POSTHARVEST QUALITY OF GREEN ONION GROWN IN SOILLESS CULTURE: EFFECT OF PACKAGING AND STORAGE TEMPERATURE

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Abstract

Several studies on quality changes of different fresh-cut vegetables for specific storage conditions have been reported but little about fresh cut green onion. The aim of this study was to evaluate postharvest quality of green onion grown in soilless culture with different packaging films and storage temperatures. Green onions were obtained from perlite production system. At harvest, plants were trimmed (leaf tips and roots cut), washed with chlorinated water and packed in bags (80 ± 5 g of product per bag). Two packaging films were used: non-perforated and perforated film. The bags were stored 10 days in refrigerated chambers at 1 ± 0.5ºC and 8 ± 2ºC. Overall visual quality, gas concentration inside the bags (carbon dioxide and ethylene), color parameters (L, a*, b*), total chlorophyll, weight loss and reducing sugars were measured during storage time and electrolyte leakage at the end of the period. Experiments were conducted as completely randomized design with three replicates. The best quality was obtained maintaining the product at 1 ± 0.5ºC with non-perforated film and these results indicate that it is possible to maintain green onion quality for up to ten days in modified atmosphere packaging with adequate storage temperature.*

Key words: passive modified atmosphere, polyolefin bag, leafy vegetables, reducing sugars, chlorophyll, electrolyte leakage

INTRODUCTION

Quality is meant as all characteristics of the product related to consumer satisfaction. Vegetables quality is a combination of characteristics, attributes, and properties that give value to the commodity for human food. Crop management adjustments tend to improve the yield and the product quality over the year. Quality losses of vegetable products between harvest and consumption, and the change of marketing ways led to an improvement of production and postharvest technology in order to keep good inner and outer quality traits of fresh products. Food packaging is seen as a vital link in the overall chain of food production, processing, marketing and consumption (Piagentini et al., 2005).

Food packaging is an integral part of the processing and preservation of these staple foods and can also minimize many of the potential spoilage changes, imparting improved keeping quality and increased shelf life to the processed and packaged food. Minimally processed vegetables are a relatively new and rapidly developing segment of the food industry. These products will have been freshly trimmed, peeled and/or cut, washed, packaged and maintained with refrigeration to offer consumers high nutrition, convenience and flavour (Sandhya, 2009).

Several studies on quality changes of different fresh-cut vegetables for specific storage conditions have been reported but little in fresh cut green onion, not only in postharvest but also in preharvest factors. Green onions provide an interesting challenge as a minimally processed product. In Argentina, their demand has increased markedly in the last years and industry has expectations of further growth. Although it is still relatively new market, it represents 20% of the total of vegetable sales in supermarkets. Therefore, this kind of product appears destined to become an important component of the food industry but efforts must be taken to ensure products of high quality (Piagentini et al., 2005)

There has been great interest in marketing value-added, fresh-cut or minimally processed vegetables. However, there are many limitations to post cutting shelf life of these products due to undesiderable physiological changes caused by the minimal processing (Hong et al., 2000).

For fresh-cut green onion there are important additional defects. Due to lack of precision in the cutting process and frequent complete removal of the compressed stem, growth or extension of the white inner leaf bases may occur (Hong et al., 2000).

The aim of this study was to evaluate postharvest quality of green onion grown in perlite, packed in modified atmosphere with different films packaging and stored in refrigerated chambers at different temperatures.

MATERIALS AND METHODS

Green onions (*Allium cepa* L. red type) were obtained from perlite production system. At harvest, the plants were trimmed (leaf tips and roots cut off), washed with chlorinated water (100 ppm active chloride) and packed in bags. Two packaging films were used: non-perforated (passive modified atmosphere) and perforated film (control). Non-perforated film (15 μ) gas transmission rates of 31 000; 8900 $cm^3.m^{-2}$ to 23ºC 1 atm. 0% RH and 23 $g.m^{-2}$ at 38ºC, RH 100%, 1 atm in 24 hrs for O_2, CO_2 and water vapour, respectively. Perforated film (15 μ) has 0.3 $holes.cm^{-2}$, 0.3% perforated area and perforation diameter is 1.1 mm. The bags contained 80 ± 5 g of product were placed in plastic boxes and stored 10 days in refrigerated chambers at 1 ± 0.5ºC and 8 ± 2ºC.

