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An Review Article: Modified Atmosphere Packaging of fruits and vegetables: A promising concept

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ABSTRACT

Modified Atmosphere Packaging is an optimal blend of pure oxygen, carbon dioxide and nitrogen within a high barrier or permeable package. A finely adjusted and carefully controlled gas blend is developed to meet the specific respiration needs for each packaged food product. Plastic films, foils and other packaging materials that demonstrate specified gas permeability properties and/or water vapour permeability properties are selected for use. These high barrier substrates become MAP Packages after they are formed into trays, lid stock or bags and filled with a select blend of oxygen, carbon dioxide and nitrogen environmental gasses.

Keywords: MAP, Package, Gas, Co2, O2, N2, Dairy.

1. Introduction

Modified atmosphere packaging (MAP) is a way of extending the shelf life of fresh food products. The technology substitutes the atmospheric air inside a package with a protective gas mix. The gas in the package helps ensure that the product will stay fresh for as long as possible. Modified Atmosphere Packaging is an optimal blend of pure oxygen, carbon dioxide and nitrogen within a high barrier or permeable package. A finely adjusted and carefully controlled gas blend is developed to meet the specific respiration needs for each packaged food product. Plastic films, foils and other packaging materials that demonstrate specified gas permeability properties and/or water vapour permeability properties are selected for use. These high barrier substrates become MAP Packages after they are formed into trays, lid stock or bags and filled with a select blend of oxygen, carbon dioxide and nitrogen environmental gasses. There are excellent publications that describe commercially viable methods of temperature reduction (Thompson *et al*., 1998) for fruits as well as factors influencing transit temperatures (Kasmire *et al*., 1982). Although Crisosto *et al*. (1993) found that 'Bing' cherries were one of the least susceptible to bruising, the Washington industry has always had a challenge in minimizing impact bruising that is manifested by pitting. Bruising and pitting are related to temperature and fruit maturity (Lidster *et al*., 1980; Porritt *et al*., 1971; Wade *et al*., 1980). Crisosto *et al*. (1993) concluded that cherries should be cooled to 32 ºF within 4 to 6 hours after harvest and handled between 50 and 68 ºF to prevent pitting. Washington cherries are hydro cooled twice: upon receipt at the packinghouse to remove field heat, and again as the final step in the sorting process prior to the box filler (Kupferman, 1995; Young, 1994). Patterson (1987) and Hevia *et al*. (1998) describe the consequences of slow heat removal as increased respiration rate (lower sugar levels), moisture loss (shrivel, especially of stems) and an increased risk of decay resulting in shorter shelf life. In some cases cooling does not take place rapidly enough due to design flaws (lack of functioning equipment) or management problems (overloading the system) (Kupferman, 1995). Another tool used to extend postharvest life is modification of the atmosphere in the shipping container or box. Traditionally, up to 30% of the cherries grown in the Pacific Northwest have been marketed in Asia. Ten years ago most fruit was transported by air, which added significant cost to the final product. In addition, transport by air often required the palletized fruit to sit on airport loading areas in non-refrigerated conditions for extended periods of time.

2. Gases Used in MAP

The basic concept of the MAP of fresh foods is he replacement of the air surrounding the food in the package with a mixture of atmospheric gases different in proportion from that of air.

Table 1. Gaseous composition of dry air at sea level (Parry, 1993)

Gas	Percentage
Nitrogen (N2)	78.03

Oxygen (O_2)	20.99
Argon (Ar)	0.94
Carbon dioxide (CO_2)	0.03
Hydrogen (H_2)	0.01

3. Oxygen (O_2)

Food deteriorates due to physical, chemical and microbiological factors. Oxygen is probably the most important gas in this context being used metabolically by both aerobic spoilage microorganisms and plant tissues and taking part in some enzymic reactions in food Including the compounds such as vitamins and flavors. For these reasons, in modified atmosphere packaging, oxygen is either excluded or the levels set as low as possible. The exceptions occur where oxygen is needed for fruit and vegetable respiration, color retention as in the case of red meat or to avoid anaerobic conditions in white fish (Parry, 1993). In MAP, oxygen levels are normally set as low as possible to reduce oxidative deterioration of foods. Oxygen will generally stimulate the growth of aerobic bacteria and can inhibit the growth of strictly anaerobic bacteria, although there is a very wide variation in the sensitivity of anaerobes to oxygen. One of the major functions of O_2 in MAP meats is to maintain myoglobin in its oxygenated form, oxymyoglobin. This is the form responsible for the bright red color, which most consumers associate with fresh red meat (Farber, 1991).

