

Development of a Novel Bulk Packaging System for Retail Cuts of Meat





DEVELOPMENT OF A NOVEL BULK PACKAGING SYSTEM FOR RETAIL CUTS OF MEAT

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CONTENTS

Summary	1
Introduction	3
The importance of meat colour	3
Packaging systems for retail meat cuts	4
The technical challenge	4
Overcoming the challenge	6
Description of the new packaging system	7
Colour assessments	8
Results	9
Results with beef	11
Results with lamb	14
Results with pork	15
Conclusions	17
Publications from this project	18



SUMMARY

Meat colour is an important criterion in the appeal of meat to consumers at the point of sale. The bright red colour of fresh beef and lamb and the pinkish colour of fresh pork are due to the oxygenation of the myoglobin pigment when the meat is exposed to air. However, exposure to air over several days causes irreversible browning and rejection of the meat by consumers. The rate of browning is most rapid at low oxygen concentrations (less than 1%). The gaseous environment in which retail cuts are stored is therefore critical to ensure a good colour over the display life.

Most beef that is exported from Irish factories to the UK is in the form of vacuum packed primals. These are broken down into retail cuts and packed at specialised factories for distribution to retail outlets. If the same beef were exported in the form of retail ready cuts the industry and the economy would benefit from this additional labour and added value. Existing packaging systems ensure a good meat colour by using bulk mother packs containing several retail packs in a high-oxygen modified atmosphere. However, these do not have a sufficiently long storage life for the additional time required for exports from Ireland to the UK or continental Europe. The objective of this project was to develop a bulk packaging system for retail cuts that would have a sufficient shelf life to be used by the Irish industry to export retail ready cuts.

The main technical barrier to overcome was the fact that in order to extend the shelf life while at the same time ensuring a good colour during display the oxygen concentration within the mother packs would have to be maintained at a very low level (below 0.1%) throughout the storage period. This was achieved by using oxygen scavengers within the retail packs and mother pack. It was found that striploin steaks in overwrapped trays could be stored for up to 6 weeks and look as red as fresh steaks for up to 3 days on retail display. Results for other muscles showed that the system could be used for some, but not all cuts.



A further development was to devise a means of achieving the same result without having a scavenger sachet in the retail pack, which could be considered undesirable by some consumers. This was achieved by using a shrunk bag around the tray rather than overwrap film. By flushing the bag with carbon dioxide before sealing and shrinking it was possible to achieve very low residual oxygen levels in the retail packs. Steaks stored for 6 weeks using this method then placed on retail display were as red as fresh steaks for 7 days.

The packaging system was also shown to work well for lamb loin chops and pork boneless loin chops. For lamb, a modified atmosphere containing 100% carbon dioxide in the mother pack resulted in a better colour during display than a 50:50 mixture of carbon dioxide and nitrogen. Storage times for pork were shorter than for beef or lamb, which was expected given the poorer keeping quality of pork generally. Nevertheless, chops stored for 3 weeks had as good colour as fresh chops for at least 2 days of retail display.

In conclusion, a packaging system has been developed on a laboratory scale which is capable of extending the storage life of some beef cuts, lamb loin chops and pork loin chops. The display life of these after storage is comparable to fresh cuts. In order for this system to be commercialised it would have to be shown to work on a larger scale in a production environment. Also, it is highly desirable that it be developed to give good results in terms of colour stability for a wide range of cuts.



INTRODUCTION

The importance of meat colour

Colour has a major effect on the desirability of fresh red meat cuts to the consumer. For beef and lamb a bright red colour is associated with freshness, while pork should have a pinkish appearance. It is important therefore that packaging systems for fresh meat allow the development and retention of this desirable meat colour during retail display.

The red colour of meat is due to the oxygenation of the myoglobin pigment as illustrated schematically in Figure 1. In the oxygen-free conditions within muscles, the pigment is purple. On exposure to air, the colour quickly turns to bright red due to the relatively high (21%) concentration of oxygen. Long term exposure to air, however, causes a further change to the pigment which results in an increasing amount of brown discolouration. When this becomes noticeable the meat will be rejected by consumers so it must be removed from retail display. High oxygen concentrations (70-80%) delay the onset of browning, while very low concentrations (less than 1%) accelerate it. The atmosphere in which meat is stored is therefore critical in determining its display life.

