Seafood Services **Australia Ltd**

SEAFOOD SERVICES
AUSTRALIA

SSA PUBLICATION

TECHNICAL WORKSHOP & DISCUSSION FORUM
CARBON MONOXIDE IN MAP FOR THE RED MEAT & RELATED INDUSTRIES

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Seafood Services Australia Ltd is a company set up by the Fisheries Research and Development Corporation and the Australian Seafood Industry Council

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Seafood Services Australia's mission is to be a catalyst for sustainable development of the Australian seafood industry. The company fulfils its mission by working with stakeholders to provide services that help the industry to continually improve its practices and to add value throughout the seafood supply chain

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Report to Seafood Services Australia

Technical Workshop and Discussion Forum 'Carbon monoxide in MAP for the red meat and related industries´

Held 18 March 2004
Food Science Australia, North Ryde, Sydney, NSW.

Allan Bremner, 26 March 2004

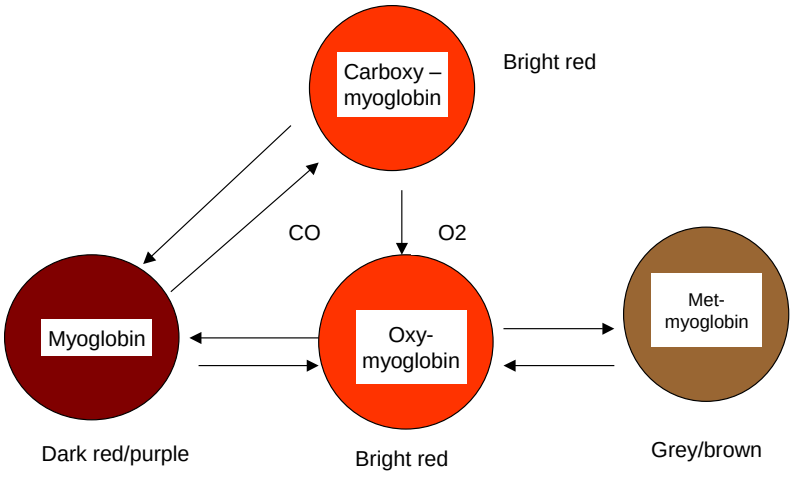

Fig 1 Simplified diagrammatic representation. Coloured states of myoglobin

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Summary

- Packaging in atmospheres containing CO (generally at the level of 0.4%) can maintain the red appearance of products that have high natural contents of myoglobin
- There are two common ways of preparing CO-MAP products by (a) having the gas mixture in each pack, or by b) pre-treating the product with CO then sealing in an outer pack which is then filled with a modified atmosphere gas mix.
- Equipment and materials are available to achieve these two options
- There are other options to the above, but these were not canvassed at the meeting
- Food packaged in CO is inherently as safe as food in MAP or other packages
- Residual levels of CO are low and controlled exposure of product can replace the CO with oxygen
- The regulatory situation with the use of CO is not fully elucidated yet
- There are negligible occupational hazards to workers in the use of pre-mixed gases containing less than 1% CO
- Liquid forms of CO as tasteless smoke are available and are effective, but the regulations may prevent their use
- Supermarkets are moving to case-ready systems for many products
- This information has relevance for the seafood industry as CO may be useful in maintaining the appearance of a range of species in MAP

Recommendations

- FRDC and SSA establish liaison with MLA in regard to use of CO
- SSA maintain a watching brief on developments in the use of CO and acquire working files of equipment and packaging materials
- FRDC and SSA consider the issue of explanatory guidelines on MAP for the industry that includes description of basic mechanisms, the rationale and decision-making processes to justify a need, the capabilities of equipment available, properties of packaging material and the system as a whole
- FRDC and SSA consider holding a workshop, or a seminar series, on MAP and other packaging techniques to discuss the advantages and disadvantages of use, the nature of products that may benefit, the range of equipment and materials available, the market requirements, export, and consumer angles.

Disclaimer

This report is written in narrative form from notes taken during the workshop and forum, from paraphrasing of material provided, and from the general knowledge of the author.

Origin of this report

AFFA invited SSA to attend the workshop and forum on the use of carbon monoxide and MAP (modified atmosphere packaging) in meat and related industries (hereafter called the meeting) (Appendix 1). Because of the potential relevance to the seafood industry and also the continuing interest of the industry in various forms of packaging, SSA considered it important that they be kept aware of the developments to be discussed.
Consequently, I attended the meeting, funded by SSA, to provide a detailed report that covered the content of the meeting and which placed the information into context relevant to SSA, and the SSA Network.

