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Agriculture Intensive dans les Iles de la Caraibe : enjeux, contraintes et perspectives

Intensive Agriculture in the Caribbean Islands : stakes, constraints and prospects

Agricultura Intensiva en la Islas del Caribe : posturas, coacciones y perspectivas

TRENDS IN POST HARVEST PROCESSING

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ABSTRACT

Loss in quality and quantity are of great concern in the marketing of fresh fruits and vegetables. Losses, due to post harvest deterioration of fresh produce affect over 40% of the harvested produce in the world. Some methods to reduce losses include various food processing and preservation techniques such as through application of heat, dehydration, cold storage and freezing as well as chemical preservation or low dose irradiation. However, many of these methods are energy intensive and often change sensory and nutritive qualities, mainly because of rather drastic application of heat, cold or acidity to the fruits and vegetables

Current consumer trend is towards fresh, natural, preservative free, minimally processed shelf-stable and yet, convenience foods. This trend has spurred the development of many innovative processing and preservation techniques. Foremost among these are retortable pouches, aseptic packaging, controlled atmosphere storage and vacuum and modified atmosphere packaging. The last one being most extensively studied at the present time. The modified atmosphere packaging (MAP) involves the packaging of perishable products in high gas-barrier packages, in which the gaseous environment has been changed. In a modified environment the product' s natural flavor, color and texture are retained because enzymatic and biochemical degradation are greatly reduced. The effect of temperature combined with modified atmosphere packaging of fruits and vegetables and the product-package compatibility requirements for successful use of this technology is also discussed.

INTRODUCTION

The impact of horticultural and technological improvements have not been fully realized for many fruits and vegetable at the wholesale, retail and consumer levels because of product spoilage and deterioration during distribution. The situation can best be characterized by the fact that about 40% of the produce harvested is not consumed because of spoilage (Salunkhe and Wu, 1974). Longer transit times, higher energy costs, and dramatically increased volumes of food products have forced new developments and improvements in refrigeration technology and food preservation. One of such improvements is supplementing or aiding refrigeration with modification of normal composition of air in contact with food, resulting in a modified atmosphere . This is done to retard the metabolic processes of stored product by lowering the temperature and reducing the amount of O_2 and increasing CO_2 content of storage atmosphere (Fi g .1) .

Controlled/modified atmosphere (CA/MA) has emerged as one of today' s most significant food preservation technologies. It has been ranked fifth in order of importance in top ten most important innovations in food industry in last 50 years (Ooraikul and Stiles, 1990). Today only a fraction of that potential has been realized. Hence, there is tremendous interest in the use of CAP to extend the shelf life of fresh produce. The technology has, however, not kept pace with the needs of diverse food industry. The reason for this lag is that designing packaging system to accommodate the various classes of fresh produce is a difficult task (Marston, 1989). The system needs to be designed to maximize the shelf life, retaining the quality and freshness of produce. This paper dicusses technical concepts, research advances and recent trends in modified atmosphere packaging of fruits and vegetables.

TECHNICAL CONCEPTS

CA storage is known to reduce respiration and the action and production of ethylene, with resultant delays in the ripening and/or senescence processes. Modified atmosphere packaging offer similar responses, with major difference being that the atmospheres can be created or atleast maintained by the interaction of commodity respiration with the permeation of respiratory gases through packaging films (Prince, 1989). MA can be used both to extend shelf life (Wolfe, 1980) and to maintain high quality (Fig 2). Misuse of CA/MA is, however, both easy and dangerous since even closely related fruits or vegetables, and even different varieties of the same fruits, have specific and so far unpredictable tolerances for low O_2 and/or high CO_2 concentration.

MA packages are dynamic systems where respiration and permeation occur simultaneously. Factors affecting both respiration and permeation rate must be considered when designing a package. Commodity mass, stage of maturity, temperature, O_2 and CO_2 partial pressures, ethylene levels, and light are known to influence net product respiration in a package. Packaging film type, thickness and surface area of films, as well as temperature, relative humidity, and partial pressures (CO_2 and O_2) across the film, are known determinants of permeation. All of the above factors interact to create equilibrium levels of CO_2 and O_2 in a sealed package. The package equilibrium is defined as the point when the commodity CO_2 production and O_2 consumption rates are equal to the permeation rates of the respective gases through a package at a given temperature. A poorly designed package will become anaerobic or develop unacceptable levels of CO_2 before equilibrium is obtained. The ideal package system will equilibrate at the levels of CO_2 and O_2 that are known to be optimal for enhancement of storage potential of a specific species or v ariety (Prince, 1989) .