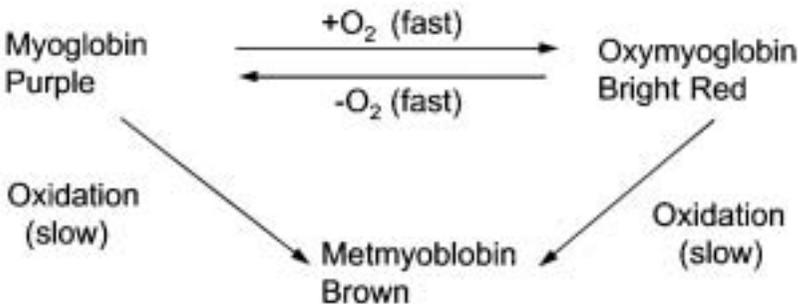


Figure 1. Oxygen & meat colour.



Packaging systems for retail meat cuts

Supermarkets have for many years used oxygen permeable film to overwrap meat cuts in trays prior to placing in display cabinets. This prevents the meat from drying out while allowing oxygen to permeate to ensure the development of a bright red colour. More recently, the move towards centralised packaging of fresh meat cuts to take advantages of economies of scale has led to the adoption of individual modified atmosphere packs (MAP). These are filled with an atmosphere containing 70-80% oxygen to ensure good colour, with the balance being carbon dioxide to prolong the shelf life.

A further development is the MAP mother pack in which several overwrapped trays are placed in a large bag which is flushed with a high oxygen atmosphere and then sealed (Figure 2a). When packs are needed for display, the mother bag is opened. The meat develops a bright red colour in the mother pack due to the oxygen-rich atmosphere and this is maintained during retail display. An extended storage life is achieved due to the carbon dioxide, while at the same time retaining the traditional form of presentation i.e. the overwrapped tray.

The technical challenge

Beef is exported from Irish factories to the UK mainly in the form of boneless vacuum-packed primals (large cuts), which are later cut into retail portions and packed in central packing plants for supplying to retail outlets. The added value and labour associated with this operation is therefore lost to the Irish economy. Existing packaging systems do not give a sufficiently long storage life for the export of retail ready cuts to the UK, let alone to continental Europe. The objective of this project was to develop packaging systems for retail ready cuts which would give a sufficiently long shelf life for this operation.

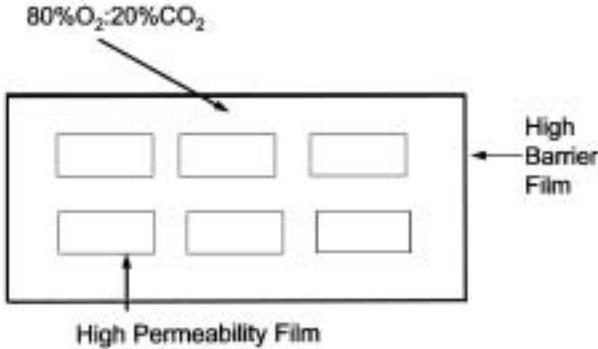


Figure 2a. The mother pack system of bulk packing of retail cuts – the meat has a bright red colour in the pack and during subsequent retail display.

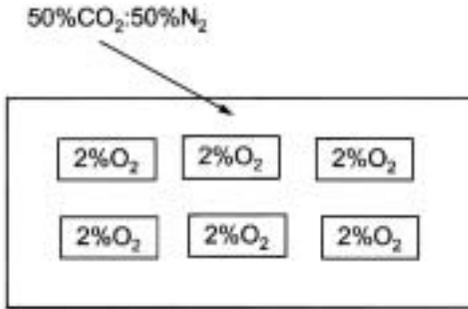


Figure 2b. The effect of residual oxygen on meat colour in a mother pack system – the meat turns brown in the pack.