4. Carbon dioxide (CO_2)

Carbon dioxide is both water and lipid soluble and although it is not a bactericide or Fungicide, carbon dioxide has bacteriostatic and fungi static properties. The overall effect on Microorganisms is an extension of the lag phase of growth and a decrease in the growth rate during the logarithmic growth phase. However, the former effect is greater and therefore as Bacteria move from the lag to log phase of growth the inhibitory effects are reduced. Thus, the earlier the product is gas packaged the more effective CO_2 will be (Brody, 1989). This bacteriostatic effect is influenced by the concentration of CO_2, the partial pressure of CO_2, volume of headspace gas, the type of micro organism, the age and load of the initial bacterial population, the microbial growth phase, the growth medium used, the storage temperature, acidity, water activity, and the type of the product being packaged (Church, 1994; Farber, 1991; Phillips, 1996; Church and Parsons, 1995). Yeasts which produce carbon dioxide during growth are stimulated by high levels of carbon dioxide and thus for some products where they are potentially a major cause of spoilage, MAP may not be an advisable option. Also the food-associated pathogens *Clostridium perfringens* and *Clostridium botulinum* are not affected by the presence of carbon dioxide and their growth is encouraged by anaerobic conditions. In general carbon dioxide is most effective in foods where the normal spoilage organisms consist of aerobic, gram-negative psychotropic bacteria (Hotchkiss, J., 1989; Phillips, 1996).

5. Nitrogen (N_2)

Nitrogen is an inert tasteless gas, which displays little or no antimicrobial activity on its own. Because of its low solubility in water and fat, the presence of N_2 in a MAP food can prevent pack collapse that can occur when high concentrations of CO_2 are used. In addition, N_2, by displacing O_2 in the pack, can delay oxidative rancidity and also inhibit the growth of aerobic micro organisms. In foods such as nuts, removing oxygen to <%1 by nitrogen flushing helps prevent oxidative rancidity of fats. Nitrogen can also indirectly influence the micro organisms in perishable foods by retarding the growth of aerobic spoilage organisms (Farber, 1991; Phillips, 1996). The second role of nitrogen in MAP is to act as a filler gas and keeps flexible packages from developing a vacuum.

6. Other Gases

The potential of various other gases such as chlorine, ethylene oxide, nitrogen dioxide, ozone, propylene oxide and sulphur dioxide for modified atmosphere packaging have been investigated experimentally but their commercial use for packaging foods is unlikely to meet with approval from the regulatory authorities.

Gas Mixtures

There are three types of gas mixtures used in modified atmosphere packaging (Goodburn and Halligan, 1988):

1) Inert blanketing (N_2)

2) Semi-reactive blanketing (CO_2/N_2 or $O_2/CO_2/N_2$)

3) Fully-reactive blanketing (CO_2 or CO_2/O_2)

The gas mixtures recommended for a typical range of products are listed in Table 2.

Table 2. Recommended gas mixtures of MAP (Parry, 1993)

Product	% Oxygen	%Carbon dioxide	%Nitrogen
Red meat	60-85	15-40	-
Cooked/cured meats	-	20-35	65-80
Poultry	-	25	75
Fish (white)	30	40	30
Fish (oily)	-	60	40
Salmon	20	60	20
Hard cheese	-	100	-
Soft cheese	-	30	70
Bread	-	60-70	30-40
Non-dairy cakes	-	60	40
Dairy cakes	-	-	100
Pasta (fresh)	-	-	100
Fruits and vegetables	3-5	3-5	85-95
Dried/roasted foods	-	-	100

7. Methods of Creating Modified Atmosphere Conditions

Modified atmospheres can be created either passively by the commodity or intentionally via active packaging (Kader et al, 1989; Zagory and Kader, 1988) Passive modified atmosphere: Modified atmospheres can passively evolve within a hermetically sealed package as a consequence of a commodity's respiration, i.e. O2 consumption and CO2 evolution. If a commodity's respiration characteristics are properly matched to film permeability values, then a beneficial modified atmosphere can be passively created within a package. If a film of correct intermediary permeability is chosen, then a desirable equilibrium modified atmosphere is established when the rates of O2 and CO2 transmission through the package equal a product's respiration rate. Active packaging: By pulling a slight vacuum and replacing the package atmosphere with a desired mixture of CO2, O2 and N2, a beneficial equilibrium atmosphere may be established more quickly than a passively generated equilibrium atmosphere.

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