A PROCESS FOR CENTRAL PREPACKAGING OF FRESH MEAT

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SUMMARY

A process to extend shelf-life of fresh retail cuts, such as pork chops, was developed and tested. The process involved treatment of meat with a three component solution (polyphosphates, ascorbic acid and citric acid) followed by packaging in a MA containing high levels of CO2. Results of this test show that centrally prepackaged fresh meat subject to this process has sufficient colour and microbiological shelf-life to accommodate 10-14 days refrigerated storage in commercial distribution and 3 days display.

INTRODUCTION

Centralized prepackaging of retail meat cuts has been an elusive objective for the meat industry and a research and development subject for the past several decades in the USA. It is well known that optimal utilization of by-products, labour and space, along with strict hygiene and temperature control can result in consistent high quality products with economical advantages. However, conventionally prepared, retail packaged meat cuts are prone to microbial spoilage and detrimental chemical changes which work against the necessary requirements of extended shelf-life needed for distribution and storage of display-ready, offsite prepared products. These problems result in surface discoloration and loss of desirable sensory characteristics.

Modified atmosphere (MA) containing a high level of carbon dioxide (CO_2) has been shown to effectively inhibit microbial spoilage of fresh meat under optimal temperature conditions but may also cause acceleration of oxidative reactions (Breidenstein 1982). Hence, additional means are necessary to control oxidative changes with the concomitant loss of desirable sensory characteristics in extended storage. A solution consisting of polyphosphates, ascorbic acid and citric acid was found to be very effective in retarding the oxidative reactions of the pigment and lipid components of meat with an added benefit of improving and maintaining organoleptic properties. Voegeli et al. (1964a & b) tested a solution with similar composition to extend colour shelf-life of fresh meat but only met with limited success.

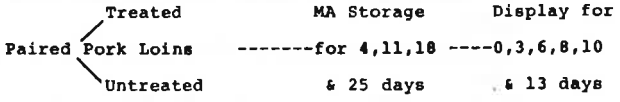
The Wilson-developed process involves two steps:

1) treating (Treatment WT) fresh meat with a solution of polyphosphates (0.2-0.5%), ascorbic acid (0.02-0.05%) and citric acid (0.01-0.05%); followed by,
2) packaging in a modified atmosphere (MA) containing carbon dioxide (CO_2, 20-80%), oxygen (O_2, 2-25%) and balance of nitrogen (N_2).

Results of extensive tests in a model system, pilot plant and commercial production showed that microbiological and colour shelf-life of fresh pork chops were effectively extended with this process (Cheng 1987; Cocoma and Cheng 1988 unpublished data). These beneficial effects were further verified by an outside laboratory. Portions of the later test results are presented in this report. One of the concerns in treating fresh meat with ascorbic acid is that colour could be enhanced and extended beyond the point that meat is actually rancid or spoiled. This phenomenon of colour masking is evaluated.

EXPERIMENTAL

A. Experimental Design:



B. Production, distribution, storage and display:

For each MA storage cell, one paired loin was treated (WT) and one untreated, sliced (1.6 cm thick),and packaged (4-5 chops per tray). Six primary trays were placed in thermoformed trays (master container) and hermetically sealed after flushing with CO_2. Details of the Treatment (WT) and the packaging in MA are described elsewhere (Cheng 1987; Lefens 1987; Packaging Digest 1987). Chop packages from the same loin were placed in one master tray and marked so that chops from the companion paired loins were evaluated at each designated time during MA storage. Product was shipped in a refrigerated truck and received by the test laboratory two days after production. Boxed products were held at 0o + 1oC until the time designated for display under light (80-110 foot candles) at 2° ± 1°C.

C. Analytical Methodology:

1. Meat Surface Colour: Surface colour was visually evaluated by 3-7 trained panel members using a 1-7 colour scale (1, extreme brown gray; 7, bright pinkish red). A colour score for each chop was recorded and mean scores of all chops from all panel members for each treatment and day were analyzed. References of newly cut chops and discolored chops were provided during each evaluation session.

2. Microbiological Analysis:
(a) Aerobic Plate Count (APC) was plated with APT agar (DIFCO 0654) and incubated at 10°C for 7 days.
(b) Peptone Tergitol Glucuronide (PTG) agar plate was used for testing total Enterobacteriaceae and E. Coli. The poured plates were incubated at 35°C for 24 hours.

3. Chemical Analyses: A membrane pH electrode was used to measure the pH value at the meat surface. The TBA method was that reported by Tarladgis et al. (1960). Ascorbic acid followed the method outlined in the USDA Chemistry Laboratory Guidebook Method 6.004, March 1986.

4. Off-Odour Determination: Off-odour (spoilage or rancid) was determined when the primary tray was opened for microbial analyses by a 3 person panel using a 1-4 scale (1, strong; 4, not detectable).

