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The Influence of Different Centralised Pre-packaging Systems on the Shelf Life of Fresh Pork

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SUMMARY: Efficiency in the fresh meat industry could be increased with the application of centralised processing and packaging of retail cuts. A bulk packaging method (mother bag) was evaluated to determine its influence on the quality and shelf life characteristics of fresh pork. Both the storage periods (days in the mother bag) and the subsequent retail shelf life had a significant influence on the total counts. A storage period of 21 days in the mother bag with a subsequent retail display life of a further 4 days was possible. The odours of the mother bag packaged samples were only slightly unacceptable after 21 days bulk storage and 4 days retail display. The mother bag centralised packaging method is a feasible alternative to the traditional wholesale and retail PVC-packaging systems for fresh meat and may be a suitable, cost effective system to use.

INTRODUCTION: Centralised processing and packaging of retail cuts, could realise labour savings and decrease product spoilage for the retailer, while providing the consumer with a variety of products of more consistent quality especially in products with a low turnover rate. At the central pre-packaging plant, personnel, equipment, material costs and quality can be more efficiently controlled and utilised (COLE, 1986; HINKSMAN, 1981; KIRSTEN, *et al.*, 1983; NORTJÉ & SHAW, 1989). The retailer benefits because the responsibility of processing and packaging retail cuts is transferred to the wholesaler, while more uniform products are received. Furthermore there is also the release of in-store butchery space for merchandising and the maintenance of the cold chain to assure an extended shelf life (COLE, 1986). Disadvantages the retailer may experience are the lack of consumer acceptance of centrally prepackaged fresh meat products, as well as the lack of consumer marketing expertise on the part of the central packers. As retailers concentrate on merchandising, rather than processing fresh meat items in the store, central pre-packaging will become more essential in providing a true display ready product (COLE, 1986).

The shelf life of such packaged products could be influenced by the raw materials and processing and be extended by the packaging process and materials used. According to supermarket and/or butchery managers, the main problem with retailing pork in South Africa is the obtained shelf life (3 days at 3 °C). JOLL (1981) also reported on this problem, therefore pork was used in this study. The objective was to determine the influence of a bulk packaging method (mother bag) on the quality characteristics and shelf life of fresh pork.

MATERIALS and METHODS: *Meat:* At a city abattoir 3 pig carcasses were selected according to normal muscle pH_1 (>6.00 in the *M. longissimus thoracis*, in the area of the last three ribs), 1 hour *post mortem* and a mass of *ca.* 65 kg. Only the loin cuts were used.

Treatments: The loins of each carcass (3 days *post mortem*) were individually vacuum packaged (vacuum bag OTR - *ca.* 67ml/m^2/24h/atm at 23 °C and 75 % RH) at the abattoir and transported, using a refrigerated truck operating at 0 - 4 °C (travelling time *ca.* 1h), to a meat packaging and processing outlet. The six loins represented 3 repetitions of the experimental procedure, with duplicates of each sample included in each loin. These loins were each cut into 18 chops on a clean bandsaw. Each chop was placed in a shallow styrofoam tray and individually overwrapped with PVC (OTR - *ca.* 5000 ml/m^2/24h/atm at 22 °C 75 % RH) at the packaging plant. These 18 chops represented 6 PVC-overwrapped controls and 12 PVC-overwrapped bulk packed samples (mother bag) (BB4L Cryovac Vacuum bags OTR - *ca.* 39ml/m^2/24h/atm at 23 °C 75 % RH

Mother bag (bulk gas flushing): Twelve PVC-overwrapped samples per loin were bulk packed. Each bulk pack contained 6 PVC packs. A vacuum (*ca.* 80%) was drawn and the mother bag heat sealed with a Röschermatic vacuum

machine. Each mother bag was then filled with 100 % CO_2 by inserting a needle attached to a industrial gas cylinder with a plastic tube. The ballooned bulk pack was again heat sealed to close off the puncture. The volume ratio of gas headspace to meat was approximately 3:1. One hour after bulk packaging, 3 replicate mother bags were opened. One set of samples (2) from each mother bag were assessed immediately after opening and the remaining samples (4) were displayed for 2 and 4 days respectively in an open deck retail display cabinet (0 °C).

The remainder of the mother bags (9) were stored at 0 °C for either 7, 14 or 21 days. After each specified storage period another 3 replicate mother bags were opened and the samples displayed and assessed as above.

Assessment: After being subjected to mother bag storage and subsequent shelf life, samples were withdrawn and the different PVC-overwrapped chops assessed regarding potential shelf life, colour and odour.