Background

Meat & Livestock Australia (MLA) have funded Food Science Australia to carry out a research project (No. RMIPCK.005) on the use of carbon monoxide (CO) in MAP in meats. Carbon monoxide has the ability to bind with the red pigment (myoglobin) in flesh and the resulting red pigment (carboxymyoglobin) is very stable during chilled storage and the flesh retains the desirable bright cherry red colour and does not go brown during storage.

Although this has been known for more than a century, it's use was patented in 1890, it has rarely been employed for this purpose. The exception has been in Norway where it has been used successfully in packaging of the whole range of fresh meats and meat products for the domestic market for nearly 20 years. This is a long record of utility and safety as about 60% of fresh and processed meats are packed with CO. The levels required in the atmosphere are small, 0.4% by volume. The other gases are mainly carbon dioxide, about 60%, and nitrogen 39.6%; although for some products 5-10% of oxygen may be included according to the processor's own ideas.

Research on the use of CO in meats was done in the USA and Canada in the 1970s but in the 1980s it's use was disallowed (see later discussion under regulatory aspects), but interest and use has been revived in the USA. The use of CO in packaged meats has also been revived in New Zealand and modern packing systems for it's use have been developed. The aim of the MLA project is to re-visit the use of CO for Australian products, particularly it's potential for high quality exports. The project forms part of the Program for Red Meat Innovation that is constructed to support value adding at all stages, including development of new technologies. The project aims are to be achieved through a literature review, the meeting that is the subject of this report, the formal report of the meeting and relevant issues raised such as safety and regulatory aspects. At this stage the decision whether to proceed, or not, will be made before sensory, microbiological and consumer trials are made.

To this end, they have invited as a consultant, to Australia, Dr Oddvin Sørheim from Matforsk in Norway. Matforsk (literally, Food Research) is the Norwegian Food Research Institute situated on the campus of the

Norwegian Agricultural University and a sister institute of Akvaforsk (Marine Research) also on campus. These are premier institutions which I have visited several times, the last being October 2002. Dr Sørheim is an expert in the use of CO in packaged meats and he provided much of the information recorded here.

Issues

Colour of meat is known to be one of the important characteristics in consumer choice. A bright red colour is favoured and is broadly equated in the consumer mind to freshness (albeit, that aged meat is tastier and more tender). The current method used to retain the bright red colour in packaged meats is to have a gas atmosphere of nearly 100% oxygen to keep the red pigment in its oxygenated red form (oxymyoglobin). Oxygen does not inhibit spoilage microbes and no extension of shelf-life or retention of other properties such as flavour or texture is obtained. In fact, oxidation leading to rancidity may be promoted in some instances.

Relevance to packaging of seafood

Most fish flesh is not very red as it has only low levels of myoglobin. The main exception is the tunas, which have reasonable levels of myoglobin and are quite red. Redness is a very, very important criterion for assessing the flesh of tuna that is destined to be eaten raw as sushi and sashimi. It is used as an indicator of both quality and freshness as it too, like meat, can brown with period of storage.

There are other species such as nannygai, snapper, mahi mahi and billfish - like swordfish - in which myoglobin provides the acceptable bright pinkish colour characteristic in the fresh flesh. It is certain that all these species could benefit from packaging in CO.

Note that the desirable colour of salmonids and crustacea is not derived from myoglobin but from carotenoid pigments gained through the feed. These pigments do not react with CO and it confers no likely advantage; but, since the combined atmosphere contains no oxygen (is anoxic), blackening (melanosis) of raw crustacea will be inhibited.

Explanation of Mechanism

Myoglobin changes colour when it reacts with various gases (Figure 1).The native form of myoglobin is red/purple but in fresh flesh, exposed to oxygen, the pigment is in the bright red oxymyoglobin form. When it is packed in vacuo or is in a situation where it is oxygen deficient as occurs during post-mortem storage, the pigment then reverts to the purple myoglobin form. If this is exposed to oxygen it gradually becomes

red again in a process commonly called blooming. However, the myoglobin structure gradually deteriorates during storage and it changes to the less desirable dark brown metmyoglobin structure which cannot take up oxygen to bloom. As the proportion of this metmyoglobin increases, so the flesh becomes darker, browner, loses its sheen and is generally less acceptable.