5. Sensory Evaluation of Cooked Meat: Pork chops were fried in a preheated skillet at 190°C for 8 minutes (alternating on each side for 2 minutes) and served to a panel of 6 members. Sensory evaluation included flavour, tenderness, juiciness and overall impression (Scale 1-7; 1, extremely poor and 7, excellent) and off-flavour (scale

1-5; 1, no off-flavour and 5, very strong off-flavour). Data was statistically analyzed for paired observation using Plus*Ware Statgraphics Software (STSC 1985).

D. Acceptance Criteria for treated meat:

1) APC of 6.5 log per gram of meat is arbitrarily set as the microbial acceptance level with the knowledge that some higher counts are organoleptically acceptable.
2) Meat with surface colour score of 5.0 or higher in the scale 1-7 has desirable pinkish appearance.
3) Acceptable off-odour score of raw meat is 3.0 or higher.
4) Maximum acceptable TBA value of raw meat is set at 1.50.
5) Acceptable sensory score for flavour of cooked meat is 4.0 or higher and for off-flavour is 2.0 or lower.

RESULTS AND DISCUSSION

Initial microbial counts including aerobic plate count, total Enterobacteriaceae and E. Coli count of treated and untreated pork during MA storage were low for 4-day MA storage samples (Tables 2, 3, & 4, Fig. 1a). The low microbial levels are the results of strict hygiene, temperature control, and rapid processing from carcass to packaged retail cut. This combination of low initial microbial load, high CO_2 atmosphere, and low storage temperature ($0° \pm 1°C$) was shown to be very effective in inhibiting microbial growth during further MA storage (Tables 2, 3 & 4, Figs. 1a-1d). No additional microbial growth was evident in the pork chops under MA storage after 11, 18 and 25 days at $0° \pm 1°C$.

A continued microbial static effect was observed in treated and untreated pork chops after removal from master trays. Microbial counts increased slowly during display at $2° \pm 1°C$ (Tables 2, 3 & 4, Figs. 1a-1d). During display, acceptable microbiological shelf-life ranging from 8-10 days was recorded after product was stored for 4, 18 and 25 days in MA (Table 1). For MA storage 11-day samples, microbiological shelf-life was only 6 days or less during display. The temperature history of the display case was noted to elevate during display, accounting for the deviation of 11-day samples. Maximum microbiological shelf-life of pork chops does reach 25 days in MA storage, plus 8-10 days display at $2° \pm 1°C$.

Test results show that colour shelf-life of pork chops in MA storage and during display was extended by the Treatment (WT). Acceptable colour of fresh pork chops was extended from 4 days for untreated samples to 18 days for treated samples in MA storage (Table 1, Figs. 1a-1d). During display, discoloration developed rapidly in untreated 4-day MA storage samples. Three day colour stability was recorded for treated 4 and 18-day MA storage samples. Less than three days colour stability for treated 11-day MA stored samples was recorded due to elevated temperature in the meat case during display (Table 1, Fig. 1b).

Treated stored pork had sufficient microbiological and colour shelf-life to accommodate 10-14 day MA storage during commercial distribution and 3 day display after removal from MA. Untreated pork was discolored after only 4 days in MA storage. No treated sample maintained colour when its microbial or organoleptic characteristics were judged to be unacceptable. Therefore, no colour masking of microbial spoilage occurred in treated pork. Product stored in MA and subsequently displayed had shorter colour shelf-life than microbiological shelf-life (Table 1). Thus, the consumer's initial indicator of acceptable product (colour) remains the same for treated meats.

In treated pork, off-odour development is retarded during display. Development of rancid off-odour was more rapid in untreated product (Figs. 2a & 2b).

TBA value is a measurement of a reddish complex that malonaldehyde forms with 2-thiobarbituric acid (TBA). This test is most usually correlated with oxidative rancidity in meat (Melton 1985). TBA value of treated and untreated pork chops increased during MA storage and also during display. In untreated, the TBA value increases at a faster rate than the treated (Figs. 3a & 3b). The results showed that the Treatment (WT) was effective in retarding oxidative lipid reactions.

The added reducing component of the Treatment (WT), ascorbic acid, continued to deplete during MA storage and display eventually reaching a level equivalent to the endogenous reducing activity of untreated pork (Figs. 4a, 4b & 5d). It appeared that depletion of ascorbic acid was closely related to an increase in the TBA value reported over time (Figs. 5a-5d).

Generally, pH values of treated pork chops were equal to or slightly higher than the untreated companion loin chops when compared. (Table 5).

Results of sensory panel testing showed that organoleptic properties of pork chops were significantly improved with the Treatment (WT) (Figs. 6a-6d, 7a-7d, & 8a-b). Higher panel scores for flavour, texture, juiciness and overall impression were found in the treated samples after MA storage for 4, 11, and 18 days (Figs. 6a-6d, 7a-7d and 8a-8b). On prolonged MA storage of 25 days, difference in flavour of the treated and the untreated samples became insignificant (Fig. 6d). The Treatment (WT) was effective in retarding off-flavour development. Control of the oxidative reaction in treated meat under extended MA storage and subsequent display (Figs. 8a, 8b) is the postulated mechanism. The Treatment (WT) also includes small amounts of salt and dextrose which contributes to the improved flavour of the treated meat.