During the storage period the following parameters were evaluated on days 1, 3, 7 and 10:

Overall Visual Quality (OVQ): using a scale of 9 to 1, where 9 = excellent and 1 = unusable, a score of 6 will be considered as the limit of commercial acceptability (Hong et al., 2000).

Gas concentration inside the bags (carbon dioxide and ethylene): A sample of the atmosphere inside the bag was taken to determine CO_2 and ethylene concentration by gas chromatography with HP 4890.

Color values (L*, a*, b*): green onion leaves were measured using a Minolta CR 300 chromameter calibrated to a standard white tile (Y: 92.1, x 0.3163 and y: 0.3322). The illuminant was the CIE (Commission International de l´Eclairage) D_{65}. Color changes were quantified in the L*a*b* color space. L* refers to the lightness, ranging from 0 (black) to 100 (white), a* is a positive or negative coordinate defining a locus relative to a purplish-red-bluish-green axis, and b* is positive or negative coordinate defining a locus relative to a yellow-blue axis.

Chlorophyll content: leaves were frozen in liquid nitrogen and crushed in a laboratory grinder. Extractions were done using prerefrigerated acetone (1:3 weight:volume). An aliquot of this extract was used to determine total chlorophyll spectrophotometrically by Bruinsma technique. The results were expressed as mg of chlorophyll/100 g fresh tissue.

Weight loss: weight of green onions bags was recorded initially and after storage and the difference was used to calculate the weight loss percentage.

Reducing Sugars: extraction and determination was conducted by Somogyi-Nelson technique. The results were expressed as μg of reducing $sugars.g^{-1}$ fresh weight.

Electrolyte leakage was measured in 5 mm length portion of the leaf onions and following the procedure described by Fan and Sokorai (2005).

Experimental design and statistical analysis

Experiments were conducted as completely randomized designs with three replicates. Data were analyzed by ANOVA (SAS Institute Inc., Cary, NC, USA) at $p < 0.05$ with mean separation by Tukey test. For analysis of overall visual quality non parametric methods were used according to the Friedman test.

RESULTS AND DISCUSSION

Overall visual quality

OVQ declined during storage period and quality losses were mainly attributed to yellowing. Hong et al. (2000) also found that the main cause visual quality loss in intact green onions was the yellowing of the outer oldest leaf.

Type of film and storage temperature affect the evolution of this parameter and the best quality was obtained at 1 ± 0.5ºC with non-perforated film until the end of experiment. With perforated film commercial limit of acceptability was reached at third day of storage period at both temperatures (Figure 1).

It is known that fruit and vegetables lose their typical fresh appearance after being held in cold storage for only a short time. It is important to realize that storage in modified atmosphere will not improve the quality of the product; it will only delay the rate of spoilage. General appearance in the most important quality attribute that consumers use to evaluate the quality of fruits and vegetable, as people “buy with their eyes” (Piagentini et al., 2005; Ufuk Kasim, 2009).

