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SHELF LIFE OF PORK MEAT DURING STORAGE IN MODIFIED ATMOSPHERE

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Abstract

Commercial, bone-in pork loins were divided into four portions. One portion of each loin was vacuum packaged, then stored at -1.5°C. The other portions were each divided into three chops, which were retail packaged. The retail packs were master packaged under atmospheres o/N_2, CO_2 *or* O_2 + CO_2 *(2:1, v/v), then .stored at 2°C. The pork was assessed after storage for up to 42 days. At each assessment, a vacuum pack and a master pack of each type, each containing product from the same loin, were withdrawn from storage. The vacuum packaged portion was cut into three chops, which were retail packaged. The chops from all packagings were displayed in a retail cabinet which maintained average air temperatures between 3 and 6°C. The chops were assessed twice daily until they were judged to be of undesirable appearance. After storage for 1 or 2 days, the chops from all master packs appeared less desirable than the freshly cut chops. After all longer storage times, chops from* N_2 *and* CO_2 *atmospheres appeared as desirable as freshly cut chops, as did chops from* O_2 + CO_2 *that were stored for up to 16 days. However, chops stored under* O_2 + CO_2 *for 21 days appeared undesirable. Chops stored under* N_2 *or* O_2 + CO_2 *developed spoilage odours, after storage for 28 or 21 days, respectively.*

Key words : shelf life, pork meat, meat storage, modified atmosphere.

INTRODUCTION

The central preparation of packs of meat can be more economical than the traditional, in-shop preparation of product for display. Central cutting systems can be operated with product in conventional, overwrapped trays, but only if times are short between meat cutting and display. For wider trading of retail ready meat, a modified atmosphere must be used to extend the storage life of the product (Young et al, 1988).

Modified atmospheres of O_2 + CO_2, which may also contain some N_2 to guard against pack collapse, are commonly used within retail packs. Unfortunately, a ratio of about 1:3 in meat to gas volume is required to maintain an adequately preservative composition of the atmospheres in that type of pack. Hence, modified atmosphere display packs in commercial use are often of a size sub-optimal for meat preservation, and so confer only a modest extension of product storage life. The retail problems with oversized display packs can be avoided by sealing a number of display trays into a

master pack which contains the preservative atmosphere. As the product is exposed to air when the master pack is opened, a desirable, bright, red meat colour need not be maintained by the master pack atmosphere, provided that the product can bloom after removal from the master pack. Consequently, anoxic atmospheres as well as atmospheres rich in O_2 can be considered for use in master packs (Gill, 1990).

In commercial practice, the time between packing of meat and its display at a retail outlet may extend to about 3 weeks even when there is only a short distance between the plant and the outlet, because of the need to cope with unpredictable fluctuations in consumer demand (Gill & McGinnis, 1993). Under current commercial conditions, display ready packs of beef cannot be stored for such a time under an O_2-rich atmosphere without unacceptable deterioration of the product. However, ground beef or steaks that are master packaged under N_2 or CO_2 atmospheres can be stored for 3 weeks or longer, at a usual, commercial temperature, while retaining a display life equal to or better than that of product freshly prepared for display from vacuum packaged meat of the same age.

Those findings indicate that anoxic atmospheres would probably have to be used for the wide marketing of master packaged, display ready beef through existing distribution systems. However, anoxic atmospheres for master packs are at present less readily implemented, and are more costly, than are O_2-rich atmospheres. The use of anoxic atmospheres with other retail ready meats could then be advocated only if such atmospheres conferred advantages similar to those observed for beef. Pork, in particular, appears from some reports to have an adequate storage stability in O_2-rich atmospheres. The display life of display packed pork chops after their storage in master packs under atmospheres of N_2, CO_2 or O_2 + CO_2 was, therefore, examined, to discern if there could be some commercial advantages from the storage of retail ready pork under an anoxic atmosphere.

MATERIALS AND METHODS

Preparation and storage of pork chops and loin portions

Bone-in pork loins of normal muscle quality character and with *m. longissimus dorsi* muscle of pH < 5.8, from animals slaughtered in the previous day, were collected from a abattoire. The loins were stored at 15°C. and used for the preparation of chops on the day that they were collected.