CONCLUSIONS

The application of strict microbial-based production requirements coupled with rapid processing from carcass to packaged retail cuts results in low initial microbial counts. Further, microbial growth was inhibited by the high level of CO_2 in the MA and good storage temperature. Oxidative reactions in the pigment (discoloration) and in the lipid components (increased TBA value) were retarded by the Treatment (WT). All organoleptic properties were improved by the Treatment (WT). Treated product had a maximum colour shelf-life of 18 days in MA storage and 3 days normal atmosphere display. A maximum microbiological shelf-life of 25 days in MA storage and 6-8 days display was observed. No colour masking of microbial spoilage was observed. Results of this test show that central prepackaged fresh meat subject to this process has sufficient colour and

microbiological shelf-life to maintain acceptability during distribution, refrigerated storage, and display.

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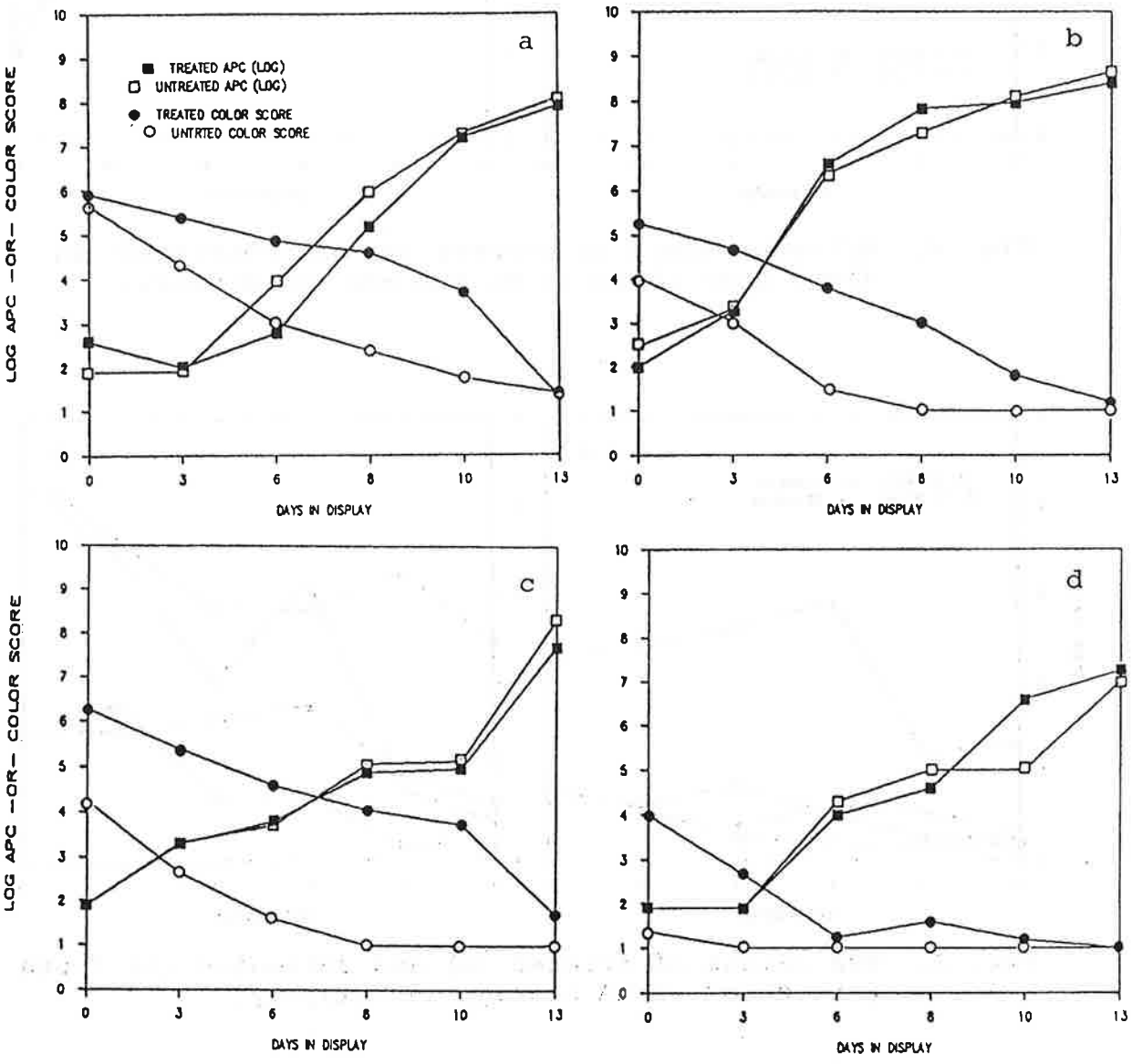

Fig. 1. Aerobic Plate (log) Count (APC) per gram of meat and meat surface color score of treated and untreated pork chops in MA storage and display. a, MA storage 4 days; b, MA storage 11 days; c, MA storage 18 days; d, MA storage 25 days.