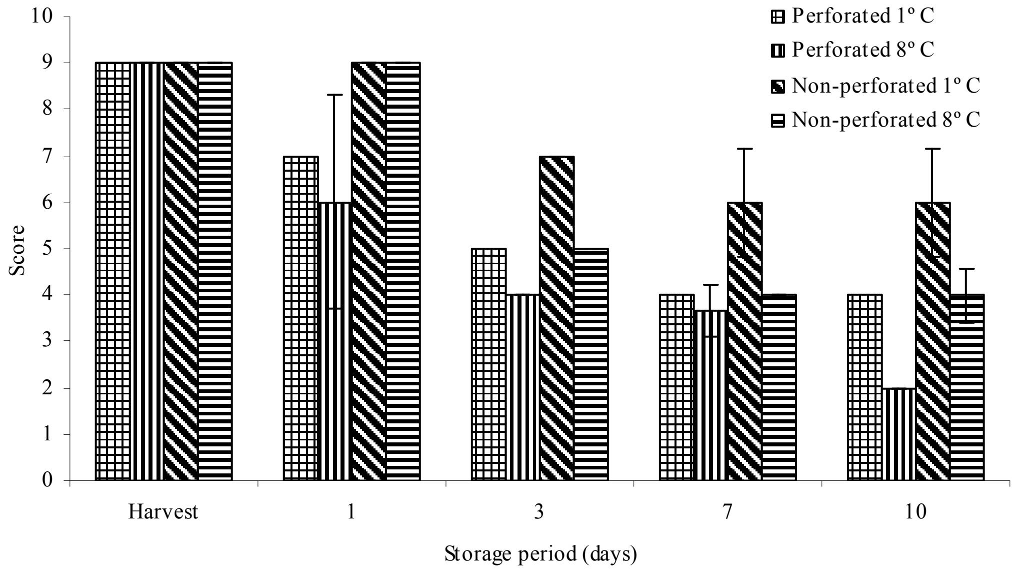
Gas concentration inside the bags

An increase in the carbon dioxide concentration inside the non-perforated bags was measured (Table 1). Storage temperature had effect on carbon dioxide concentration inside the bags.

Ethylene concentration decrease during the storage period. At 1 ± 0.5ºC the peak of ethylene concentration was measured one hour after sealed of the bags, while at 8 ± 2ºC maximum ethylene concentration was observed after one day of storage (Table 2).

High carbon dioxide concentration during the first hours of storage would indicate an imbalance in the permeability of the film and that it is not suitable for this product at 8 ± 2ºC. Similar results were obtained by Hong and Kim (2004) with a low density polyethylene film and polypropylene film.

Figure 1: Overall visual quality scores for green onions stored with non-perforated and perforated films (control) at 1 ± 0.5ºC and 8 ± 2ºC during 10 days. Data were the average of 3 replicates + standard deviation



Carbon dioxide concentration up to 5% affect chlorophyll concentration by accelerates degradation (Woo Park et al, 1999). This was corroborated in this experiment, because an increase of the CO_2, especially at 8 ± 2ºC, increased the yellowing of leaves. However, Hong et al. (2000) reported that some commercial packages of trimmed green onions with carbon dioxide concentrations of 6–10% CO_2, depending on the temperature, have no effect on overall visual quality of the product.

Color

Color parameters were significantly affected by film packaging and storage temperature (Figure 2).

All color parameter values showed a trend to decrease with a yellowing in green onion specially using non-perforated film, however, Hong and Kim (2004) found that the color of modified packaging bunched onions was not significantly influenced by different packaging treatments.

Tab. 1: Carbon dioxide concentration (%) inside the non-perforated bags of green onion stored 10 days at 1 ± 0.5ºC and 8 ± 2ºC

Storage temperature	Storage period (days)				
	1 hour	1	3	7	10
1ºC	2.8 (Sd: 0.792)	4.9 (Sd: 0.759)	6.4 (Sd: 1.034)	5.2 (Sd: 1.239)	6.3 (Sd: 2.344)
8ºC	3.7 (Sd: 0.376)	7 (Sd: 0.453)	5.9 (Sd: 3.556)	8.3 (Sd: 0.786)	9.5 (Sd: 0.868)

