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Effect of Modified Atmosphere Packaging on the Kinetics of Vitamin C Degradation in Mangos

Efeito da Embalagem de Atmosfera Modificada na Cinética de Degradação de Vitamina C em Mangas

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SUMMARY

The kinetics of vitamin C degradation was determined in mangos cv. Keitt, individually sealed in low-density polyethylene films and in a heat-shrinkable copolymer (Cryovac® D-955) film using non-sealed mangos as the control. Samples were stored for up to 5 weeks at 12°C, 17°C and 22°C. The use of modified atmosphere packaging reduced the rate constant of degradation at all temperatures studied. A first order kinetics model was observed for vitamin C degradation. Vitamin C content of individually packaged mangos was less affected by storage temperature than the control. Values for Q_{10} were 1.3 and 1.0 for mangos wrapped with the heat-shrinkable copolymer and the low density polyethylene films, respectively, and 2.8 for the control.

RESUMO

Foi determinada a cinética de degradação de vitamina C em mangas cv. Keitt, embaladas individualmente, em filme de polietileno de baixa densidade e em um copolímero termoencolhível, e em mangas não embaladas (controle). As amostras foram armazenadas por 5 semanas a 12°C, 17°C e 22°C. O emprego da embalagem de atmosfera modificada reduziu a taxa de degradação em todas as temperaturas estudadas. A degradação de vitamina C seguiu uma cinética de primeira ordem. Os teores de vitamina C das mangas embaladas foram menos afetados pela temperatura de armazenagem que o controle. O valores de Q_{10} foram iguais a 1,3 e 1,0 para as mangas embaladas com o copolímero termoencolhível e com o filme de polietileno de baixa densidade, respectivamente, e 2,8 para o controle.

PALAVRAS-CHAVE
KEY WORDS

Vitamina C; Manga; Atmosfera modificada; Cinética de degradação / Vitamin C; Mango; MAP; Kinetics of degradation.

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1. INTRODUCTION

The nutritional importance of fruits and vegetables is assigned to their vitamin and mineral contents. Mangos are considered to be a relevant source of vitamin C and pro-vitamin A but are one of the most perishable fruits during long-term storage because of decay and shrivelling due to moisture loss (HULME, 1971). Vitamin C is highly susceptible to the common processing and storage conditions and can be used as an indicator of general quality changes.

According to BEN-YEHOSHUA (1985), individual wrapping in plastic films may extend the shelf life by reducing shrinkage, weight loss and the occurrence of various blemishes.

The stability of vitamin C has been established for some tropical fruits stored under modified atmosphere packaging, like kinnow (LAL-KAUSHAL, THAKUR, 1996) and ciku (MOHAMED *et al.*, 1996) but for mangos there are no available reports in the literature.

The objective of this work was to determine the effect of modified atmosphere packaging on the kinetics of vitamin C degradation in mangos cv. Keitt. Fruits were individually sealed in low-density polyethylene films and in a heat-shrinkable copolymer film and compared with non-sealed mangos, used as the control. Samples were stored for up to 5 weeks at 12°C, 17°C and 22°C.

2. MATERIAL E METHODS

One hundred and fifty mangos cv. Keitt, harvested at physiological maturity (pre-climateric, hard green stage), from commercial orchards in Uberlândia, MG, Brazil, were sorted for size (397 ± 44g) and physiological damage. They were dipped in a cold solution of Benomyl at 100 ppm to reduce postharvest storage rots.

Fifty fruits were individually sealed in a heat-shrinkable film, Cryovac® D-955 (Grace Prod. Químicos e Plásticos Ltda.), using a manual sealer. The film was shrunk using a Weldotron heat tunnel model 7121 LG at about 140°C for 6-8 s. Another fifty mangos were individually sealed in a low-density polyethylene film (LDPE) using a Selovac machine model CV 60 at 27 inch Hg vacuum pressure. The last fifty fruits were stored without a film as control. Physical characteristics of the films are in Table 1.