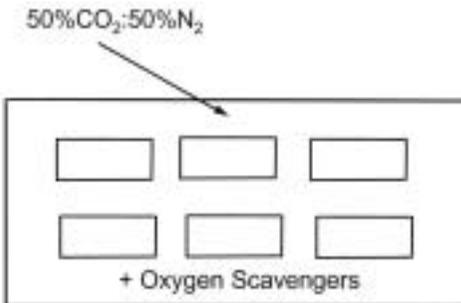
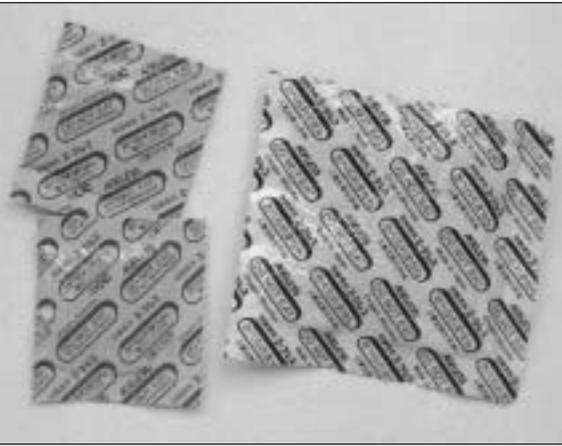


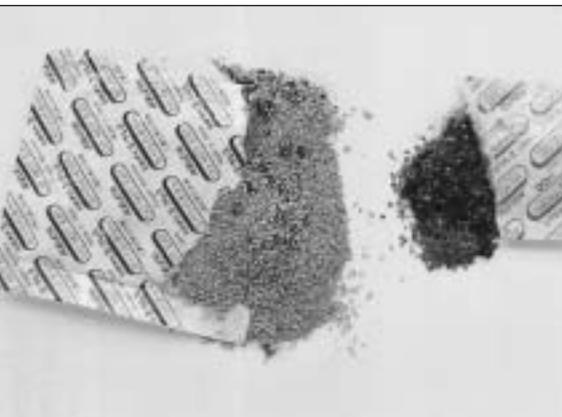
Figure 2c. The oxygen-free mother pack system – the meat remains purple in the pack, but turns red during retail display.



The storage life of mother packs can be prolonged by flushing with a high-carbon dioxide, oxygen-free gas mixture. However, the low level of oxygen in the residual air that cannot be removed during flushing causes the meat to go brown and it will not attain the desirable bright red colour during subsequent retail display (Figure 2b). The challenge in this project was to devise a system which would extend the shelf life while preserving the ability of the meat to achieve a desirable colour during display.



▲ *Oxygen scavengers were used to mop-up residual oxygen in packs after flushing and sealing.*



▲ *Oxygen scavengers are sachets of iron powder.*

Overcoming the challenge

The key to solving this problem was the use of oxygen scavengers to mop up the residual oxygen before it caused irreversible browning of the meat in the mother packs (Figure 2c). These scavengers are sachets of iron powder, which in the presence of moisture and oxygen undergoes a chemical reaction which uses up the oxygen. These are available from a number of manufacturers in a range of sizes and for different environments (temperature, humidity etc.). In this project we used “Ageless” made by Mitsubishi Corporation.

A number of experiments were carried out in the development of a workable system. The highlights of these are reported here.



DESCRIPTION OF THE NEW PACKAGING SYSTEM

Retail prepared cuts were placed in plastic or expanded polystyrene trays together with an “Ageless” scavenger with a capacity for absorbing 200cc of oxygen. The trays were then overwrapped with film with a high oxygen permeability. Six trays were placed in a mother bag made of low permeability material (CVP Ltd.) together with another scavenger having a capacity to absorb 2000cc of oxygen. Using a CVP A300 gas flush machine the bag was then evacuated and flushed with an oxygen-free gas mixture (either 50% CO₂:50%N₂ or 100%CO₂, depending on the experiment) using a triple cycle. Bags were then stored at 0°C (for up to 6 weeks for beef, up to 4 weeks for lamb or up to 3 weeks for pork) until packs were required for retail display. To maximise the period of good colour retention, retail packs should be displayed at as low a temperature as possible. In these experiments packs were displayed at temperatures of between 0° and 5°C, depending on the experiment.

