

QUALITY ATTRIBUTES AND CARBON DIOXIDE EVOLUTION OF BELL PEPPERS AS AFFECTED BY MINIMAL PROCESSING AND STORAGE TEMPERATURE

CELSE L. MORETTI, WASHINGTON L. C. SILVA
AND ALESSANDRA L. ARAÚJO
Embrapa Vegetables
CP 218, CEP 70.359-970
Brasília, DF, Brazil

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Abstract. Minimal processing and storage temperature of 'Magali' Green bell peppers (*Capsicum annuum* L) had significant effects on the respiration rate and quality of bell peppers. Respiration rate of minimally processed fruits stored at ambient conditions was around 2.5 times higher than intact fruits stored in the same conditions one hour after processing. Minimal processing did not significantly affect pH, total soluble solids and total vitamin C content. However, minimally processed fruits contained significantly less total chlorophyll than intact fruits when compared to fruits stored at ambient conditions, exhibiting 27% less pigments. It is suggested that the association of minimal processing with refrigerated storage conditions can overcome the undesirable effects related with mechanical stresses such as increasing in CO₂ evolution, and degradation of sugars and pigments.

Minimally processed products are defined as any fruit or vegetable submitted to a process of physical alteration (cutting, trimming, slicing) but ensuring that they remain in the fresh state after processing. Minimal processing is an activity showing exponential increase in different countries, specifically in the vicinities of medium and large metropolitan areas (Moretti, 1999). The main objective is to obtain a fresh and healthy product that, in most cases, does not need further preparation to be consumed (Rolle and Chism, 1987).

Despite all the interest and work done with minimally processed products, processors still face many technological problems. The occurrence of mechanical damages on minimally processed products can cause physiological and biochemical alterations in the fresh tissue, such as increase in carbon dioxide and ethylene evolution, loss of membrane integrity, accumulation of phenolic compounds and increase in the activity of many enzymes such as polyphenol oxidase (PPO) and peroxidases (POD) (Priepke et al., 1976; Rolle and Chism, 1987; Avena-Bustillos et al. 1993; Kim et al., 1994; Nicoli et al., 1994).

Among many vegetable crops of economical importance, green bell peppers fruits have been minimally processed to a large extent in Brazil. However, there is a lack of information in the literature regarding changes in their respiratory behavior and quality alterations associated with minimal processing.

The present work was carried out to evaluate carbon dioxide evolution and quality alterations in minimally processed green bell peppers stored under ambient and refrigerated conditions.

Material and Methods

Plant material. 'Magali' green bell peppers were harvested in the third week of January, 2000, at the experimental fields of Embrapa Vegetables (Brasília, Brazil). After harvest, fruits were graded for external blemishes and color (100% of fruit surface with green color) and pre-washed in tap water.

Minimal processing. Half of fruits were then transferred to a cold room (12 ± 2°C) and submitted to minimal processing, which included slicing (5 mm thick), rinsing, sanitation for 10 minutes (NaClO, 150 mg·kg⁻¹) and centrifugation for 5 minutes.

Carbon dioxide evolution. Minimally processed and intact fruits were placed inside sealed glass jars and stored at ambient (22 ± 2°C, 75-85% RH) and at refrigerated conditions (2 ± 0.5°C, 95-90% RH). Every hour during a 4-hour period, gas samples were taken from inside the glass jars and CO₂ evolution was assayed using a gas chromatograph.

Quality evaluation. Minimally processed and intact fruits were stored at ambient (22 ± 2°C, 75-85% RH) and at refrigerated conditions (2 ± 0.5°C, 95-90% RH) for 5 days. On the fifth day, fruits were analyzed for pH, total soluble sugars, total soluble solids, total vitamin C and total chlorophyll contents. Total soluble sugars were evaluated according to Dubois et al. (1956). Total vitamin C was assayed according to Terada et al. (1979) modified by Nunes et al. (1995). Total chlorophyll was analyzed according to the procedure described by Inskeep and Bloom (1985). Total soluble solids were analyzed using a hand refractometer and pH was measured using a digital pH-meter.

Statistical analysis. Analysis were performed using a completely randomized design, arranged in a factorial scheme with four treatments (intact and minimally processed fruits and 2 storage temperatures) and four replicates (n = 8). Data were subjected to analysis of variance and means were compared by Duncan's multiple range test (5%).

Results and Discussion

Carbon dioxide evolution. Minimal processing and storage temperature had significant effects on carbon dioxide evolution of green bell peppers. Minimally processed fruits stored at ambient conditions (22 ± 2°C, 75-85% RH) showed the highest CO₂ evolution during the entire experiment (Fig. 1). Carbon dioxide evolution continued until the third hour after processing, when it reached around 29 ml CO₂·kg⁻¹ FW·h⁻¹ (Fig. 1). On the other hand, minimally processed fruits stored under refrigerated conditions (2 ± 0.5°C, 95-90% RH) had a significant increase in CO₂ evolution only the first hour after processing, being three times higher than intact fruits stored at the same conditions (Fig. 1). After that, there were no statistical difference in carbon dioxide evolution between minimally processed and intact fruits (Fig. 1), showing that low temperature was able to reduce CO₂ evolution in both intact and minimally processed fruits.