MAP of fruits and vegetables require materials with a series of gas barrier properties in the medium to low range. This is becoming possible through the availability of suitable conventional and novel materials, and through novel treatment of films. The gas permeability of properties of a selection of commercially available packaging films are presented in Table I (O'Beirne, 1990). In developing an MA package, the objective is to match the respiration rate of the commodity to the gas permeability of the packaging. Work on MAP of fresh potato strips illustrated this point (O'Beirne and Ballantyne, 1987). Matching the gas exchange requirements of products with the highest respiration rates (asparagus, broccoli, mushroom, shredded vegetables) presents great challenge. A wide range of packaging materials is used for packaging products with varying respiration rates. Considerations such as attractlveness of the film, ease of machine handling and sealabilty are also considered (O'Beirne, 1990).

As the data in Table 1 indicate, much of the information available on gas permeability is not based on measurements at chill temperatures. However, this type of data is now being generated (Zagory and Kadar, 1988). As a result, the gas permeability data available to date are useful as an overall guide, but are not always sufficiently precise to be used in predictive mathematical modeling of MA system.

RESPONSE OF FRUITS AND VEGETABLES TO MODIFIED ATMOSPHERES

In MAP of fruits and vegetable the reduced O_2 and elevated CO_2 levels can be beneficial as they significantly reduce the respiration rate (Table 2). Beneficial respiratory responses of fruits and vegetables to lowering the O_2 levels do not take place until the level reaches about 12% or less [Kadar *et al.* 1989]. For apples and broccoli, the respiration rates are reduced by about one-half when the O_2 levels are dropped to about 4 to 5% [Zagory and Kadar,1988]. When whole fruits and vegetables are sliced, the respiration rate increases and the heat production rises [Rosen and Kadar 1989]. The respiration rates of some of the representative fruits and vegetables at different temperatures and in different environments have been reported by Kadar *et. al.* [1989] .

The relative tolerance limits of the fruits and vegetables to reduced O_2 and elevated CO_2 levels in MA have been studied by Kadar and Morris [1977]. When O_2 level drops below the O_2 tolerance value for a commodity, specific physiological injuries and quality deterioration may occur. They further pointed out that the tolerance limits can vary with the type of commodity, cultivar, storage temperature, physiological age, storage time and added supplemental gases. Low temperature as an adjunct to MA is essential but is not always beneficial for vegetables. It has been found that lettuce stored at 0°C under MA attained brown stain whereas at a storage temperature of 10°C, no brown stain was evident (Brecht, 1980).

When fruits and vegetables are exposed to micro atmospheres with levels less than 8% 0_2, the ethylene production decreases and the sensitivity of commodities to ethylene is reduced. At an 0_2 level of 2.5%, ethylene production was reduced to one-half the rate in comparison with air.

Quality attributes such as taste, odor, color and texture which are dependent on the chemical composition and structural features of fruits and vegetables may be retained by low 0_2 and high CO_2 micro atmospheres in MAP. Off-flavors in fruits and vegetables can be produced by subjecting them to low 0_2 (lower than the critical level of 2%) and high levels of CO_2 (15% and above). When broccoli is held under MA at 0.5% or less 0_2 and more than 15% CO_2, a mercaptan/H2S odor is evident in a few days at 5°C. The degradation of pigments in commodities have been reported to be reduced considerably by MA [Isenberg, 1979] .

In a recent study, Everson *et. al* . [1992] studied the effects of modified atmospheres on textural and cell wall changes of asparagus. Gariepy *et. al.* [1991] studied the effect of precooling and modified atmosphere storage of green asparagus and concluded that precooling the asparagus prior to storage reduced losses by 20% and the MA stored asparagus had better color, fresher appearance, firmer texture and lower mass loss (<12%) than that stored for same period under normal atmosphere with 80% RH (mass loss of 60%) or with >95% RH (mass loss of 41%).

Some simulation studies were conducted and mathematical models have been developed on post harvest changes in fruits and vegetable. Labuza *et. al.* [1972] developed model for optimization of flexible film packaging of foods for storage. Henig and Gilbert [1975] developed computer-aided solution to the mathematical equations representing the changes in respiratory gas concentrations within tomato packages. Mannapperuma *et. al.* [1991] developed a mathematical model based on simultaneous gas diffusion and chemical reaction to represent the gas exchange in foods stored in modified atmospheres. The respiration process was developed as first order chemical reaction and gas transfer process was modeled as ordinary diffusion. Emond *et. al.* [1991] conducted laboratory experiments to determine gas exchanges through perforation. They also developed empirical equations to predict the effective permeabilities to CO_2 and O_2 for different values of diameter, thickness and temperatures. A computer program was developed to simulate gas exchange for three kinds of package covering. Simulation results provided answers to the appropriate package for storage of broccoli and strawberries under modified atmosphere. Lee [1987 l developed a theoretical method to design a package to maintain a desired concentration of O_2 and CO_2 inside a single consumer package of fresh produce.