Mother packs were evacuated, flushed and sealed on a CVP A300 gas flush machine. ▶





COLOUR ASSESSMENTS

Objective colour measurements were made using a Hunterlab Spectrophotometer on a daily basis throughout the display period (4-7 days depending on the experiment). The Hunterlab records the colour in terms of three values - L, indicating lightness; a, indicating redness; b, indicating yellowness. A rising a-value shows that the meat is 'blooming' to a bright red colour. After prolonged display this falls and the b-value rises due to the meat becoming brown. Meat that has browned is unacceptable to consumers and must be removed from retail display. The length of time that it takes for a piece of meat to turn brown is called its display life. Muscles turn brown at different rates, that is they are said to vary in their colour stability.

In these experiments, colour was also assessed subjectively by a panel at the end of the display period. Panellists were asked whether, based on the colour, they would buy the meat if offered for sale. This helped to link the objective measurements to the way people actually judge meat.



◀ *Colour measurements were made using a spectrophotometer.*



RESULTS

Oxygen level within packs

The effectiveness of the oxygen scavengers in mopping up the residual oxygen in the mother packs and trays is illustrated in Figure 3. From an initial level of about 1.5%, the oxygen concentration fell to below the critical level to prevent browning of 0.1% within 24 hours. The scavengers were able to maintain this low level during a 4 week storage period, with a slight increase after 6 weeks.

The gas composition in packs was checked using a gas chromatograph ▶



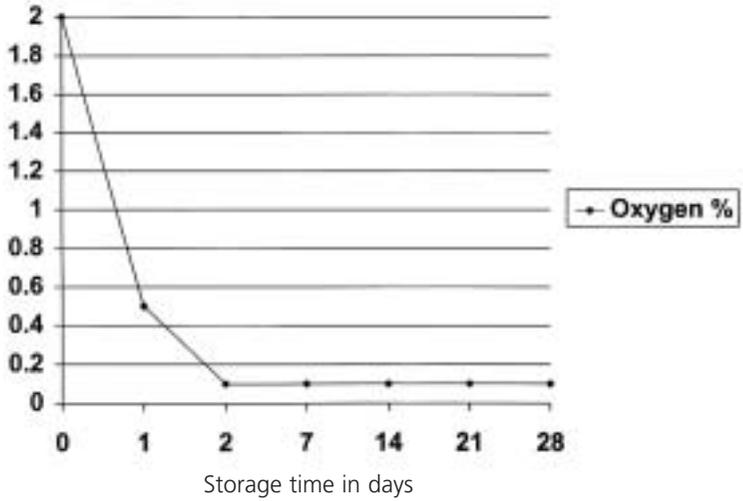


Figure 3. The effect of oxygen scavengers on the O₂ concentration in mother packs.



◀ After storage for up to 6 weeks retail packs were placed in a display cabinet for up to 7 days.



Results with beef

Initial experiments were carried out on the *longissimus dorsi* muscle, which is the striploin steak, or the larger muscle of the T-bone. This is known to be the muscle with the greatest colour stability. The colour stability results for striploin steaks stored for 6 weeks with and without oxygen scavengers are shown in Figure 4. The data are redness values measured during 3 days of retail display after 6 weeks storage in the mother pack. For comparison, data are also shown for steaks from the same muscle that were put on retail display immediately after cutting.

Oxygen scavengers prevented beef striploin steaks from turning brown during storage for up to 6 weeks. With Scavenger (L) Without Scavenger (R)