Each loin was divided into four portions. One portion was vacuum packaged in a pouch of a polyvinyledene chloride laminate that has an O_2 transmission rate of about 40 cc/m^2/24 hr/atm at 25°C and 100% RH. Three chops, each about 30 mm thick, were cut from

each of the three remaining portions. Each chop was placed in a solid polystyrene tray of dimensions 210x 150x25mm that contained a soak pad. Each tray was placed in a pouch of a shrinkable film with antifogging properties and an O_2 transmission rate of about 11000 cc/m^2/24 h/atm at 25°C and 75% RH. After being sealed, the pouch was shrunk to the tray using a hot air gun. A 3 mm hole made in the film at one corner of the tray allowed the film to form as a flat lid to the tray.

The filled trays were distributed, in groups of three, into three pouches, composed of a laminate of two metallized polyester layers and an inner layer of ionomer. The bi-metallized laminate had no measurable rate of O_2 transmission. The pouches were evacuated, filled with gas and sealed, using a modified chamber plus snorkel machine (Multivac) which can reliably establish an atmosphere of N_2 containing about 100 ppm O_2. The three pouches were respectively filled with 4l of CO_2. 4l of N_2 or 2l of CO_2. Within 15 min of the last pouch being filled, it was further rilled with 41 of O_2, via a hypodermic needle inserted through a stick-on septum. Immediately after the needle was removed, the area which it had penetrated was sealed.

The loin from which the chops had originated, and the type of atmosphere were noted on each pouch. The loin origin was also noted on each vacuum pack. The vacuum packaged meat was stored at -1.5 ± 0.5°C. The master packaged chops were stored at 2 ± 0.25°C.

Sampling and display of pork chops

Packs were withdrawn after storage for 1. 2. 4, 8, 16, 21, 28, 35 or 42 days. At each time, a vacuum packaged portion and the three master packs which contained the chops from the same loin were withdrawn. The vacuum packaged portion was removed first. It was cut into three chops, which were packed into display trays identical to those used for the master packaged chops. The three master packs were then withdrawn, and all 12 packs were placed in a display case where the average air temperatures in the vicinity of displayed meat were between 3 and 6°C.

The appearances of the displayed chops were assessed 1 hr after opening the master packs. The enveloping film was then removed from each tray, and the odour of the meat was assessed. A sterile cork borer was used to obtain a 5 cm^2 sample of muscle tissue surface that was 1 cm thick. An area of approximately 5 cm^2 of a fat surface that was exposed in the undivided loin was swabbed, first with a swab moistened with 0.1% w/v peptone water, then with a dry swab. The sampled area was not delimited by a template. The trays were then repackaged in

the shrinkable film, displayed, and assessed for appearance at alternating periods of 6 and 18 hr.

Each set of retail packs from the same storage packaging was removed from display when the majority of the panel considered that two or three of the chops appeared undesirable, or after display for 4 days. On its removal from display, each chop was assessed for odour and sampled as before for microbiological analysis.

Panel evaluations of the chops

All assessments were made by a 5-member panel. The overall appearances of the chops and the appearances of the muscle, fat and bone tissues were assessed, using a 7 - point scale where 1 = extremely undesirable, *2* = undesirable, 3 = slightly undesirable, 4 = neither desirable nor undesirable, 5 = slightly desirable, 6 = desirable and 7 = extremely desirable. A set of packs was removed from display when a majority of the panel recorded an overall appearance score of 3 or less for two or three of the set of three packs.

Odour was assessed on a 4 - point scale where 1 = no off-odour, 2 = slight off-odour, 3 = moderate off-odour and 4 = strong off-odour. Note was made of the types of off-odour that were detected.

RESULTS AND DISCUSSION

Evaluation of chops removed from storage

When the appearances of chops were assessed after their removal from storage, the score for the appearance of the muscle tissue of each chop was generally the same as, or a point less than, the score for the overall appearance, while the scores for the appearances of fat or bone were generally the same as, or a point more than, the score for overall appearance. The exceptions were the scores for bone in chops stored under $O_2 + CO_2$ for 21 days or longer, all of which were less than the equivalent scores for overall appearance. Chops prepared from the vacuum packaged portions or stored under N_2, CO_2 or $O_2 + CO_2$ appeared desirable after storage times inclusively between 1 and 35, 4 and 42, 4 and 42, or 4 and 12 days, respectively (Table 1). After storage times $\leq$ 2 days, all the chops from master packs were of less desirable appearances than chops cut from the equivalent vacuum packaged portions, because their muscle tissue was dull with brown discoloration at the edges. Chops stored under $O_2 + CO_2$ appeared undesirable after storage for 21 days or longer, because of the browning of both muscle tissue and the cut surfaces of bone.