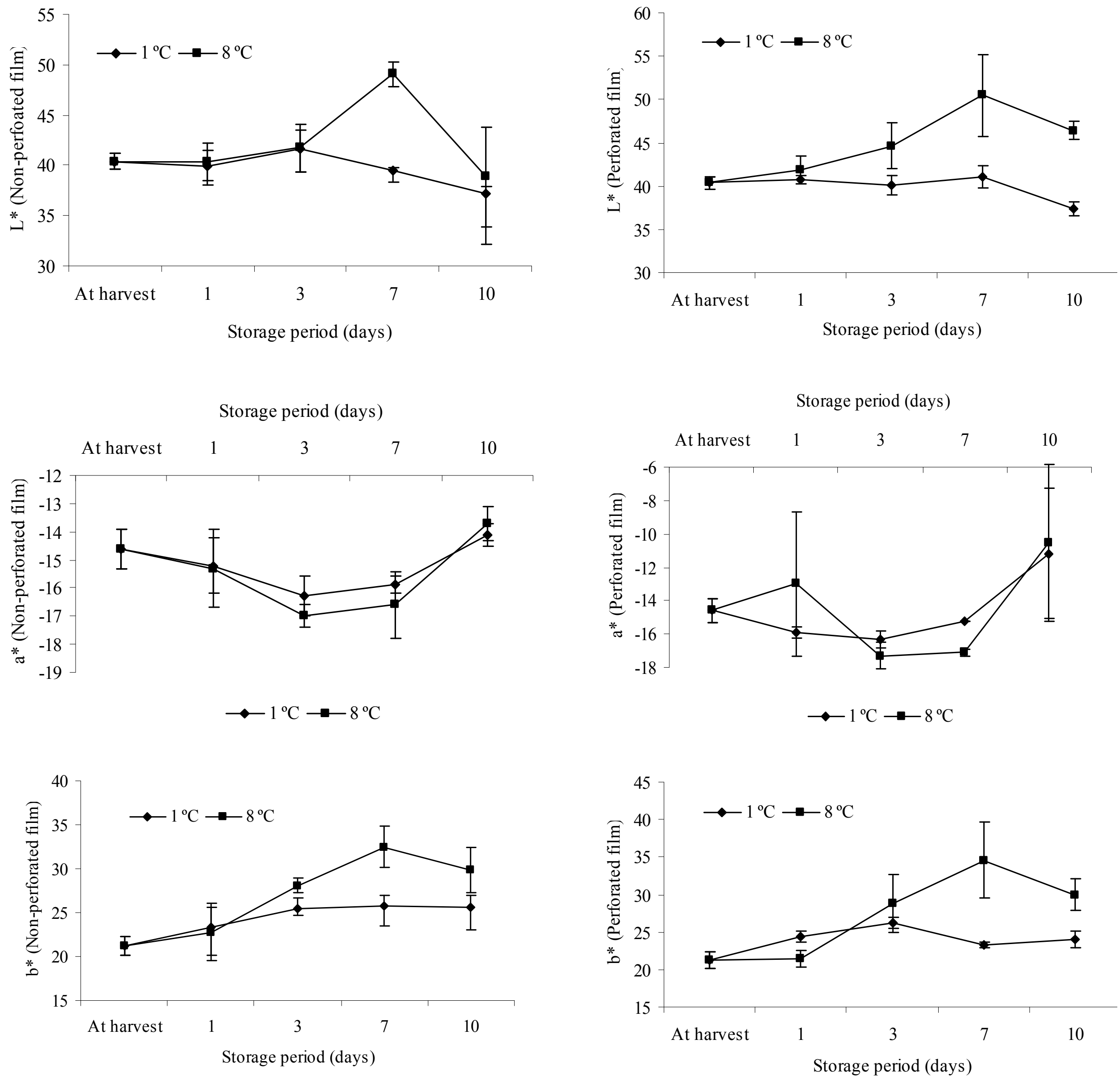
Sd = standard deviation

Tab. 2: Ethylene concentration (%) inside the non-perforated bags of green onion stored 10 days at 1 ± 0.5ºC and 8 ± 2ºC

Storage temperature	Storage period (days)				
	1 hour	1	3	7	10
1ºC	1.16 (Sd: 0.20)	0.72 (Sd: 0.14)	0.11 (Sd: 0.06)	0.10 (Sd: 0.02)	0.08 (Sd: 0.04)
8ºC	0.3 (Sd: 0.16)	0.62 (Sd: 0.10)	0.26 (Sd: 0.20)	0.28 (Sd: 0.17)	0.23 (Sd: 0.08)

Sd = standard deviation

Figure 2: Changes of color values (L*, a* and b*) of green onions with non-perforated and perforated films (control) stored at 1 ± 0.5ºC and 8 ± 2ºC during 10 days. Data were the average of 3 replicates + standard deviation