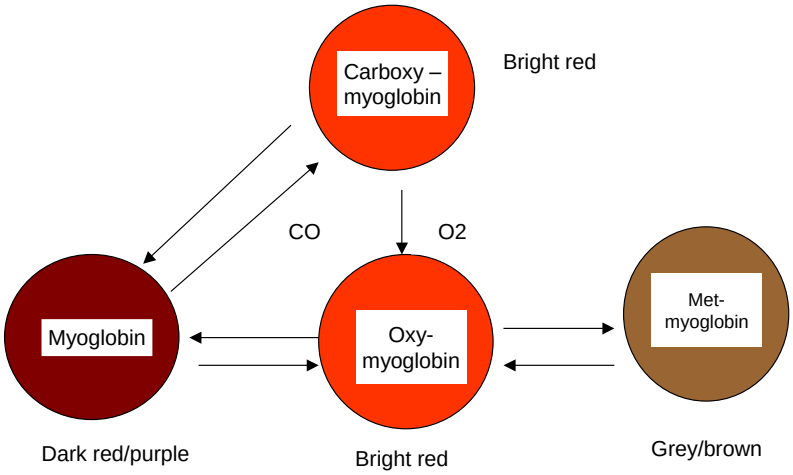

Fig 1 Simplified diagrammatic representation. Coloured states of myoglobin

These processes occur in fish as well as in meat. It is one reason why even fillets of relatively white-fleshed fish lose their appealing bright appearance and why drip liquor often has a brownish tinge.

CO can react with the haem group in the core of the myoglobin and the carboxymyoglobin thus formed is a very stable red colour that is virtually identical in hue to that of oxymyoglobin. In meat flesh the carboxymyoglobin will gradually revert to oxymyoglobin when exposed to oxygen. This occurs because there is an abundance of oxygen in the atmosphere, even though the binding strength of CO is about 1-200 times greater than for oxygen.

This mechanism has been put into use in newer packaging systems in which the meat is only exposed for a short time to CO and only the surface myoglobin has tIme to react. When the pack is opened, either for display, or for use, the surface blooms to the red oxymyoglobin at about the same rate as if it had never been treated by CO. This means that the meat in the pack looks good and red during storage and transport, and all through its display life.

Case-ready systems and retailing

The world-wide trend in developed countries is for shoppers to buy all their food needs in supermarkets. This is true for fish and for meat. For years many supermarkets had butchery departments in which carcasses and primal cuts were sliced down to size and packaged in overwrap film for display and sale. The buffer stocks were the primal cuts and packs were prepared daily and mostly sold that day or the next. The trade is not attracting new apprentices and, more and more, supermarkets rely on deliveries of pre-packed portions. Increasingly, too, these packaged portions come in master cases that only require opening and placement of packs on display. This system is also used in catering in large and small establishments as it provides flexibility in use and potentially a greater range of stock as master cases of mixed cuts are available.

This case-ready system relies on central processing facilities and good distribution chains. It also means that assured, and often extended, shelf-lives are necessary for the range of products. The savings obtained in efficiencies are considerable. This is particularly so for meat, since meat is often wrapped and re-wrapped as it moves through the chain and the wrappings are disposed of at each point. Case-ready operations provide labour savings, prevention of shrinkage (pilfering and spills) and situations of being out-of-stock. This means a restaurant may order, or open, packs of 50 steaks, or of only 6, according to need.

All supermarket chains have not moved entirely in this direction but it is an increasing trend. In the catering trade many part-prepared dishes and semi-cooked meats, e.g., in sauces, are being used in restaurants. This places heavy reliance on safe systems and intact chill chains and the reliability of the distribution chains and the operations of the restaurant and supermarket storage and display units to control temperature. Currently, these are all weak points that need improving.

This means that conditions within the package must be chosen to provide the highest quality shelf-life, consistent with safety, and with circumstance, as is possible. This must be done in a manner that is not only safe and effective but that is affordable. Efficiencies need to be balanced with costs and the costs of the package relative to the price of the product are critical. An additional 50c for packaging on a $25 product is less significant than if it were on a product worth only $5.

These case-ready systems are widely used oversea; Wal-Mart in the USA is an example, but US costs for packaging are lower, due to greater savings in volume, and prices (at least for meat) are dearer. A

typical price for fish fillets in QLD supermarkets is about $27 per Kg.; packs contain 300g, so the cost could be 50c on a $9 package.

The developments in case-ready products have not yet had as widespread an effect on the seafood industry in Australia as on the meat industry: but they will.

Associated matters and trends

With many goods, physical separation into a case-ready state at the point of manufacture and identification for delivery to specific stores is a reality. Generally, the final label is applied at the store.

The problem of traceability should eventually be overcome by the use of RFID tags, but currently there are no universally agreed standards and there are a variety of incompatible tags and readers. Additionally, RFID tags are expensive.

Incompatibility of IT systems between businesses plagues development on a whole range of fronts.

Mention was made of a sleeping OH&S problem in that current cases are 25Kg in weight but OH&S regulations state that 15Kg is the maximum weight that staff should carry.