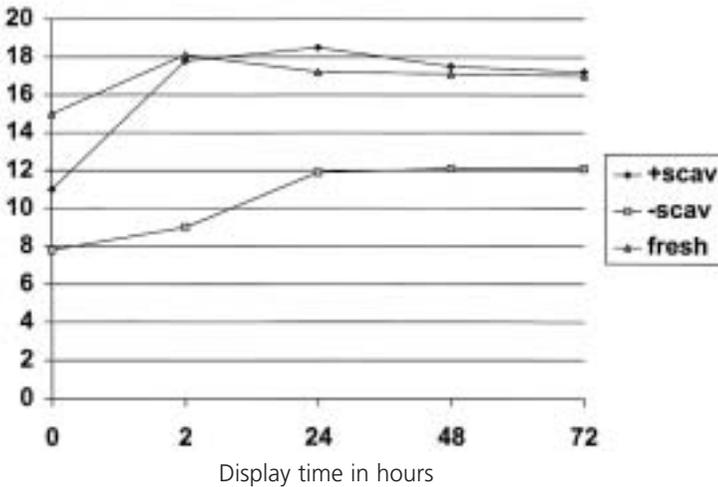


Figure 4. The redness (Hunter a-value) of beef striploin steaks stored for 6 weeks in mother packs with and without oxygen scavengers compared to fresh steaks

The positive effect of the presence of oxygen scavengers on the subsequent colour of steaks is apparent. Within 2 hours of exposure to air, the steaks packed with scavengers were as red as the fresh unpackaged controls and they maintained their red colour for 3 days. On the other hand, the steaks packaged without scavengers failed to develop a good red colour due to the presence of a low concentration of oxygen in the packs during storage. Similar results were obtained after 2 and 4 weeks storage.

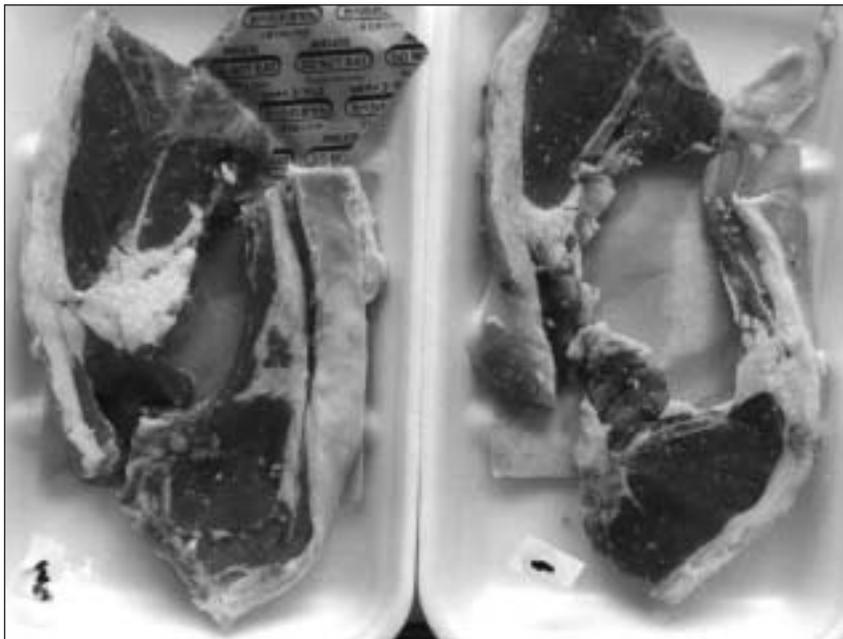
The variability in colour stability between different muscles has already been referred to. Unfortunately, this packaging system does not provide a solution to the problems presented by muscles with poor colour stability. The *psaos major*, which is the fillet steak, is well known to go brown much faster than any other. When fillet steaks were packaged in the mother pack system with oxygen scavengers and subsequently displayed, they failed to reach the redness of striploin steaks and they went brown much faster. However,



comparative data for fresh unpackaged fillet steaks showed that their colour stability was not much affected by the packaging system. Results for other muscles were mixed, indicating that the system needs further development if it is to be suitable for all cuts, which would be commercially desirable.

The next stage in the development of a system that could be commercialised was to find an alternative to having an oxygen scavenger sachet inside each retail pack as it was not thought likely that consumers would accept this. The use of more scavengers in the mother pack with none inside the retail packs was examined but did not work because the oxygen level did not fall fast enough to prevent browning. The next solution was to use a shrinkable bag for the retail trays rather than overwrap film. When sealed this has the appearance of a very good overwrap. By flushing the bag with carbon dioxide before sealing, it was possible to achieve much lower levels of residual oxygen in the retail packs. Good colour stability results were then achieved after storage in the mother pack with a 2000cc capacity scavenger for 6 weeks.