Weight loss

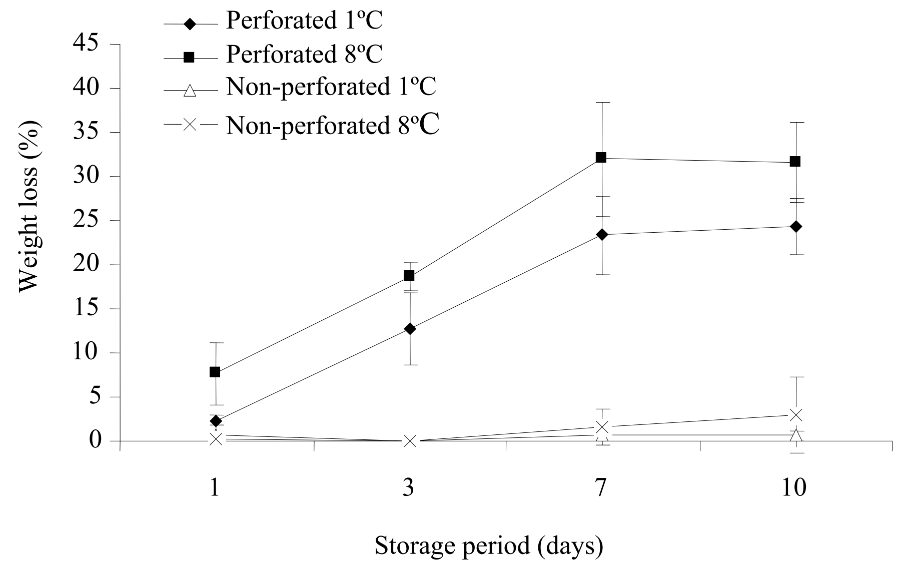
Storage temperature and type of film significantly affect this parameter. At the end of the storage at 8 ± 2ºC with perforated film weight loss of the products were around 30%, while non-perforated film, at both temperatures, were lower than 3% (Figure 3). These results agree with those reported by Hong and Kim (2004) who stated that non-perforated film acts like a water vapor barrier reducing weight loss of products and report values between 1.5 to 3% for minimally processed bunched onions within polyethylene and polypropylene bags.

Plant tissues are in equilibrium with an atmosphere at the same temperature and a relative humidity of 99 to 99.5% and any reduction of water vapor pressure in the atmosphere below that in the tissue results in water loss as in the case of perforated films. In the case of non perforated films the relative humidity is very high, so dehydration is not a common problem (Hong and Kim, 2004).

Total chlorophyll

Chlorophyll concentration was affected by type of film and storage temperature. There was a decrease in total

Figure 3: Weight losses (%) of green onions stored with non-perforated and perforated films (control) at 1 ± 0.5ºC and 8 ± 2ºC during 10 days. Data were the average of 3 replicates + standard deviation



chlorophyll during storage and lowest concentration was found with non-perforated film and stored at 8 ± 2ºC (Figure 4).

The loss of chlorophyll is responsible of the yellowing of fresh cut products and is the result of disruption of compartmentation that occurs when cell are broken, allowing substrates and oxidases to come in contact. Lowest concentration of chlorophyll in non-perforated film stored at 8 ± 2ºC could be explained because ttemperature and air atmosphere were the two major factors that affect chlorophyll degradation (Woo Park et al., 1999).

Reducing sugars

This parameter was affected by storage period and temperature. After 10 days of storage at 8 ± 2ºC reducing sugars concentration of green onions with perforated film decreased more than 30% (Figure 5).

This result agrees with the results found by Hiroshi et al. (2000) in *Brassica campestris* L. var. *komatsuna* leaves.

Electrolyte leakage

Electrolyte leakage was affected significantly by type of film and storage temperature and presented 52% greater disruption of the membrane permeability when was stored in perforated film and at 8 ± 2ºC (Table 3).