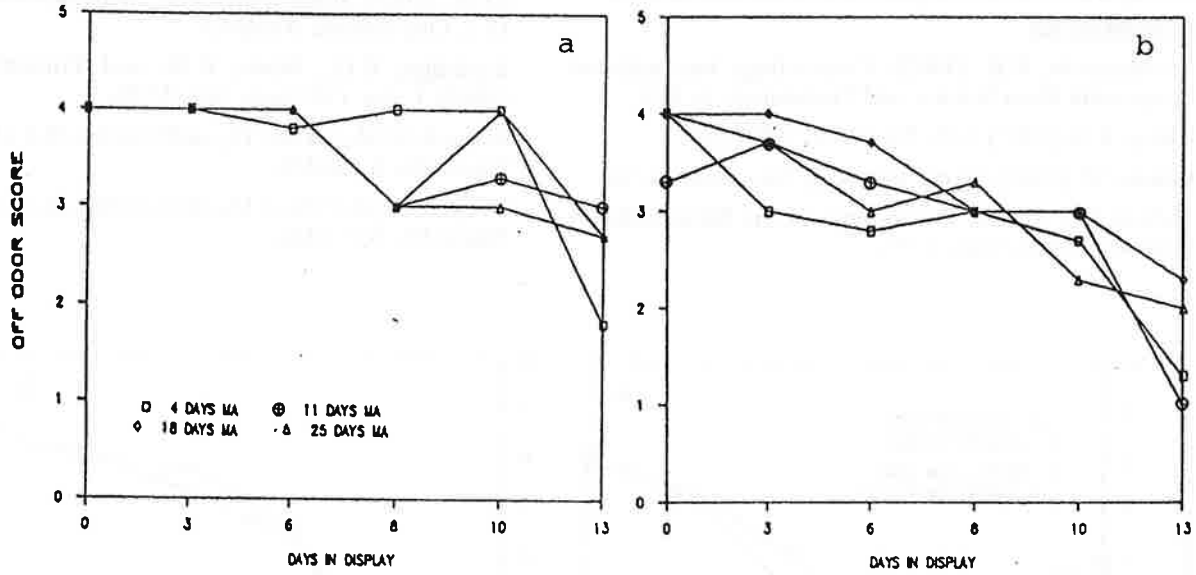

Fig. 2. Off-odor score of treated (a) and untreated (b) fresh pork chops in MA storage and display.

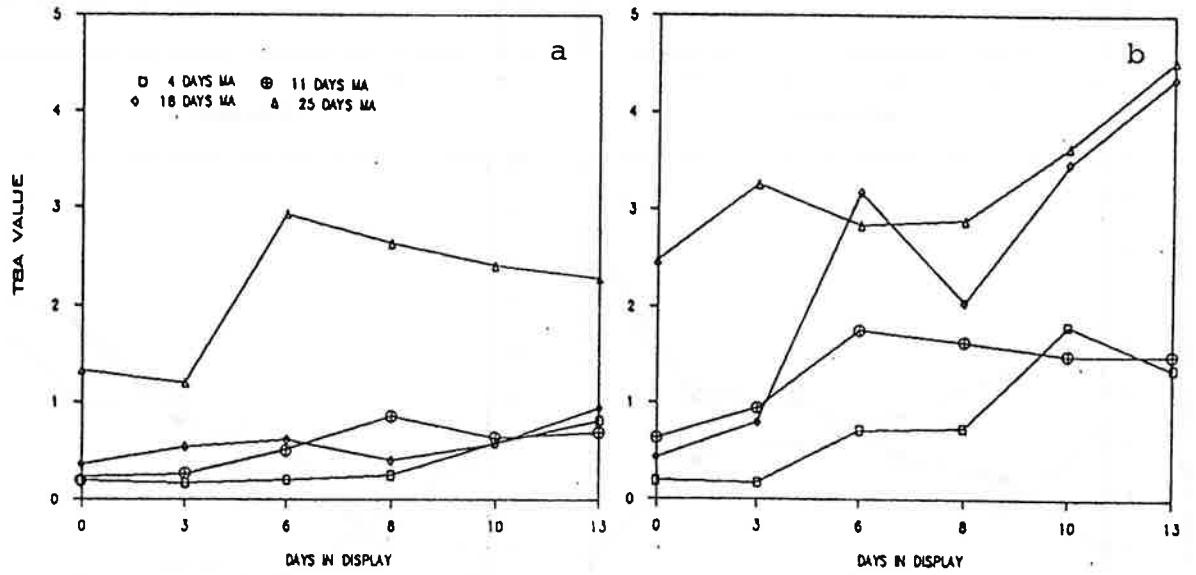

Fig. 3. TBA values of treated (a) and untreated (b) fresh pork chops in MA storage and display.