MAP

MAP is the process of drawing the air from a package by applying vacuum and re-filling the head space with a mixture of other gases. Invariably the main gas in MAP is carbon dioxide (CO2), since it has the properties of being able to inhibit spoilage bacteria and delay the deterioration of the product. Its activity in this action depends entirely on its concentration in the atmosphere, but generally 40% is used (for fish), although lower concentrations are effective with some products. The remainder of the mixture is commonly nitrogen and sometimes, small proportions of oxygen are used.

Meat and fish are comprised of 70-80% water, less if they are extremely fatty, and CO2 can dissolve in water. As a result up to 1.3 times the volume of CO2 can dissolve in the flesh. A sealed package must therefore be overfilled at the start to allow for this absorption. If the pack is based on a tray (many are) the materials of the tray must be rigid to prevent collapse and its edges relatively wide to provide a good seal for the film that comprises the lid.

MAP is gradually being adopted in the case-ready systems. MA packs have some inherent disadvantages of cost and bulk in that transport costs are greater. The individual packs are more difficult to stack on display, and require more trips to the storage room.

Thus two systems of MAP have evolved:-

1. in which the gas mixture is filled in the pack itself, and the materials of the pack are impermeable to gas and the outside atmosphere, and
2. in which the materials of the pack are gas permeable and a number of packs are placed in a master case or carton lined with a gas impermeable film, into which the MA gas mix is introduced to permeate into the product.

The approach using a master pack has some technical and cost advantages; the unit package costs for individual packs are lower; the edges are thinner and they fit together in the outer box more readily; the packs are flat; the packs can be stacked on display when removed from the carton; each pack is filled with product. To the consumer it looks as though they are buying the product, not an hollow pack and so are not paying for fancy packaging material.

In the case-ready systems for flesh foods the individual packs or master packs (according to size) are often stacked in returnable open plastic cases (crates), these may be collapsible. They support the gas-filled master bags in the outer and are a convenient means of carrying product from storage to display. Different individual trays of product may be stored in the outers so that orders can be prepared for one single outlet from the required mix of different products.

Systems and uses

The systems in Norway use the first option in which the gas mixture containing 0.4% CO is added to each individual tray as it is packed. The product is held for a short period (about 24h) to allow the CO to equilibrate through the flesh and to react with the myoglobin.

The system developed by Vertex Pacific, now being used in NZ, is based on the second type where product is treated with CO first then packed in a master carton. The CO concentrations and time of exposure are proprietary information but the vlevels are less than 0.4% CO and the idea is to form a layer of carboxymyoglobin near the surface, not through the depth of the product. This layer provides the required bright red appearance. The system is being developed using suitably modified package machinery (Captec system) normally employed with MAP gas mixtures that do not contain CO. Open cell foam trays that do not require soaker pads are used to improve presentation and decrease mess in the display cabinet and in subsequent sale and use by the consumer.

Figure 2. Tray packs of mince, chops and meat stored chilled ~7 days in master cartons containing with an atmosphere of 40% CO2/ 60% N2. Meat pre-treated with CO are on the left hand side of photo, untreated on right.

Figure 3. On the left: a pack of mince containing an atmosphere of 0.4% CO /40% CO2 / 59.6% N2. On the right: mince packed in 100% O2. Both packs stored chilled ~7 days.

These central systems are part of the flow in a production line and require capital input for facilities and equipment. For small processors, these costs are probably prohibitive but for large processors they may be appropriate, providing they have a very good, fast, temperature-controlled distribution

systems. Equally importantly, they require supplies of fresh fish in good condition.

Safety and consumer reaction in Norway

There is no question that the products are safe. In nearly twenty years production in Norway of millions of packs of meats from several species of animals, in several product forms and cuts, there has been no incidence of safety problems. From the outset, consumers took to the product.
The labelling has a form of words saying ``packaged in a protective atmosphere´´.

Investigations and reviews in USA and Canada and, more recently, by a technical committee of the EU all agree that the use of CO at these very low levels poses no hazard to consumers. The residues are small and, after cooking, beef that has been stored in an atmosphere of 1% CO, has a residue of about 0.1mg/kg. Any rise in CO blood level from eating this amount is undetectable. There is normally less than around 1.5% carboxyhaemoglobin in blood. It is well known that ingested CO is much less well absorbed than if it is breathed. Smokers of tobacco or inhabitants of large cities have intakes greatly in excess of this.