The senescence of tissues induces changes in the membranes by altering the chemical properties leading to a loss of normal physiological processes, washing ion tissue damage and therefore the extent of loss of electrolytes is generally considered an indirect measure of

Figure 4: Changes in total chlorophyll of green onions with non-perforated and perforated films (control) at 1º and 8 ºC during 10 days. Data were the average of 3 replicates + standard deviation

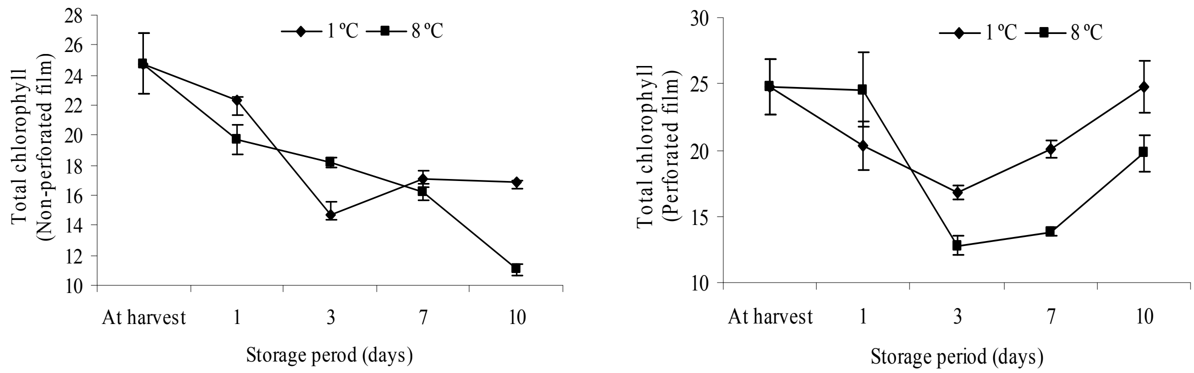
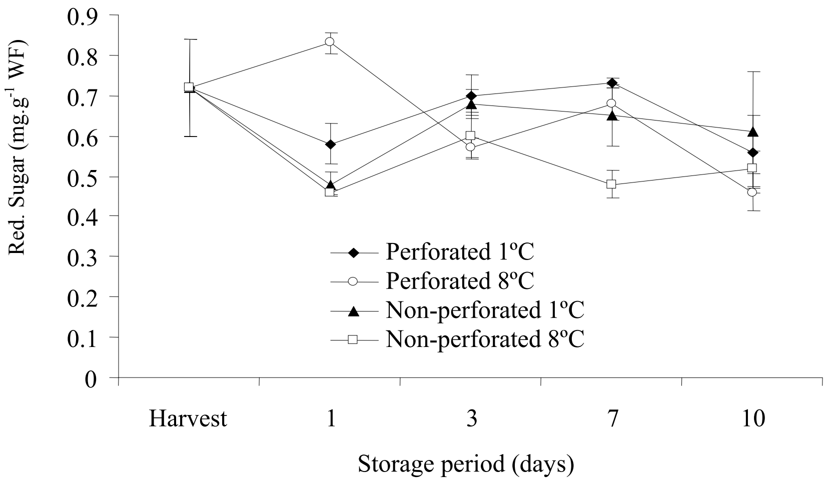


Figure 5: Reducing sugars changes in green onion with non-perforated and perforated films (control) at 1 ± 0.5ºC and 8 ± 2ºC 10 days. Data were the average of 3 replicates + standard deviation



damage cell membranes (Fan and Sokorai, 2005). Our results are according to Ufuk Kasim et al. (2008) that found that at the end of storage, an electrolyte leakage of onions without being irradiated reached 11.93%.

Tab. 3: Electrolyte leakage (%) at the end of storage of green onion with non-perforated and perforated films (control) at 1 ± 0.5ºC and 8 ± 2ºC

Storage temperature	Non-perforated film	Perforated film
1ºC	7.85 (Sd: 0.68)	8.37 (Sd: 0.91)
8ºC	8.37 (Sd: 0.91)	17.47 (Sd: 4.6)

Sd = standard deviation

CONCLUSIONS

Only green onion with non-perforated film stored at 1 ± 0.5ºC was still marketable after 10 days. The overall quality of the green onion decreased during the storage. The color of the green leaves turn into a more yellowish green and weight losses increased during storage.

These results indicate the possibility of adopting modified atmosphere packaging with adequate storage temperature for maintaining green onion quality.

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