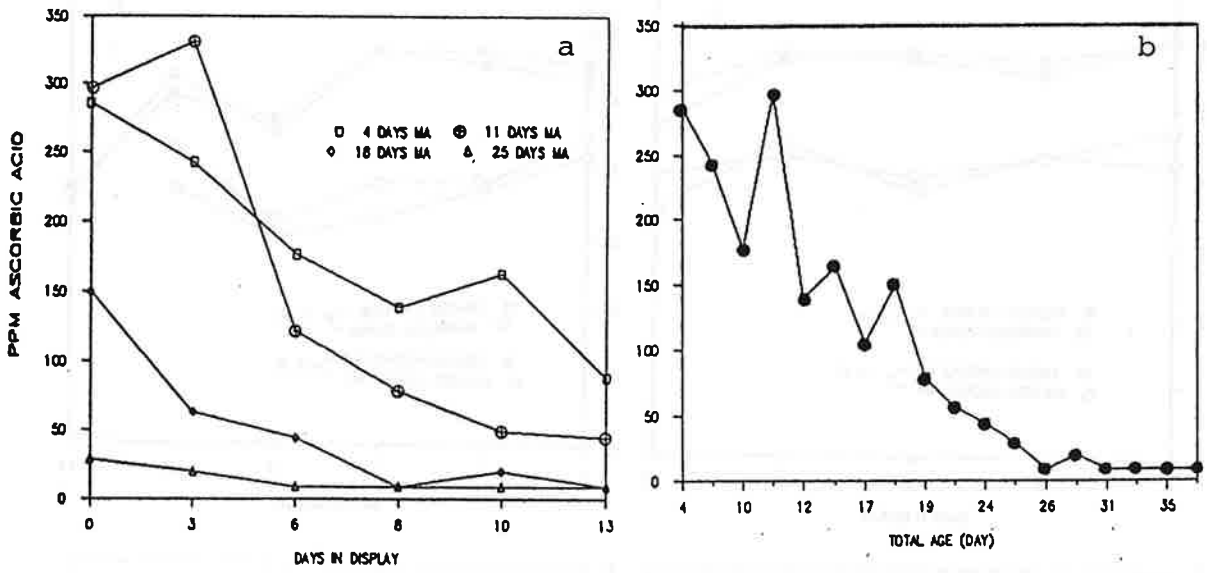

Fig. 4. Depletion of ascorbic acid in treated pork chop. a, In MA storage and display; b, Based on total age of pork chops.

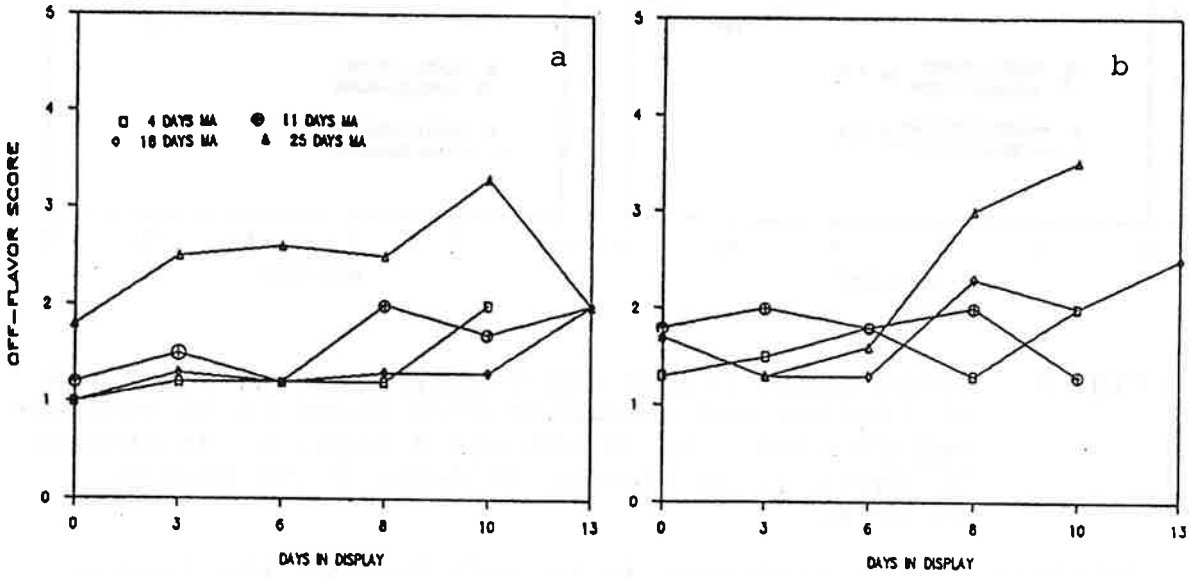

Fig. 5 Taste panel off-flavor score of treated (a) and untreated (b) pork chops in MA storage and display.