TABLE 1. Physical characteristics of films.

	D-955	LDPE
Density (g/cm^3)	0.92	0.92
Thickness (μm)	15.0	24.5
O_2 transmission rate * (cm^3/m^2/24 h)	9,870	7,081
CO_2 transmission rate * (cm^3/m^2/24 h)	39,021	23,749

*25°C - 0% RH - 1 atm partial pressure of O_2 or CO_2

After sealing, the mangos were weighed, codified and 17 fruits of each treatment placed in storage chambers at 12°C ± 1°C (75-85% RH), 17°C ± 1°C (70-80% RH) and 22°C ± 2°C (65-75% RH).

At weekly intervals for 35 days or until considered improper for consumption, two mangos from each treatment were picked at random. Samples were analyzed to determine vitamin C content using the indophenol-titration method (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, 1990) modified by BENASSI, ANTUNES (1988). Vitamin C retention was plotted against storage time. Data were subject to the Statistical Analysis System (SAS INSTITUTE INC., 1985) to determine the kinetics of vitamin C degradation as a function of packaging and temperature. Q_{10} and activation energy were calculated, using the Arrhenius equation to verify the influence of the storage temperature for each treatment (LABUZA, 1982).

3. RESULTS AND DISCUSSION

The original ascorbic acid content was 43.9 ± 6.6 mg/100g, confirming mango cv. Keitt as a good source of this nutrient. The relative concentrations of vitamin C indicated a general fall during storage. At the end of the storage time, vitamin C retention was around 50% for mangos stored at 12°C and 17°C, for all treatments. At 22°C, the retention was about 60% for the packaged fruits and 35% for the controls (Figure 1).

The ascorbic acid retention curves for all treatments showed a similar behavior, and can be modelled by first order degradation kinetics (Figure 1). For a wide number of vegetable products the literature reports that this reaction appears to follow first order kinetics, independent of the pathway followed for vitamin C degradation (VILLOTA, HAWKES, 1992).

To determine the rate constant for vitamin C degradation and the order of the kinetics, the following equation was employed: $dC/dt = -k.C^n$, where "C" was the vitamin C content, "t" the storage time in days, "k" the rate constant for vitamin C degradation reaction and "n" the order of the kinetics. The results are listed in Table 2. All coefficients of determination were higher then 0.70 and the confidence levels lower then 0.05.

Mangos sealed in LDPE and stored at 12°C showed the lowest vitamin C degradation rate ($1.95x10^{-2}$/day) and the control at 22°C presented the highest value ($6.39x10^{-2}$/day) (Table 2). This behavior indicates a reduction in the metabolism of the wrapped fruits caused by the modified atmosphere, since plastic films act as a barrier to gas exchange.

No reports for mangos were found, but for several vegetables and fruits, observed values for the rate constant of vitamin C degradation of from 10^{-5} to 10^{-2} day^{-1} have been reported, and activation energies from 3,000 to 40,000 (kcal/kg mol) (THOMPSON, 1982, VILLOTA, HAWKES, 1992).