RESEARCH TRENDS

The potential of this useful food preservation technique for several fresh produce remains untapped. However, recently MAP is being used to an increasing extent during transport of several fruits including strawberries, tomatoes, sweet cherries, and bananas. A detailed review reveals that significant quantum of fundamental knowledge has been published on the technique of modifying the atmosphere to enhance the shelf-life of perishables during storage. However, limited studies appear to have been attempted to fully understand the mechanism of gas diffusion in the packaged product. Additional information is needed on the resistance of fruits and vegetables to diffusion of O_2, CO_2 and C_2H_4 under different atmospheric and temperature conditions. Changes in Respiration Quotient (RQ) in response to changing atmospheres could have great influence in atmospheres inside packages. Studies on product texture need to be conducted as well.

Most data on packaging film permeability are generated at single temperature and often at very low relative humidity. The responses of film permeability to temperatures between 0 and 20°C to relative humidities between 85% and 95% must be determined. If possible, irradiation may be combined with MAP as indicated in some studies [Langerak,1972]. Radiation and MAP of strawberries extended the shelf life by 50-100%. Another important point to consider before MAP can be applied commercially is whether or not these system can be economically j ustified .

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Table 1: Manufacturer's specifications for gas permeability in a range of flexible films (O'Beirne, 1990)

Film	Thickness (μm)	Gas permeability (ml /m ^{2}/days/atm)' 0_2	$C0_2$
PVC (plasticised)	14-18	15-20 000	80-120 000
EVA	10	32 500	134 000
	25	13 000	53 000
LDPE	50	3 000	10 000
	35	4 300	14 000
	25	6 000	20 000
Polystyrene	50	3-4 000	13 000
Oriented polypropylen	15	2 600	7 500
Cellulose acetate	40	1500-3000	15 000

Table 2: Respiration percentage at different level's of 0_2 and $C0_2$ in apples stored at 3.3°c (Gorini, et. al. 1990)

02 (%)	C02 (%)	Respiration (%)
21	0	100
10	0	80
10	5	56
7	0	58
7	5	50
5	0	63-70
5	5	38
3	0	49
3	2	47
3	5	43
1-5	0	39
1-5	5	25

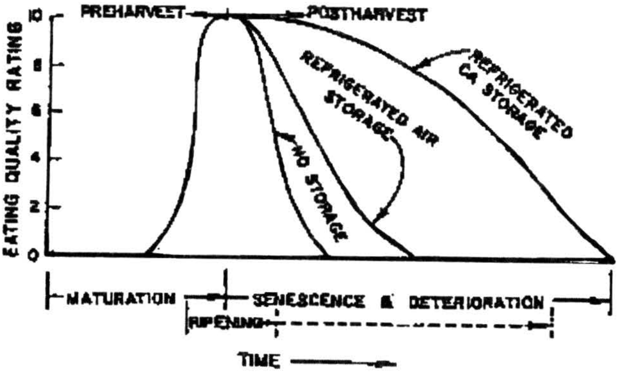

Fig. 1 Influence of various postharvest systems on the eating quality of horticultural produce (Bartsch, 1980)

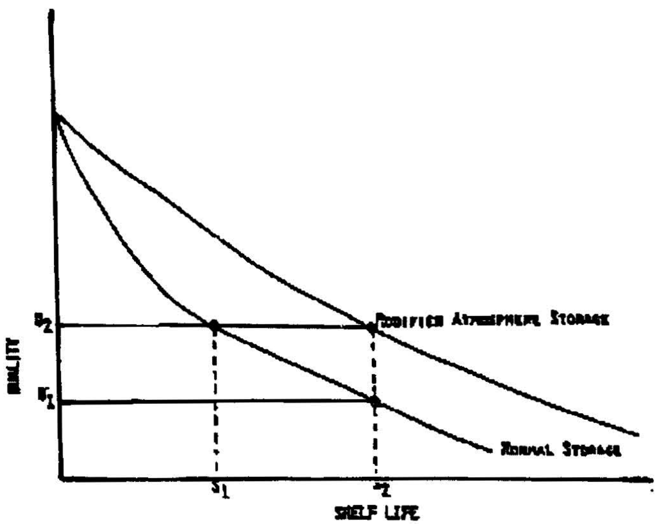

Fig. 2 Trade-off options between quality and shelf-life with and without MAP (Wolfe, 1980)