EU regulations

Norway is not a member of the EU but it does come under the rules of the European Economic Area and must comply with their regulations. Application to use CO was made in June 2000 by the Norwegian industry. An EU scientific committee gave it a positive report, but an environment committee of the EU voted 27 to 23 against it. Although it is only used domestically, Norway must cease the use of CO by 1 July 2004. This is estimated to cost $35-80 million USD annually in a country of less than 5 million persons.

Occupational hazards

The gas mix never contains more than 1% CO, but it is invariably never more than 0.4% in the pre-mix supplied by gas companies. In the USA, higher concentrations may be delivered, since it is more economic for large packers to make their own mix. Naturally, this requires greater safety precautions. A concentration of about 2.5% is required for sensitive persons to show signs of intoxication and for most people it is 4%.

Ventilation systems on the packaging line must be adequate and their performance be monitored. The hazards are very low when pre-mixes are used.

Deception

One argument that has been mounted against CO is that is use is deceptive. This is based on the attitude that colour is an indicator of freshness and that

by retaining the colour through the use of CO a well-coloured product may be stale, or even spoilt, or worse still, unsafe.

Usage in Norway has shown that it is safe. The supermarkets must employ the normal due diligence and monitor their displays for product that is out of date. So, at the point of sale it is not deceptive. CO at these low levels does not affect bacteria and spoilt product still smells so. The use of CO does not increase the danger over that for any normal package for a consumer who stores the product at too high a temperature, or for too long a period. Common sense still applies.

Australian attitudes to use of CO

FSANZ was represented by Jim Gruber. He stated that the FSANZ position was that CO was considered as a processing aid; meaning that it would not need declaration as regulations are based on function. But, the CO leaves a residue in the final pack, and in the product even after it is cooked. This residue performs no function in the food and thus would be considered by enforcement authorities as an additive, for which a case must be made.

Unfortunately, no AQUIS or AFFA representative was present, but Jim Gruber mentioned that a meeting had been held in recent weeks to discuss this very topic. He thought the opinion was that process aids should have no function in the final food. For sashimi fish, such as tuna, the CO may retain its function till the point of consumption but no work has yet been published to demonstrate whether this is the case or not.

This situation must be cleared up before any fish processor considers the use of CO, at least for domestic product.

There was general discussion at the meeting, inferring that it may be more likely that CO is used for export products.

It was pointed out that there is not uniformity between FSANZ, US FDA and Codex about just what is a process aid and what is an additive. The use of CO will possibly depend on this resolution.

Recent studies in the USA reported in the 2004 Jan/Feb edition of the Journal of Food Science (Hunt *et al.*, 2004, J Food Sci. 69:45-52) demonstrate quite clearly that the carboxymyoglobin complex will exchange its CO for oxygen to become the normal red oxymyoglobin of fresh meat when exposed to air. By selecting appropriate storage and display conditions CO could be ´gassed off´ at point of sale, there would be no residue and CO could then be considered as a process aid.

Tasteless smoke

Smoke contains a high proportion of CO in the range 15-30% and smoke can be condensed into a liquid form. The taste chemicals and particulate matter

can be extracted from this liquid to result in what is effectively a solution of CO.

This has been used as a means of achieving a CO pre-treatment for tuna meat over a 1-2 day period to convert myoglobin to red carboxymyoglobin. The flesh is then vacuum packed and frozen for sale. The claim is that the tasteless smoke is a processing aid and is different from using CO gas itself. The use of this product seems to be allowed in USA and in the Netherlands, but its use there is being debated in the EU.

Overall implications for SSA and Australian seafood processors

The use of CO cannot really be entertained until the regulatory position is made clearer. This is likely to depend on the proposed nature of the MAP system under consideration.

Many Australian processors are still struggling with the concepts of MAP and how to apply it. For those who do use MAP, the use of CO in their gas mix should not even enter into their considerations at this stage.

The exceptions to this are those processors that deal with, and package, tunas and billfish. Packaging with CO should only be considered once considerable experience with packaging has been gained. The principles of the technology are not complex, but the practice is if the principles are not understood.

Packaging with CO must be considered as a technology for the future when regulatory and technological aspects have been worked out at the Australian level. The results of the MLA project will provide guidance.

Of potentially greater importance for the seafood industry is the move of supermarkets to require products in the case-ready form. This will test the ability of the industry to organise efficient chill-chains and to package product effectively.

Technical situation for seafoods

To the best of my knowledge there have been no reported investigations into the use of CO in this country. Indeed there is very little published work on the use of MAP on Australian species.

There is a case for preliminary investigations to be conducted on the use of CO to demonstrate its use as a process aid, before the seafood industry attempts to explore its application. I suggest that a careful watch is taken over the MLA project to use it as a guide and that liaison with MLA be taken at the highest level of FRDC and SSA to achieve this.