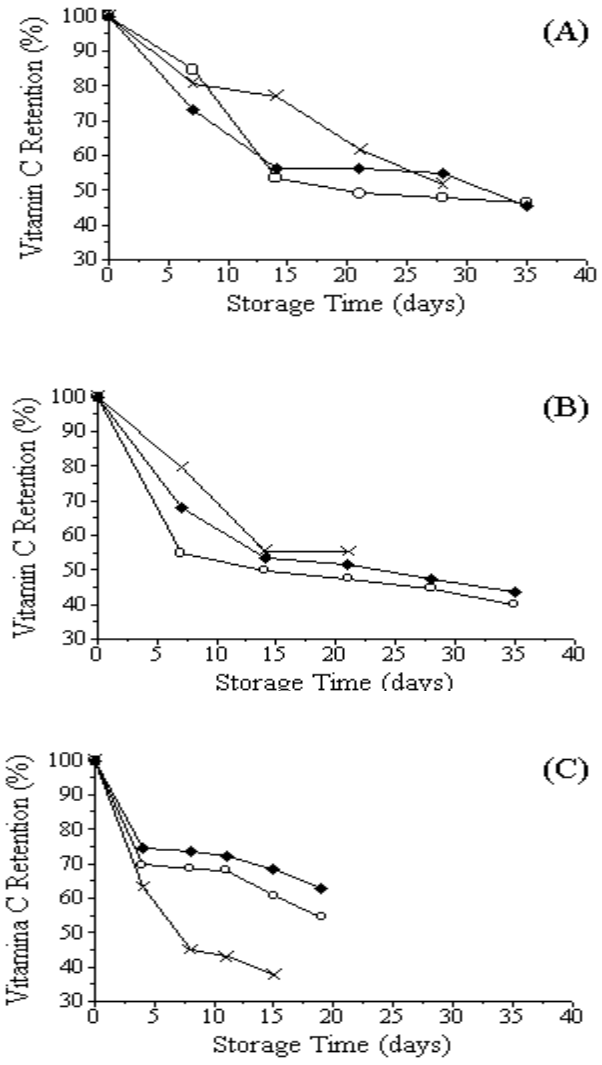

FIGURE 1. Vitamin C retention in mangos cv. Keitt, sealed in LDPE (◆) and D-955 (❍) and Control (X), stored at 12°C (A), 17°C (B) and 22°C (C).

TABLE 2. Rate constant for vitamin C first order degradation (k), coefficient of determination (r^2) and confidence level (P) of the correlation, in mangos cv. Keitt stored at 12°C, 17°C and 22°C.

Treatment	Temperature (°C)	Storage time (days)	k x 100 (1/day)	r^2	P (*)
CONTROL	12	28	-2.27	0.98	0.002 (5)
D-955	12	35	-2.03	0.83	0.012 (6)
LDPE	12	35	-1.95	0.85	0.009 (6)
CONTROL	17	21	-3.06	0.90	0.049 (4)
D-955	17	35	-2.14	0.74	0.027 (6)
LDPE	17	35	-2.16	0.85	0.009 (6)
CONTROL	22	15	-6.39	0.90	0.013 (5)
D-955	22	19	-2.66	0.83	0.012 (6)
LDPE	22	19	-2.00	0.79	0.018 (6)

*Numbers of points.

In the range from 12°C to 22°C, an increase of 10°C in the storage temperature triplicates the degradation rate of vitamin C in control mangos. For the packaged fruits, however, the temperature effect on ascorbic acid was not significant. Mangos packaged in LDPE showed a lower value for Q_{10} than D-955, probably due to a greater permeability of the latter (Table 3). Even though a greater vitamin retention was observed, it should be mentioned that after long-term storage, mangos packaged in LDPE film can develop an off-flavor, reducing their shelf life (YAMASHITA *et al.*, 1997).

TABLE 3. Apparent activation energy and Q_{10} for vitamin C degradation kinetics in mangos cv. Keitt stored at 12°C, 17°C and 22°C.

Treatment	Temperature Range (°C)	Apparent Activation Energy (kcal/kg mol)	Q_{10}
CONTROL	12 - 22	17,237	2.8
D-955	12 - 22	4,496	1.3
LDPE	12 - 22	440	1.0

4. CONCLUSIONS

Vitamin C losses in mangos cv. Keitt, in the range studied, could be fitted to a first order kinetics model. Individual film sealing of mangos reduced the rate constant of vitamin degradation at all storage temperatures tested. In the range from 12°C to 22°C, the degradation rate for non-sealed mangos was highly influenced by storage temperature. For the packaged fruits, the temperature effect was not significant, presumably due to a reduction in the metabolism of the wrapped fruits, caused by the modified atmosphere.

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