initial Enterobacteriaceae counts (Day 0) of log 1.30 cm^{-2}.

Colour assessment

The statistical analysis of the colour scores indicated that the packaging treatments, storage period and display period main effects all influenced the colour of the retail samples significantly (P0.05). The colour of the samples from the 0 Day storage, ca. 25% CO_2:50% N_2:25% O_2 packaging treatment was normal during the subsequent display period (Figure 1). After 7, 14 and 21 days bulk storage and subsequent display the colour of these samples was found to be pale to normal. The colour of the samples stored in ca. 80% O_2:20% CO_2 for 0 days was also found to be normal initially (Day 0), but as display progressed colour paled. This trend seemed to persist throughout the rest of the storage period (Days 7, 14 or 21) and subsequent display periods.

Odour assessment

The statistical analysis of the odour scores indicated that the packaging treatments, storage period and display period affected the odour of the samples significantly ($P \leq 0.05$). The samples from the both bulk packaged treatments had a fresh meat odour until after 14 days bulk storage. Thereafter the odour scores increased as time progressed.

Acceptability assessment

The packaging treatments, storage period and display period all influenced acceptability of the samples significantly (P0.05). All the samples were initially acceptable after 0 days storage (Figure 1). Only after 21 days storage and 2 days subsequent display were the samples from the 25% CO_2:50% N_2:25% O_2 packaging treatments moderately unacceptable to the consumer panel. The acceptability score for the samples from the ca. 80% O_2:20% CO_2 followed the same trend as observed for the colour assessment. After 0 days storage the samples were acceptable but became slightly acceptable as display progressed (Day 4). This trend persisted throughout the remaining storage (Day 7, 14 or 21) and subsequent display periods.

The statistical analysis of the total bacterial counts indicated that both bulk packaging treatments did not differ significantly over the whole bulk storage period. According to the mean total counts the samples from both bulk packed treatments could be stored for 21 days with a two day shelf life (Scholtz *et al.*, 1992).

The lactic acid bacteria counts did not differ significantly between bulk packaging treatments. This might indicate that the inclusion of 20 - 25% CO_2 in a gas mixture is sufficient to effectively inhibit the aerobic spoilage organisms and thus to prolong the storage and shelf life of fresh pork retail cuts. Seideman and Durland (1984) reported that a CO_2 concentration of 20% or higher will inhibit the growth of putrefactive bacteria (associated with meat spoilage) provided

the meat is stored in the chilled condition. Lower mean pseudomonad counts were recorded for the c. 80% O_2:20% CO_2 bulk packed samples, than for the c. 25% CO_2:50% N_2:25% O_2 packed samples, during the prolonged storage period indicating the effect of the elevated O_2 level (Krefeld, 1989). Enterobacteriaceae counts were very low, during the extended storage period for both bulk packaging treatments. Various authors found that CO_2 storage and/or low refrigeration temperatures (-1 to 2 C) suppressed Enterobacteriaceae growth, which might have contributed to the present results (Blickstad and Molin, 1983; Gill & Harrison, 1989; Scholtz *et al.*, 1992).

All the samples were found to be normal to pale during the extended storage period and subsequent display periods. An interesting trend observed for the acceptability scores of the 80% c. O_2:20% CO_2 bulk packed samples is that the samples were more acceptable one hour after each bulk storage period than on the subsequent display days. This trend was also observed for the colour scores. As this trend was not observed for the other bulk packaging treatment (c. 25% CO_2:50% N_2:25% O_2), it might be that storage in high percentages O_2 and subsequent display in air could adversely affect the colour of retail PVC-overwrapped pork chops.

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Table 1. Individual microbiological counts for centralized packaged PVC-overwrapped control pork loin cuts (PVC-control 1 & 2; n=12 each).

	Display time (days)	Total count (log cm^{-2})	Standard Error
PVC-Control 1	Day 0	2.57	0.57
	Day 2	4.61	0.80
	Day 4	6.90	0.49
PVC-Control 2	Day 0	2.99	0.75
	Day 2	4.29	0.85
	Day 4	6.18	0.51

Table 2. Microbiological counts obtained for centralized bulk packaged (storage 0 °C) and a subsequent retail life study (0 °C) of pork retail cuts.

Bulk Package Applic.; display time	Total Count (log cm^{-2})	S.E.	Lactic acid bacteria (log cm^{-2})	S.E.	Pseudo-monads (log cm^{-2})	S.E.	Enterobac-teriacae (log cm^{-2})	S.E.
25% CO_2; 25% O_2 & 50% N_2								
0 DAYS								
Day 0	1.96	1.19	0.86	1.19	0.59	1.19	0.00	1.19
Day 2	2.84	1.19	0.47	1.19	2.31	1.19	0.53	1.19
Day 4	5.32	1.11	3.35	1.11	4.11	1.11	0.64	1.11
7 DAYS								
Day 0	2.96	1.19	2.50	1.19	0.80	1.19	0.00	1.19
Day 2	4.97	1.11	2.45	1.11	2.80	1.11	1.43	1.11
Day 4	6.98	1.19	5.32	1.19	6.17	1.19	3.76	1.19
14 DAYS								
Day 0	5.70	1.11	4.42	1.11	3.55	1.11	1.78	1.11
Day 2	5.76	1.19	4.16	1.19	4.40	1.19	1.47	1.19
Day 4	5.89	1.19	3.79	1.19	5.21	1.19	0.89	1.19
21 DAYS								
Day 0	5.86	1.11	3.56	1.11	3.63	1.11	1.30	1.11
Day 2	5.89	1.19	4.01	1.19	4.0	1.19	0.92	1.19
Day 4	6.49	1.11	4.18	1.11	4.96	1.11	2.00	1.11
20% CO_2 & 80% O_2								
0 DAYS								
Day 0	1.20	1.19	0.92	1.19	0.24	1.19	0.00	1.19
Day 2	5.27	1.11	2.78	1.11	4.00	1.11	1.04	1.11
Day 4	7.24	1.19	5.14	1.19	6.97	1.19	3.38	1.19
7 DAYS								
Day 0	4.87	1.19	3.89	1.19	2.81	1.19	1.41	1.19
Day 2	5.49	1.11	4.63	1.11	4.95	1.11	1.78	1.11
Day 4	6.06	1.19	3.86	1.19	4.48	1.19	1.90	1.19
14 DAYS								
Day 0	3.62	1.11	1.94	1.11	1.83	1.11	0.49	1.11
Day 2	5.35	1.19	4.52	1.19	3.27	1.19	1.87	1.19
Day 4	5.26	1.11	3.43	1.11	4.75	1.11	3.98	1.11
21 DAYS								
Day 0	4.40	1.19	2.49	1.19	2.06	1.19	0.69	1.19
Day 2	5.50	1.11	2.99	1.11	4.24	1.11	0.70	1.11
Day 4	6.33	1.19	4.21	1.19	4.54	1.19	1.41	1.19