Chops prepared from the vacuum packaged portions, and those stored under CO_2, were without objectionable odours after all storage times (Table 1). However, chops stored under N_2 for 28 days or longer, or under $O_2 + CO_2$ for 21 days or longer, had sour odours that were variously described as also stale or putrid.

TABLE 1

The Predominant Organoleptic Scores Recorded, and the Types of Off-odour Noted by a 5-member Panel at the Initial Assessments of Displayed Pork Chops, Prepared from Product Stored Under Vacuum at -1.5°C, or Stored in Retail Packs Master Packaged under N_2, CO_2 or $O_2 + CO_2$ (2:1, v/v) Atmospheres at 2°C

Storage time (days)	Storage atmosphere							
	Vacuum		N_2		CO_2		$O_2 + CO_2$	
	A	O	A	O	A	O	A	O
1	6	1	5	1	4	1	5	1
2	6	1	5	I	5	1	5	1
4	6	1	6	1	6	1	6	1
8	6	1	6	1	6	1	6	1
12	6	1	6	1	6	1	6	1
16	6	1	6	1	6	1	5	1
21	6	1	6	1	7	1	3	2S
28	6	1	6	2S	6	1	3	2S
35	6	1	6	2S	6	1	3	2S
42	5	1	6	3S	6	1	2	3S

Three chops from each type of packaging were examined at each time. A = Overall appearance; 1 = extremely undesirable, 2 = undesirable. 3 slightly undesirable, 4 = neither desirable nor undesirable, 5 = slightly desirable. 6 = desirable. 7 - extremely desirable. O = Off-odour intensity; 1 = none. 2 = slight, 3 - moderate. 4 = strong S, sour, stale: P. sour, putrid.

Display times

Chops cut from vacuum packaged portions remained acceptable on display for 2 days or longer irrespective of the time for which the product was stored (Table 2). After storage for 1 day, all the chops from master packs remained acceptable on display for shorter times than that for the chops prepared from the vacuum packaged portion, with the display life of the chops that had been stored under CO_2 being only a few hours. After storage times between 2 and 35 days inclusive, the display life of chops stored under N_2 or CO_2 were generally the same or longer than the display life of the chops prepared from the vacuum packaged portions. After 42 days storage, the display life of the chops from CO_2 was shorter than that of the chops prepared from the vacuum packaged portion. After storage times between 2 and 16 days inclusive, the display life of chops stored under $O_2 + CO_2$ was equal to or shorter than the display life of chops cut from the vacuum packaged portions.

TABLE 2

The Times at Which Chops were Removed from Display Following their Preparation from Product Stored in Vacuum Packs at -1.5°C or After Being Stored in Retail Packs Master Packaged Under N_2, CO_2 or O_2 +CO_2 (2:1, v/v) Atmospheres at 2°C

Storage time (days)	*Display time (hr) Storage pack*			
	Vacuum	N_2	CO_2	O_2 + CO_2
1	72	48	6	30
2	48	48	48	30
4	96	96	96	78
8	72	71	72	72
12	72	54	72	54
16	48	48	48	24
21	54	54	72	-
28	72	96	96	-
35	72	71	72	-
42	48	-	24	-

- Chops rejected when first assessed, after display for 1 hr.

Evaluation of chops removed from display

When the chops were removed from display, they generally appeared slightly undesirable. However, all the chops that were displayed for 96 hr appeared neither undesirable or desirable, while chops that had been stored under N_2 for 35 days, or CO_2 for 42 days, appeared undesirable.

TABLE 3

The Odours of Chops at the Times of their Removal from Display

Storage time (days)	*Display lime (hr Storage pack*			
	Vacuum	N_2	CO_2	O_2 + CO_2
1	1	1	1	1
2	1	1	1	1
4	1	1	1	1
8	1	1	1	1
12	1	2S	1	2S
16	1	2S	1	2S
21	2P	3P	2S	-
28	2S	3S	2S	-
35	2S	3P	2S	-
42	2P	-	2S	-

The off-odours were described as sour and stale (S) or putrid (P). The chops had been prepared from product stored in vacuum pack at -1.5°C or had been stored in retail packs master packaged under N_2, CO_2 or O_2 + CO_2 (2:1, v/v) atmospheres at 2°C. - Chops withdrawn when first assessed, after display for 1 hr. Off-odour intensity: 1 = none. 2 = slight, 3 = moderate, 4 = strong.