Colour: The colour of each sample was assessed, whilst the packs were still unopened, by a trained panel consisting of 10 people, using a colour chart (5 point scale ranging from "extremely pale" = 1 to "extremely dark" = 5) (ANON, 1981).

Odour: Each sample was assessed by a trained panel of 10 people immediately after the pack was opened (6 point scale ranging from "no odour" = 1 to "completely off" = 6).

Microbiological analysis: A measured area of 12.84 cm^2 was removed aseptically to a depth of *ca.* 5 mm from the upper surface of the sample and homogenised with a Stomacher 400 in 100 ml of a 1/4-strength Ringer diluent. Serial dilutions were made and 0.1 ml of each was surface plated in duplicate on various media. Total aerobic counts were monitored on Standard 1 nutrient agar (Std 1; Merck), incubated for 3 days at 25 °C and total anaerobic counts on Std 1 agar anaerobically incubated at 25 °C for 5 days, (anaerobic jar + BBL gaspacks). MRS plates (DE MAN *et al.*, 1960) incubated for 5 days at 30 °C were used for the determination of lactic acid bacteria. *Pseudomonas* spp. were monitored on cetrimide fusidin ceporin agar (CFC; MEAD & ADAMS, 1977) incubated for 3 days at 25 °C, and DHL Agar (SAKAZAKI *et al.*, 1960) was used to determine *Enterobacteriaceae* (2 days, 37 °C).

Statistical analysis: Analysis of variance was performed to determine which factors (packaging, storage days, display period) and interactions contributed significantly ($P \leq 0.05$) to the different parameters monitored. When an interaction between two or more factors was found significant, the least Square means (LSMEANS) method was used to determine which level of the factor or interaction was significantly different.

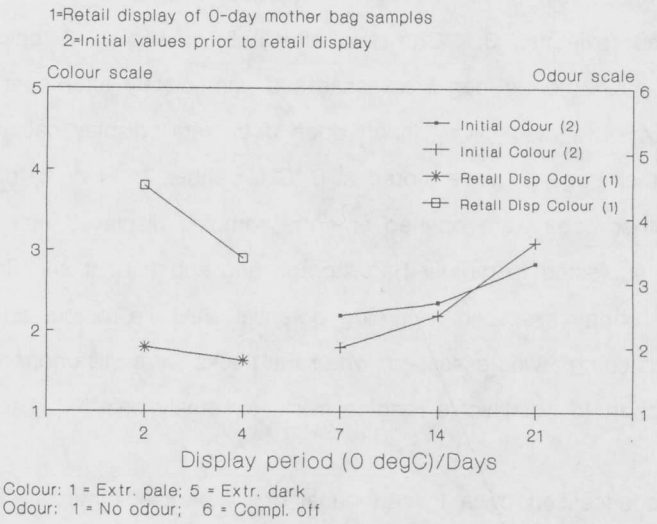
RESULTS: *Colour Assessment:* Following 0 days storage the mother bag samples were dark after 2 days retail display, although the colour became normal as display progressed (day 4) (Fig 1). The 7 and 14 day mother bag stored samples were initially pale, but after 21 days bulk storage the colour was normal. These results were significantly different from that obtained for controls ($P = 0.0041$).

Odour Assessment: The 0 day mother bag samples had a fresh and acceptable meat odour after 4 days retail display (Fig. 1). After 7, 14 and 21 days bulk storage only slightly off odours (2.5, 2.7 and 3.4 respectively) were detected.

Microbial assessment: The PVC-controls had a 4 days shelf life ($<$ log 6.00 cm^{-2}) versus the 3 days normally obtained using conventional retailing procedures (Table 1). The mother bag storage days (0, 7, 14 & 21 days) had a significant ($P = 0.0001$) influence on the total counts (Table 1). The 21 days bulk stored samples had significantly higher counts than the samples stored for 0, 7 or 14 days. The retail display period also had a significant influence on the total counts ($P = 0.0009$).

The 0 days mother bag stored retail PVC overwrapped cuts had an initial mean total count of log 3.61 cm^{-2}, which declined somewhat after 2 further days of retail display and reached a count of log 4.7 cm^{-2} after 4 days of retail display. The overall finding was that the total count after 4 days retail display was always significantly higher ($P = 0.0001$)

FIG. 1: Colour and odour assessment of retail displayed samples after bulk storage in mother bags



than the 0 and 2 day determinations for all the mother bag treatments (days 7, 14 & 21), as was the trend of a lower mean total count on day 2 of the retail shelf life period (Table 1). After 21 days mother bag storage, the total count of the retail displayed samples on day 4 (log 6.38 cm^{-2}), was regarded as microbiologically acceptable. *Enterobacteriaceae* counts were very low, during the extended storage period. After 21 days mother bag storage a count of log 3.92 cm^{-2} was recorded on day 4 of the subsequent display period (Table 1). All the other microbial counts recorded followed the same trend as was recorded for the total counts (Table 1).