Oxygen scavengers prevented lamb chops from turning brown during storage for up to 4 weeks. With Scavenger (L) Without Scavenger (R)





Results with lamb

Meat colour is also an important factor in the attractiveness of lamb chops to the consumer, although lamb does not develop as bright a red colour as beef and it maintains this colour for a shorter period. Maintenance of good colour during display is therefore an important criterion in the development of packaging systems for retail cuts of lamb.

All the lamb work was done on loin chops, the large muscle of which is the *longissimus dorsi*, the same as in the beef striploin steak. The colour stability results were similar to those found for beef, with chops that had been stored for 4 weeks with oxygen scavengers being as red as fresh chops for 3 days display while those stored without scavengers failed to develop a good red colour (Figure 5). In contrast to beef, however, those chops stored in a 50:50 mixture of carbon dioxide and nitrogen were not as red as those stored in 100% carbon dioxide (data not shown).

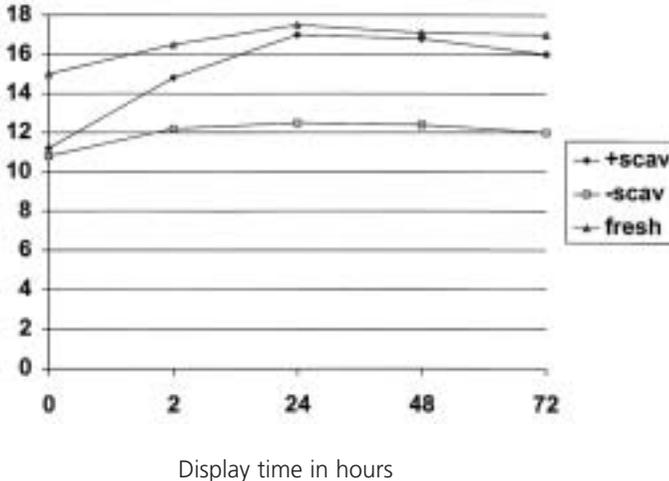


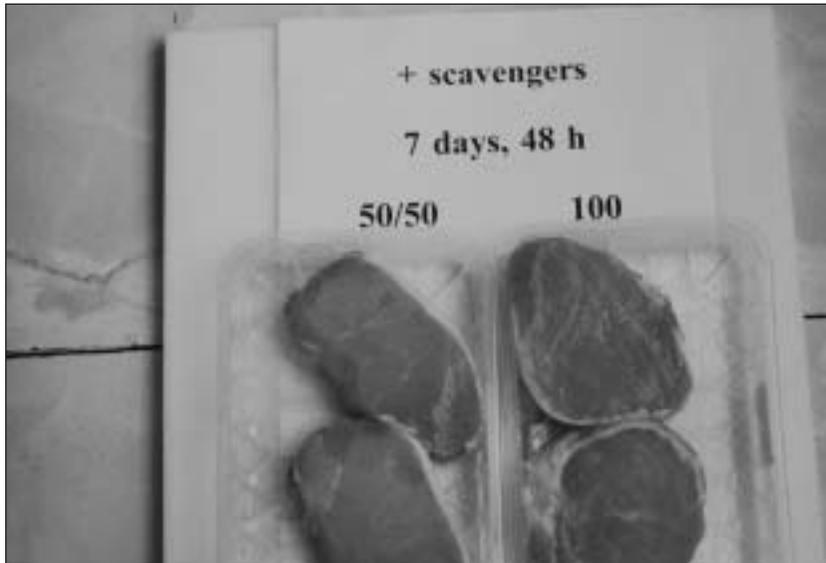
Figure 5. The redness (Hunter a-value) of lamb loin chops stored in mother packs for 4 weeks with and without oxygen scavengers compared to fresh chops



Results with pork

Pork has a much lower pigment content than beef or lamb. Therefore fresh pork has a pinkish rather than a red appearance. Nevertheless, colour is also important in consumer appeal since pork that has been on display too long becomes grey. Pork also spoils more rapidly than beef or lamb so the storage life of packaged pork is expected to be shorter regardless of the type of packaging used. In these experiments packs were stored for no longer than 3 weeks, compared to 6 weeks for beef and 4 weeks for lamb.