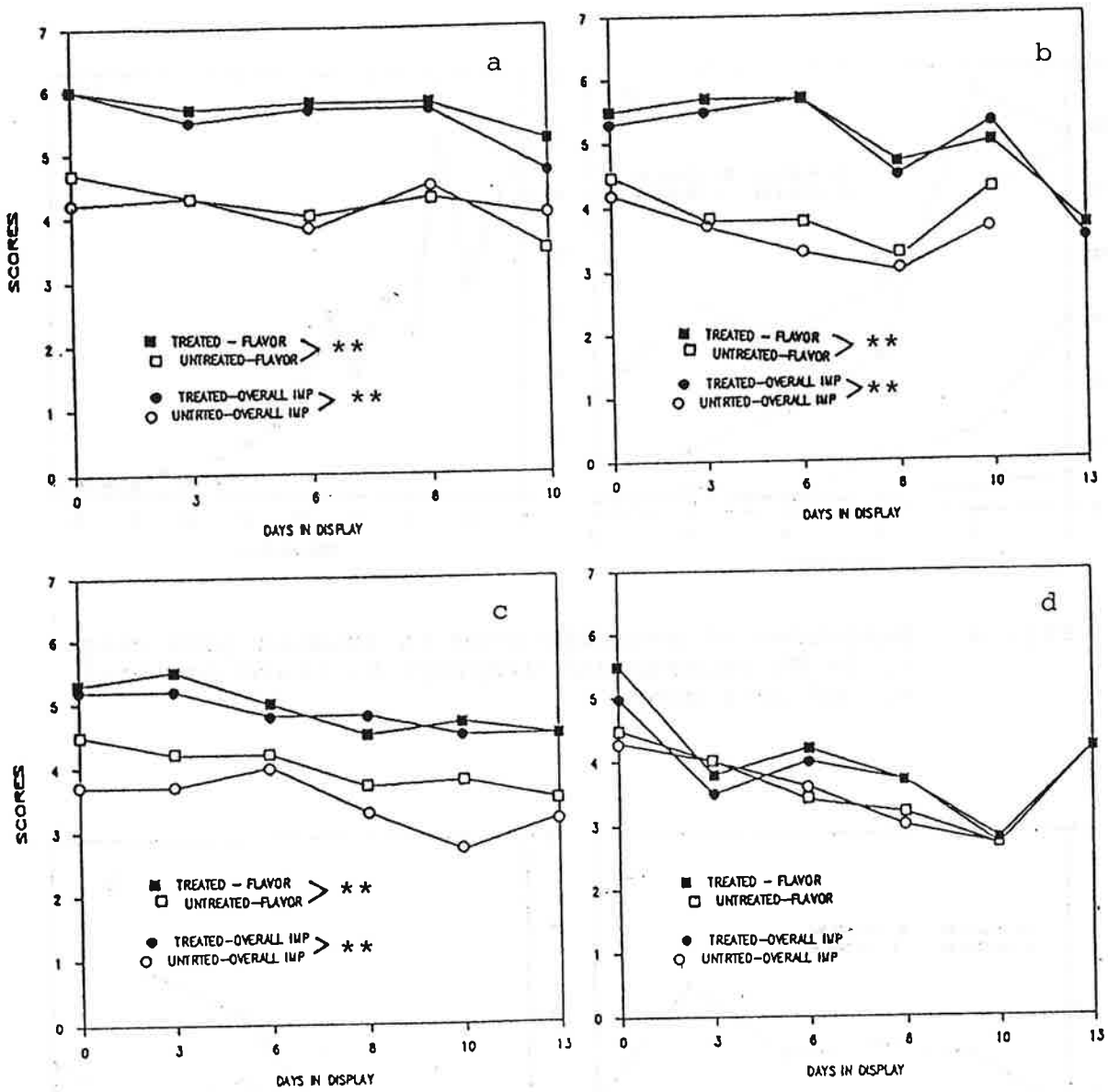

Fig. 6. Taste panel flavor and overall impression scores of treated and untreated pork chops in MA storage and display. a, MA storage 4 days; b, MA storage 11 days; c, MA storage 18 days; d, MA storage 25 days.