Mechanical injuries such as cuts, impacts, compression and abrasion are associated with increase in carbon dioxide evolution of different vegetable crops (Moretti et al., 2000).

C. L. Moretti, CNPq fellow; e-mail: celso@cnpq.embrapa.br.

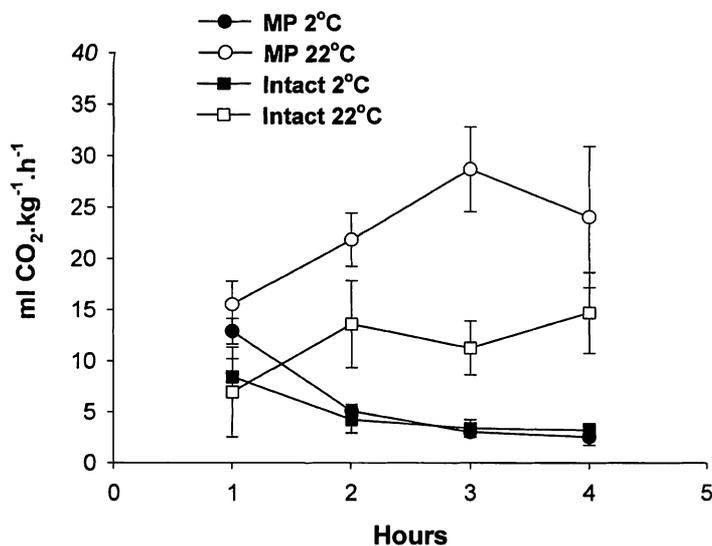


Figure 1. Carbon dioxide evolution of bell pepper fruits stored at ambient ($22 \pm 2^\circ\text{C}$, 75-85% RH) and refrigerated conditions ($2 \pm 0.5^\circ\text{C}$, 95-90% RH). Vertical bars indicate \pm SD.

Increased CO_2 and ethylene evolution in tomato fruit in response to impacts were observed by MacLeod et al. (1976) and Moretti et al. (1998).

Quality evaluation. Storage temperature and minimal processing significantly affected the quality of green bell peppers fruits (Table 1). Minimal processing did not significantly change total soluble sugars contents when compared to intact fruits. However, storage under refrigerated conditions significantly reduced degradation of total soluble sugars for both intact and minimally processed fruits. Intact fruits stored at ambient conditions lost around 22% of their total soluble sugars content when compared to fruits stored at refrigerated conditions. Similarly, minimally processed fruits stored at ambient conditions showed 20% less total soluble sugars content than fruits stored at $2 \pm 0.5^\circ\text{C}$ (Table 1).

Chlorophyll degradation was significantly altered by minimal processing and storage temperature (Table 1). Minimal processing caused a reduction in total chlorophyll content of around 27% for fruits stored at ambient conditions and of 7% for fruits stored at refrigerated conditions, showing that storage

Table 1. Means of pH, total soluble sugars ($\text{g}\cdot\text{kg}^{-1}$), total vitamin C ($\text{mg}\cdot\text{kg}^{-1}$), total chlorophyll ($\text{mg}\cdot\text{kg}^{-1}$) and total soluble solids ($^\circ\text{Brix}$) for intact and minimally processed bell peppers stored at ambient and at refrigerated conditions.

Variable	Intact*		MP	
	$22 \pm 2^\circ\text{C}$	$2 \pm 0.5^\circ\text{C}$	$22 \pm 0.2^\circ\text{C}$	$22 \pm 0.5^\circ\text{C}$
pH	6.23 a	5.69 a	5.59 a	6.22 a
Total soluble sugars	29.20 b	37.00 a	28.23 b	35.34 a
Total vitamin C	702.57 a	725.24 a	749.58 a	694.06 a
Total chlorophyll	15.06 b	17.86 a	11.03 c	16.94 a
Total soluble solids	2.92 a	2.87 a	2.93 a	3.00 a

*Means within each quality attribute row with different letters are significantly different at $P < 0.05$ (Duncan test). MP = minimally processed.

under refrigerated conditions minimize the loss of total chlorophyll (Table 1). When comparing fruits stored at the same temperatures, there was statistical difference among intact and minimally processed fruits for storage at 22°C (Table 1).

Total soluble solids, pH and total vitamin C were not significantly affected by either minimal processing or storage temperature (Table 1). It is believed that the increase in respiration rate caused by mechanical injuries (slice and cutting) was not high enough to stimulate significant alterations in these variables. However, the rupture of cellular structures caused by minimal processing allowed substrates (chlorophyll) to react with their respective enzymes (chlorophyllase) resulting in a decrease in total chlorophyll concentration (Table 1). Bolin and Huxsoll (1991) observed that iceberg lettuce showed no alteration in pH after minimal processing.

Minimally processed bell peppers did not show a significant decrease in total vitamin C, a variable associated with nutritional concerns. This is probably one of the major findings of the present work because it demonstrates that minimally processing bell peppers does not necessarily lead to a loss of nutritional quality after processing. It is suggested that the use of refrigerated storage for minimally processed bell peppers can overcome the undesirable effects of mechanical stresses such as increased CO_2 evolution and degradation of sugars and pigments.

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