Table 1: Microbiological counts obtained during a retail shelf life study (0 °C) from pork loin cuts, PVC-mother bag stored for different periods or directly displayed

Treatments	Retail Display	Total Count (log/cm^2)	Stand. Error	An-aerobes (log/cm^2)	Stand. Error	Lactic acid bacteria (log/cm^2)	Stand. Error	Pseudo-monads (log/cm^2)	Stand. Error	*Entero-bacteri-aceae* (log/cm^2)	Stand. Error
PVC-Controls	Day 0	4.43	0.30	4.18	0.29	3.68	0.20	3.28	0.24	0.91	0.31
	Day 2	3.95	0.35	3.89	0.40	3.68	0.26	2.50	0.37	0.27	0.15
	Day 4	5.20	0.28	5.02	0.36	4.09	0.27	5.27	0.23	1.95	0.49
PVC-Mother bag storage: 0 days	Day 0	3.61	0.34	3.34	0.24	3.35	0.06	1.61	0	0	0
	Day 2	3.02	0.40	2.97	0.12	3.52	0.08	2.17	0.10	0	0
	Day 4	4.70	0.07	4.27	0.30	3.77	0.12	4.70	0.91	0	0
PVC-Mother bag storage: 7 days	Day 0	4.09	0.28	3.93	0.24	3.40	0.17	3.54	0.41	0.95	0.16
	Day 2	3.16	0.15	2.74	0.34	2.93	0.12	1.42	0.38	0	0
	Day 4	4.61	0.31	4.10	0.27	3.68	0.33	3.51	0.35	1.64	0.58
PVC-Mother bag storage: 14 days	Day 0	4.22	0.28	4.13	0.26	3.39	0.18	3.83	0.43	1.16	0.2
	Day 2	3.85	0.17	3.87	0.37	3.36	0.16	1.91	0.32	0.55	0.15
	Day 4	5.20	0.29	5.23	0.21	4.66	0.27	4.67	0.27	2.24	0.61
PVC-Mother bag storage: 21 days	Day 0	5.78	0.32	5.30	0.31	4.59	0.22	4.16	0.47	1.51	0.26
	Day 2	5.76	0.33	5.98	0.51	4.93	0.29	2.91	0.31	0.51	0.17
	Day 4	6.38	0.23	6.47	0.26	4.25	0.27	6.21	0.21	3.92	0.58

DISCUSSION: According to the odour assessment mother bag samples were judged to be still acceptable, although slight off odours could be detected by a trained panel after 21 days bulk storage. The commercial storage life of 100 % CO_2 stored pork is more likely to be limited by a loss in colour than by excessive microbial growth (GILL & HARRISON, 1989; SEIDEMAN & DURLAND, 1984).

An extended shelf life of 21 days was observed for the mother bag samples with a subsequent retail display shelf life of 4 days. The relatively low total count (log 4.7 cm^{-2}) for 0 day PVC-mother bag stored samples obtained after 4 days retail display may be due to the effect of CO_2. The CO_2 was possibly applied before the bacteria had adjusted to the new environmental conditions and despite the relatively short exposure to the gas (a few hours) and prolonged sample handling, the CO2 managed to retard bacterial growth (CLARK & LENTZ, 1969).

Even after 21 days the initial total count was $<$log 6 cm^{-2} and assured a retail shelf life of at least 4 days. This extended shelf life achieved is probably due to the residual effect of the CO_2 (SPHAL *et al.*, 1981).

Enterobacteriaceae counts were very low during the extended storage period. This might be directly related to the better hygiene control achieved in the centralised packaging system used. Furthermore, different authors found that CO_2 storage and/or low refrigeration temperatures (-1 to 2 °C) suppressed *Enterobacteriaceae* growth, which could also contribute to these results (BLICKSTAD & MOLIN, 1983; GILL & HARRISON, 1989).

The results of this study indicate that centralised packaging is a feasible alternative to the traditional wholesale and retail PVC packaging system for fresh meats. Furthermore the mother bag may be a suitable, cost effective centralised packaging system to use.

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