EVALUATION OF ACTIVE AND PASSIVE SYSTEMS OF MODIFIED ATMOSPHERE FOR PRESERVATION OF MINIMALLY PROCESSED COLLARD GREEN (*BRASSICA OLERACEAE,* VAR. *ACEPHALA*)

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ABSTRACT

EVALUATION OF ACTIVE AND PASSIVE SYSTEMS OF MODIFIED ATMOSPHERE FOR PRESERVATION OF MINIMALLY PROCESSED COLLARD GREEN (*BRASSICA OLERACEAE,* VAR. *ACEPHALA*)

Different systems of atmosphere modification were evaluated for preservation of minimally processed collard green. Vitamin C content of the produce and O_2 and CO_2 concentration in the package were determined during storage in low density polyethylene (LDPE) film of 30 or 60 mm with active or passive atmosphere modification or in 30 or 60 mm films, with or without perforations and with actively modified atmosphere. None of the systems provided adequate atmosphere modification due to low gas permeability of the films. The resulting anaerobic atmosphere inside the packages led to physiological disturbances and rapid loss of vitamin C content. Although perforations prevented anaerobiosis, the gas concentrations in the package remained unsatisfactory.

Key words: Collard green; *Brassica oleraceae,* var. *acephala;*fresh-cut; modified atmosphere; packages

RESUMO

AVALIAÇÃO DE SISTEMAS DE ATMOSFERA MODIFICADA PASSIVA E ATIVA PARA A CONSERVAÇÃO DE COUVE MINIMAMENTE PROCESSADA (*OLERACEAE DO BRASSICA,* VAR. *ACEPHALA*

Foram avaliados diferentes sistemas de modificação da atmosfera, para a conservação da couve minimamente processada. O teor de vitamina C do produto e, a concentração de O_2 e CO_2 na embalagem, foram determinados durante o armazenamento em um filme do polietileno de baixa densidade (PEBD) de 30 ou de 60 mm com modificação ativa ou passiva da atmosfera ou em filmes de 30 ou em 60 mm, com ou sem perfurações e com atmosfera ativamente modificada. Nenhum dos sistemas forneceu modificação adequada da atmosfera devido à baixa permeabilidade ao gás do filme plástico. A condição de uma atmosfera anaeróbica dentro das embalagens resultou em distúrbios fisiológicos e perda rápida do teor da vitamina C. Embora as perfurações impedissem a anaerobiose, as concentrações do gás na embalagem permaneceram insatisfatórias.

Palavras chave: couve var. *Brassica oleraceae*, minimamente processado, atmosfera modificada, embalagens.

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INTRODUCTION

Ready to use minimally processed produces are gaining market success due to aggregated value. The major factors responsible for keeping quality of minimally processed product include low temperature storage and use of a modified atmosphere, which maintain the sanity, freshness and the sensorial characteristics of the produce (Zagory, 1999a).

Modified of atmosphere is attained by interactions that have influence factors that influence package permeability and product respiration to reach an equilibrium optimum for the preservation product (Day, 1993). This equilibrium is attained when the respiration consumes the same amount of O_2 that enters the system and the CO_2 production equals the amount that leaves the package (Day, 1993, Zagory, 1995).

Modified atmosphere has the benefit of retaining the color and the freshness of the produce, reducing sugar degradation, retarding maturation and reducing production and effects of ethylene (Day, 1993, Kader *et al*., 1992, Zagory, 1999b). The negative effects, especially when anaerobiosis is reached, include texture change, exhalation of foul odors and physiological disturbances (Kader *et al*., 1992, Kader, 1993).

This study was performed to evaluate different combinations of packages and atmosphere on O_2 and CO_2 concentration at equilibrium and to evaluate its influence on vitamin C and on the total soluble solid content of minimally processed (MP) collard green.

MATERIALS AND METHODS

The Raw Material

Collard green plants from a cultivar popularly known as "mineira" were propagated by appropriate technique and cultivated at Universidade Federal de Viçosa campus. The leaves were harvested when they reached a length of about 35 to 40 cm (Medina, 1991). The harvested leaves were immediately transported to the laboratory, placed in trays with the petiole immersed in water and stored in a cold room (7 ±1 °C) until processing (8 to 14 h) (Carnelossi, 2000).

Minimal Processing

The leaves were sorted and standardized by size, color and integrity, and after petiole removal they were immersed for 10 minutes in chlorinated water (150 mg.L^{-1} active chlorine) at 5 °C (Medina, 1991) and then cut into 1.5 ± 0,5 mm thick slices with an industrial vegetable processor (Robotcoupe®), equipped with a rotating knife adjusted to 1 mm thickness. Sliced leaves were rinsed for 10 minutes in chlorinated water (5 mg.L^{-1} active chlorine) at 5 °C and then centrifuged for 10 minute at about 800 x *g* (Carnelossi, 2000).

Packaging and Storage

The characteristics of the film used for packing are shown in Table 2. Portions of 100 g of MP collard green were distributed in six different combinations of packaging and atmosphere (Table 1) using low density polyethylene (LDPE) film of 30 or 65 mm, with passively or actively (10% O_2 / 5% CO_2) modified atmosphere, without or with eight pin holes providing 0,055 cm^2 of total perforated area. To provide actively modified atmosphere, a gas mixture (10% O_2 / 5% CO_2) was injected, after partial vacuuming, in the packages through a sealant (Selovac). The packages of the passively modified atmosphere treatments were treated similarly, using synthetic air (20% O_2, 0% CO_2 and 79% N_2). All

Table 1. Modified atmosphere treatments used for preservation of minimally processed collard green.