*Flushing with ▶
100%CO₂ or
50%CO₂:50%N₂
had little effect on
the appearance of
pork loin chops after
7 days storage.*



Loin chops (*longissimus dorsi*) were used in all experiments. Chops stored for 3 weeks in either 100% carbon dioxide or a 50:50 mix of carbon dioxide and nitrogen were as pink as freshly cut chops for up to 2 days display (Figure 6). There was no apparent advantage in using 100% carbon dioxide over the 50:50 mix.

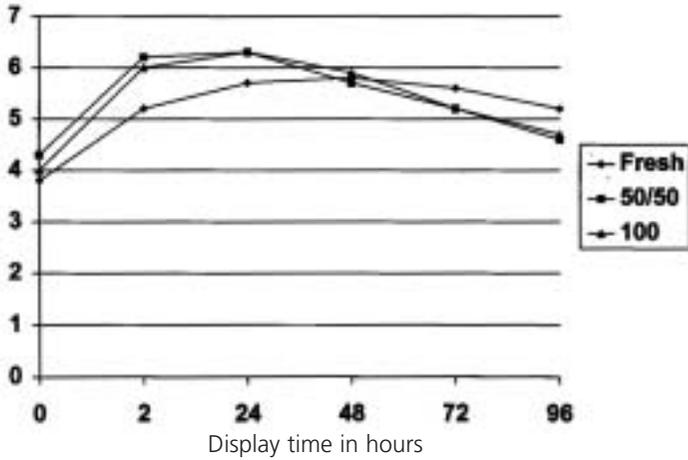


Figure 6 The redness (Hunter a-value) of pork loin chops stored for 3 weeks with oxygen scavengers in 100% CO₂ or 50% CO₂ : 50% N₂ compared to fresh chops.

Table 1 Percentage drip loss of pork loin chops after storage in different atmospheres with oxygen scavengers and 4 days retail display.

Storage time (days)	50%CO ₂ :50N ₂	100%CO ₂
0	4.4	4.4
7	5.7	6.4
14	5.7	7.1
21	6.3	6.5



Compared to beef and lamb, pork is more prone to loss of fluids during display. These collect in retail packs and look unsightly. It is important therefore that any packaging system for pork does not markedly increase drip losses. The results (Table 1) show that total drip losses during storage for up to 3 weeks and display for 4 days were higher than for fresh chops displayed for the same time, but the additional losses, which averaged less than 2%, may be acceptable for the benefit of a 3 week storage period.

Experiments were also done on pork using the shrinkable bags with no scavengers within the retail packs. As with beef, the results indicated that colour stability with this system was equal to using overwrap film and scavengers within the retail packs.

CONCLUSIONS

- Colour is an important criterion in consumer appreciation of meat at the point of sale.
- Meat discolouration associated with low oxygen concentrations is the main technical barrier to the development of bulk packaging systems for retail cuts of meat.
- This results in a loss of added value to the Irish beef industry and in reduced employment opportunities.
- A bulk packaging system for retail cuts of meat has been developed.
- The technical problem associated with meat discolouration was overcome by using oxygen scavengers to absorb the residual oxygen in mother packs and trays.
- Beef striploin steaks stored for 6 weeks in a 50:50 mix of carbon dioxide and nitrogen with oxygen scavengers before placing on retail display were as red as fresh steaks for at least 3 days.
- Lamb loin chops stored for 4 weeks in 100% carbon dioxide with oxygen scavengers were as red as fresh chops for at least 3 days retail display.



- Pork loin chops stored for 3 weeks with oxygen scavengers either in 100% carbon dioxide or a 50:50 mix of carbon dioxide and nitrogen were as pink as fresh chops for at least 2 days of retail display.
- It was possible to achieve the same results without having scavengers within the retail trays by using a shrinkable bag around them which was flushed with carbon dioxide before sealing.
- Before the commercial potential of this packaging system could be realised it must be demonstrated to be effective on a larger scale in a production environment.

PUBLICATIONS FROM THIS PROJECT

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