**Significantly different ($p < 0.005$) between the treated and the untreated.

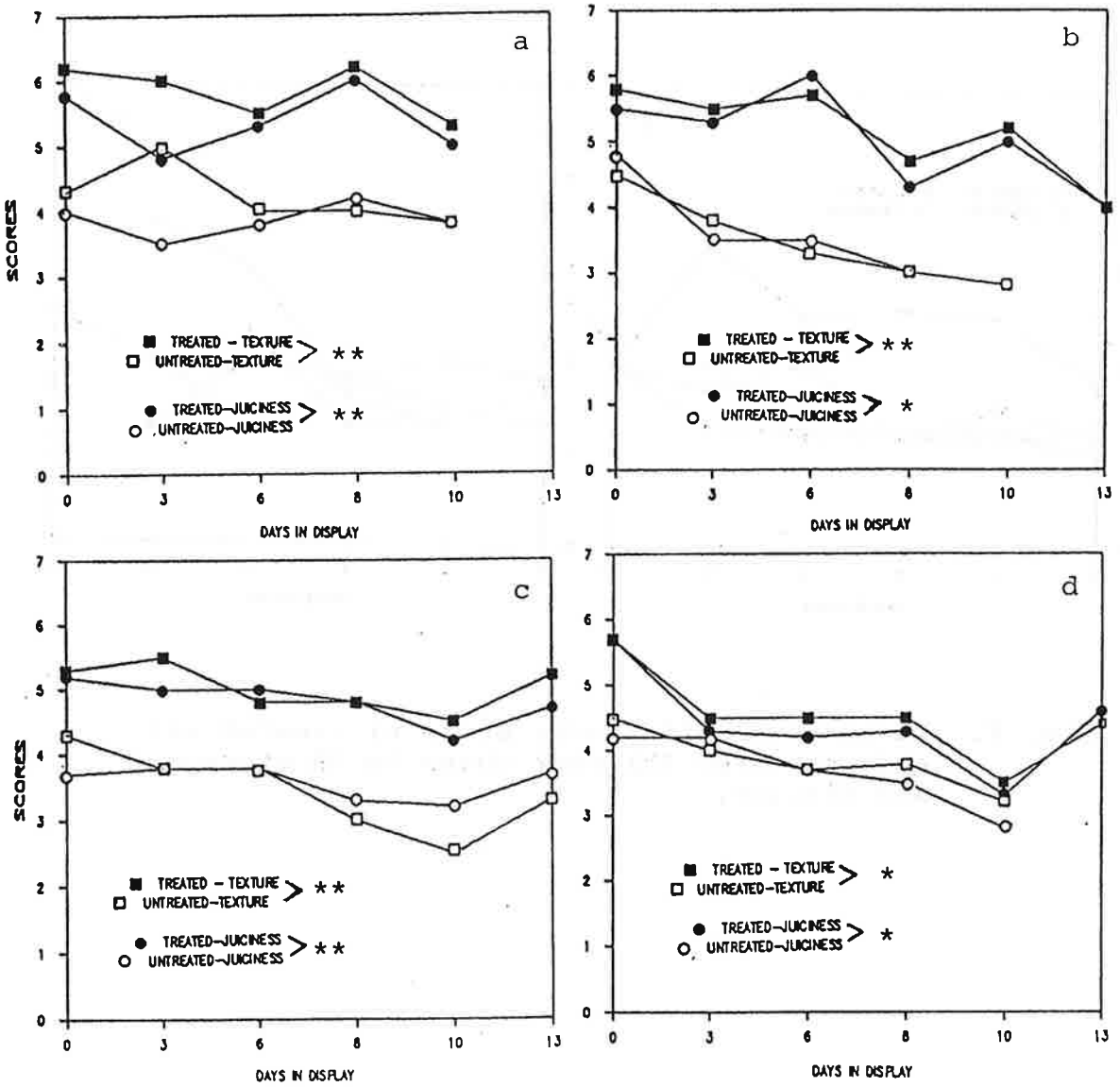

Fig. 7. Taste panel texture and juiciness scores of treated and untreated pork chops in MA storage and display. a, MA storage 4 days; b, MA storage 11 days; c, MA storage 18 days; d, MA storage 25 days.

*.**Significantly different, (*$p < 0.05$; **$p < 0.005$) between the treated and untreated.