Packaging	Thickness (µm)	Number of holes	Atmosphere	Gas (%)
LDPE[a]	30	__	Passive	Synthetic air[c]
LDPE	65	__	Passive	Synthetic air[c]
LDPE	30	__	Active	10% O_2 / 5% CO_2 [b]
LDPE	65	__	Active	10% O_2 / 5% CO_2 [b]
LDPE	30	8	Passive	Synthetic air[c]
LDPE	65	8	Passive	Synthetic air[c]

[a] Plastic bags of low density polyethylene
[b] Balanced with N_2 gas
[c] (20 % O_2, 0 % CO_2, 79 % NO_2)

Table 2. Gas permeability rates of the packing films

Packaging material	Thickness (µm)	Dimensions (cm)	Permeability rate at 25 °C and 1 atm. (cm³(STP)/m² /day)	
			O_2	CO_2
LDPE	30	18 x 25	7,147	21,849
LDPE	65	18 x 25	3,013	11,985

the packages were stored at 5 ºC in a vertical showcase equipped with forced ventilation.

Gas Concentration in the packages

The concentrations of O_2 and CO_2 in the free space of the packages were determined at 0, 1, 2, 3, 4, 7, 9, 12 and 14 days after storage. The gas was sampled by introducing a hypodermic syringe needle through a silicone septum affixed on the package.

Concentration of O_2 at was determined using 5 ml samples and analyzed with the help of an O_2 analyzer (MOCON®, HS 750). Carbon dioxide concentration was determined using 1 ml samples, and a gas chromatograph Shimadzu® (GC-14 B), equipped with Porapak-Q column of 1 m length and a thermal conductivity detector. Electric current was set at 85 mA, and temperatures were set at 60, 100 and 140 ºC for column, injector and detector, respectively.

Vitamin C Content

The vitamin C content was determined at 0, 7 and 14 days after storage according to Carnelossi (2000). Leaf samples (10 g) was macerated in a mortar and pestle containing liquid nitrogen, and the macerate was suspended in an extracting solution containing metaphosphoric acid $(HPO_3)_n$ and glacial acetic and then titrated with 2, 6 diclorofenolindofenol.

Total soluble solids

The total soluble solids (°Brix) were determined at 0, 7 and 14 days after storage with a table refrectrometer (Abbé), using 1 ml manually pressed leaf cellular juice

Experimental Design

The experiment was perfomed in a completely randomized design with subplots in time and in three replications. All the evaluations at time zero were carried out immediately after processing.

RESULTS AND DISCUSSION

Effect of active or passive atmosphere modification systesm on O_2 and CO_2 concentrations in the free space of the package

In all the passive systems of atmosphere modification, O_2 concentrations reached very low values due to low gas permeability of the films (Figure 1). The trend was same in packages of all the three thicknesses tested. Concentration of O_2 decreased rapidly, reaching less then 0.4% on the fourth day, with little fluctuation thereafter, but always remained below 0.8%.

The concentration of CO_2 increased rapidly, reaching 9,3% on the second day in the package 30 mm (Figure 1), with a slight decrease thereafter. In the packages of 65 mm CO_2 concentration reached extremely high levels, attaining 14% on the second day and remaining in this range until he seventh day, when it began to decrease. In this package the produce showed an advanced stage of senescence, which could have been caused by low O_2 and very high CO_2. The O_2 permeability of LDPE films of the three thicknesses did not allow adequate gas permeation to meet the elevated respiratory demand of the produce (Carnelossi, 2000).

The gas accumulation behavior was similar in the

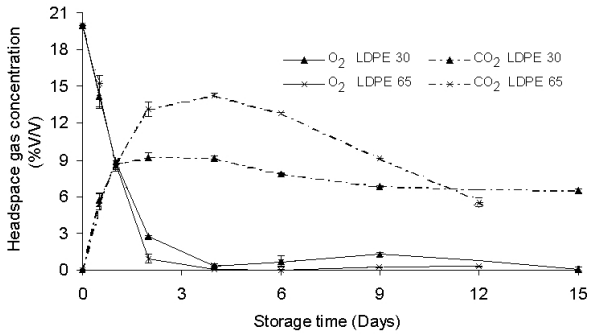

Figure 1. Concentration of O_2 and CO_2 in packages of low density polyethylene of (LDPE) of 30 or 65 mm thickness, containing minimally processed collard green stored at 5 ºC with passive atmosphere modification. Vertical bars represent the standard error

active or passive atmosphere modification systems of 30 and 65 mm packages (Figure 2). According to Zagory (1995), independent of the modification system, gas concentrations will be equal at the state of equilibrium.

When these films were used for MP collard green preservation, there was exhalation of foul odors, loss of texture, and exudation of intracellular liquid. These sensorial alterations may have been caused by low O_2 and high CO_2 concentrations (Figure 2), which induce physiological alterations, such as fermentation and production of sulfurous compounds. Kaji *et al.* (1993) observed that MP cabbage, when stored at 5 ºC under modified atmosphere ,produced sulfurous compounds if exposed to 1.6% O_2/9.1% CO_2 and also exhaled foul odors after four-day storage.