For each group of chops, the scores for the appearance of muscle tissue were generally the same as the overall appearance scores, while fat and bone tissue were generally accorded higher scores.

Most chops that had been stored in master packs under N_2 or O_2 + CO_2 for 12 days or longer had off-odours, that were described as sour, and stale or putrid, when they were removed from display (Table 3). However, such off-odours were not apparent in chops prepared from the vacuum packaged portions, or those stored under CO_2, until the product had been stored for 21 days or longer.

CONCLUSIONS

The study show the comparison of chops from master packs with product from the same pork loin which was stored under conditions that would minimize deterioration of the meat. The loins could be expected to vary in their stability with respect to both colour and microbial spoilage. However, the relative preservative capabilities of the packagings would be directly comparable for each period of storage, while the variations between loins should not be so great as to prevent discernment of the likely preservative effects of the master packagings in commercial circumstances.

Deterioration of the appearance of muscle tissue preceded the discoloration of fat or the darkening of cut bone. When beef is packaged under - depleted atmospheres of N_2 or CO_2, the trace amounts of O_2 that are initially present in such atmospheres are scavenged by the muscle pigment, with the formation of metmyoglobin at meat surfaces (Ledward, 1970). The accumulation of brown metmyoglobin dulls and discolours the meat but, during storage for 3 or 4 days, the metmyoglobin is reconverted to deoxy-myoglobin by the metmyoglobin reducing activity of muscle Consequently, the muscle tissue will bloom to a desirable, bright, red colour when it is exposed to air.

However, all the chops that were stored in master packs for 1 or 2 days appeared duller than the chops freshly cut from the vacuum packaged portions and, after storage for 1 day, the display life of the master packaged chops was less than that of the freshly cut chops. Those observations indicate that metmyoglobin is formed at the surfaces of pork muscle when it is packaged under O_2-depleted atmospheres, although the effects on meat colour are less pronounced than in the more highly pigmented beef muscle. That effect in CO_2 atmospheres would explain the very short display stability of the chops that were stored under CO_2 for 1 day. Such transient decreases of display stability would be likely to be of more practical importance than the poor blooming which was discerned in pork stored for short periods under O_2-depleted atmospheres.

Chops stored under N_2 or CO_2 retained a desirable appearance after the longest storage time, but chops stored under O_2 +CO_2 were of undesirable appearance after 21 days. Moreover, chops stored under N_2 or CO? for 42

days, or under $O_2 + CO_2$ for 16 days, did not remain acceptable on display for as long as the product from vacuum packs. Loss of colour stability would then limit the storage life of retail ready pork to about 5 weeks in N_2 or CO_2 atmospheres, but to only about 2 weeks in an atmosphere of $O_2 + CO_2$.

Chops stored under N_2 or $O_2 + CO_2$ for 4 or 3 weeks, respectively, were spoiled by off-odours before display. However, chops stored under either of those atmospheres for only 12 days spoiled during display. Chops stored under vacuum or CO_2 for 42 days were unspoiled when the storage packs were opened but spoiled during display after being stored for 21 days. On the chops stored under CO_2 or $O_2 + CO_2$ the growth of enterobacteria is inhibited, and the spoilage odours were of a sour, stale type only. However, some of the chops stored under vacuum or N_2 developed putrid odours also.

The spoilage of meat which still looks acceptable would be seriously inconvenient to most retailers, who would not wish to sell meat that consumers would inevitably reject when they came to prepare it. Being unable to ascertain the state of the meat by simple inspection, retailers would be forced to place highly conservative limits on the times of both storage and display of retail ready pork that was stored in master packagings. Those considerations suggest that, in commercial practice, the useful storage life of retail ready pork stored under N_2 or $O_2 + CO_2$ atmospheres would be little more than 1 week, and < 3 weeks for pork packaged under CO_2. Broadly similar findings with respect to the storage of retail ready pork under CO_2 have been reported by other workers.

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