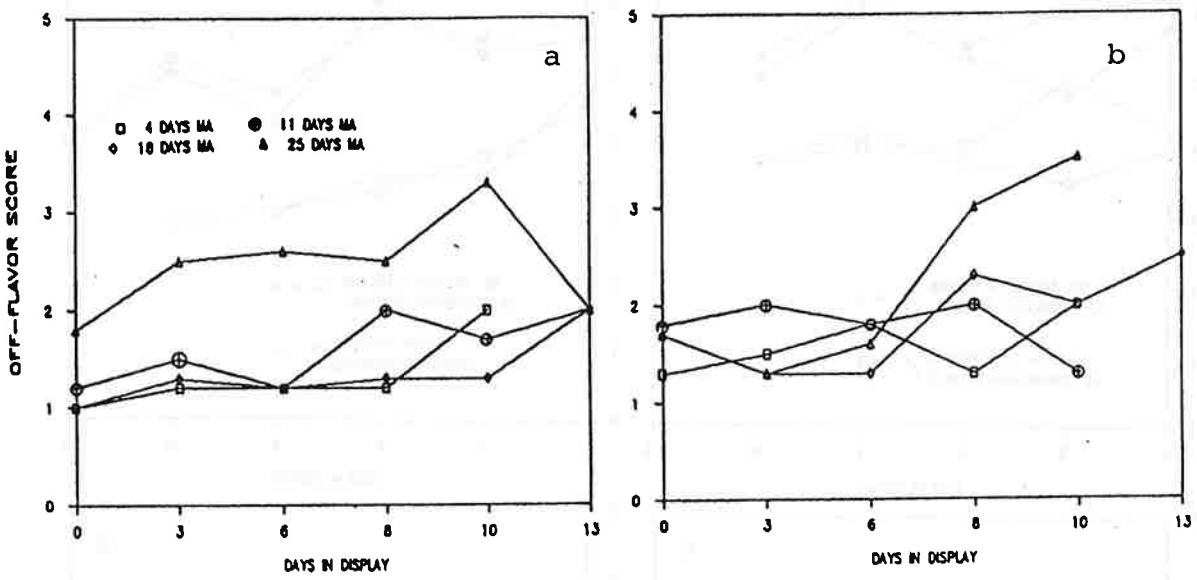

Fig. 8. Taste panel off-flavor score of treated (a) and untreated (b) pork chops in MA storage and display.

Table 1
Display-life*(day) of treated and untreated fresh pork chops using modified atmosphere storage

Item		Accepted level	Treated MA storage (day)				Untreated MA storage (day)			
			4	11	18	25	4	11	18	25
Microbial	log/g	≤6.5	8	<6	10	8	8	6	10	10
Color	Score	≥5.0	3	<3	3	<0	0	<0	<0	<0
Off-Odor	Score	≥3.0	10	13	10	10	8	10	10	8
TBA	Mg/Kg	≤1.5	13	13	13	3	8	3	3	<0
Flavor	Score	≥4.0	10	10	13	0	10	0	6	3
Off-Flavor	Score	≤2.0	10	13	13	0	10	10	6	6

*Last display day acceptable or above rating given.

Table 2
APC (log) of treated and untreated fresh pork chops during display[a]

Display (Day)	Treated & MA storage (day)				Untreated & MA storage (day)			
	4	11	18	25	4	11	18	25
0	2.60	2.00	<2.00	<2.0	<2.00	2.48	<2.00	<2.00
3	2.00	3.26	3.30	<2.0	<2.00	3.32	3.34	<2.00
6	2.78	6.58	3.80	4.00	3.90	6.38	3.72	4.30
8	5.18	7.82	4.90	4.60	5.95	7.30	5.08	5.00
10	7.20	7.98	4.99	6.59	7.30	8.11	5.15	5.00
13	7.90	8.40	7.69	7.26	8.08	8.65	8.32	7.00

a) log count per gram of meat. APT agar, incubation at 10°C for 7 days.

Table 3
Total Enterobacteriaceae count (log) of treated and untreated fresh pork chops during display[a]

Display (Day)	Treated & MA storage (day)				Untreated & MA storage (day)			
	4	11	18	25	4	11	18	25
0	<1.00	1.70	1.78	<1.00	1.60	2.40	<1.00	2.76
3	<1.00	1.30	1.00	1.00	<1.00	<1.00	1.60	<1.00
6	1.30	5.56	2.00	3.15	1.70	5.48	<2.00	3.90
8	4.46	6.58	4.11	4.64	5.28	6.43	<2.00	3.00
10	5.26	6.90	3.00	4.54	5.40	6.85	3.70	3.90
13	7.41	7.60	6.08	6.36	7.08	7.30	7.89	4.08

a) Log count per gram of meat. PTG agar plate at 35°C for 24 hrs.

Table 4
E. Coli count of treated and untreated fresh pork chops during display[a]

Display (Day)	Treated & MA storage (day)				Untreated & MA storage (day)			
	4	11	18	25	4	11	18	25
0	20	<10	<10	<10	<10	<10	<10	<10
3	<10	<10	<10	<10	<10	<10	<10	<10
6	<10	<10	100	<100	20	<10	<100	<100
8	200	<10	<100	<100	200	<10	<100	<100
10	<10	<100	<100	<1000	10	<100	<100	<1000
13	<100	<1000	14,000	2,000	<100	<1000	<1000	<1000

a) Direct count per gram of meat. PTG agar plate at 35°C for 24 hrs.

Table 5
pH change of treated and untreated fresh pork chops during display[a]

Display (Day)	Treated & MA storage (day)				Untreated & MA storage (day)			
	4	11	18	25	4	11	18	25
0	5.75	6.05	6.05	5.90	5.55	5.85	5.90	5.85
3	5.85	5.60	6.25	---*	5.60	5.55	6.05	5.55
6	5.85	5.95	----	5.75	5.85	5.85	----	5.75
8	5.75	5.85	6.00	6.00	5.65	5.50	5.75	5.75
10	5.75	6.10	5.85	5.80	----	5.80	----	5.75
13	5.85	----	5.85	5.95	5.85	----	5.55	5.85

*Sample lost.
a) pH measure by surface electrode.