Postharvest Biology and Technology 86 (2013) 240–248

Contents lists available at ScienceDirect

Postharvest Biology and Technology

journal homepage: www.elsevier.com/locate/postharvbio

Effect of hyperbaric pressure and temperature on respiration rates and quality attributes of tomato

Pansa Liplap[a,b,*], Clément Vigneault[a,b], Peter Toivonen[c], Marie Thérèse Charles[b], G.S. Vijaya Raghavan[a]

[a] Department of Bioresource Engineering, Macdonald Campus, McGill University, Sainte-Anne-de-Bellevue, QC, Canada
[b] Horticulture Research and Development Centre, Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, QC, Canada
[c] Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada, Summerland, BC, Canada

ARTICLE INFO

Article history:
Received 6 March 2013
Accepted 6 July 2013

Keywords:
Short term storage
Pressure treatment
Shelf life
Quality retention

ABSTRACT

Previous work with hyperbaric treatment of tomato focused on application at lower temperature (13 °C). In this work, hyperbaric treatment at varying pressure levels (i.e., 0.1, 0.3, 0.5, 0.7 and 0.9 MPa) at ambient temperature (20 °C) was tested as a potential alternative to conventional refrigerated storage (0.1 MPa at 13 °C) to preserve tomato quality. The experiments were divided into 3 phases: (1) 4 day of hyperbaric treatment, (2) 5 day of post-treatment ripening, and (3) 10 day of post-treatment ripening. Respiration rate (RR) of the tomatoes was continuously monitored during the course of the hyperbaric treatments. Quality attributes were assessed immediately after removal from the hyperbaric treatments and after 5 and 10 day ripening at 20 °C after removal from the treatments. Hyperbaric treatments at ≥0.3 MPa resulted in RR equal or higher than the RR in control fruit (0.1 MPa at 20 °C). The lowest RR was obtained from tomato stored at 0.1 MPa at 13 °C. Hyperbaric treatment at 0.5, 0.7 and 0.9 MPa significantly reduced weight loss, retained color, firmness, total soluble solid (TSS), titratable acidity (TA) and TSS:TA ratio at similar levels as the tomato treated at 13 °C and 0.1 MPa. Firmness after treatment was highest for fruit from 0.1 MPa at 13 °C and from 0.5, 0.7 and 0.9 MPa at 20 °C. The higher firmness advantage declined by 5 day of ripening after treatment, with higher firmness only being retained for fruit from the 0.9 MPa at 20 °C and the 0.1 MPa at 13 °C treatments. After 10 day ripening, firmness was similar for all treatments. Lightness (L^*) and hue angle were greater for all treatments compared with the 0.1 MPa at 20 °C treatment. However, only the greater hue angle difference was maintained after 5 day of ripening. After 10 day ripening, no significant differences were found in color attributes. Only 0.1 MPa at 13 °C retained higher soluble solids, lower titratable acidity and higher TSS:TA ratios after treatment and after 5 day ripening. At 10 day of ripening none of the quality attribute differences noted were retained for any of the treatments. These results show that the only consistent effect of hyperbaric treatment at 0.5, 0.7 and 0.9 MPa was to reduce weight loss and enhance firmness retention up to 5 day ripening after treatment.

1. Introduction

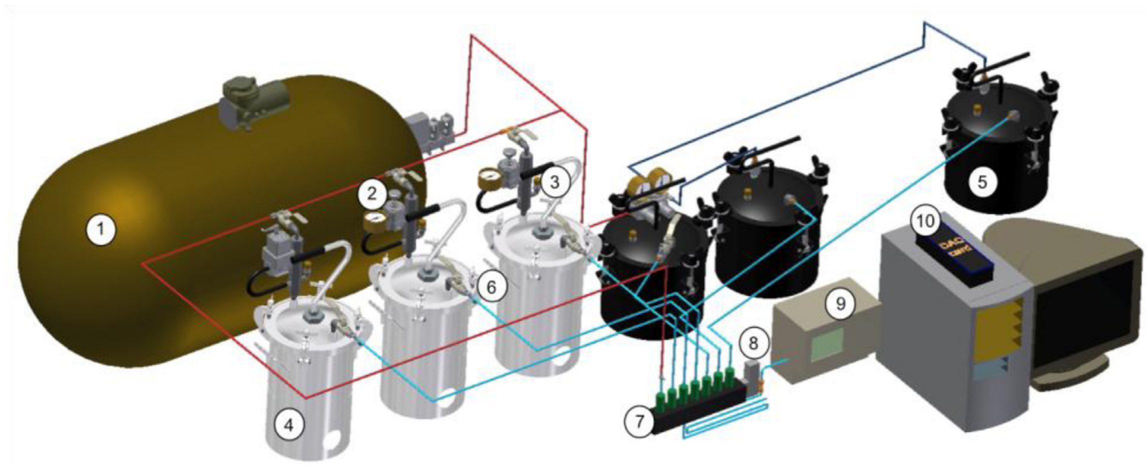
Consumption of fruit and vegetables has been reported to continuously increase over the years, due mainly to the rapid growth in population and the increased concerns about their health. Tomato is one of the most widely consumed vegetables and is considered a rich source of dietary antioxidants, including carotenoids (especially lycopene), phenolics, vitamin C, vitamin A, vitamin K and different minerals such as molybdenum, potassium, manganese, chromium (Khachik et al., 2002; Vinson et al., 1998). Epidemiological studies indicate that tomatoes and tomato products may have a protective effect against various forms of cancer, especially prostate cancer and cardiovascular diseases (Barber and Barber, 2002).

Tomato is usually harvested unripe at mature green stage or breaker stage in order to minimize their losses caused by physical damage during handling and transport and are then allowed to ripen just prior to or during marketing. Tomato is a very perishable fruit; under ambient conditions it ripens rapidly before becoming excessively soft and no longer marketable (Davies and Hobson, 1981). Substantial postharvest losses of tomato in terms of quality and quantity may be encountered due to the lack of appropriate postharvest techniques as well as the lack of postharvest facilities.

Generally, fresh produce requires low temperature and high relative humidity during storage and transport for best quality retention. Low temperature is effective in reducing physiological,

* Corresponding author at: Department of Bioresource Engineering, Macdonald Campus, McGill University, Sainte-Anne-de-Bellevue, QC, Canada H9X 3V9. Tel.: +1 450 515 2031; fax: +1 450 346 7740.
E-mail addresses: pansa.liplap@mail.mcgill.ca, pansa.liplap@gmail.com (P. Liplap).

0925-5214/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.postharvbio.2013.07.002



No.	Description	No.	Description
1	Compressed air tank	6	Flow control valve
2	Pressure regulator	7	Manifold
3	Safety valve	8	Air flow meter
4	High pressure vessel	9	CO_2 sensor
5	Low pressure vessel	10	Data acquisition card

Fig. 1. Hyperbaric system for evaluation of the effect of different pressure levels on tomato. (For interpretation of the references to color in the text of this figure citation, the reader is referred to the web version of the article.)

biochemical and microbiological activities, eventually delaying quality deterioration (Kader et al., 1989), while high relative humidity decreases physiological weight loss and shriveling of commodities. However, tomato is susceptible to chilling injury at temperatures below 11 °C (Cheng and Shewfelt, 1988). Therefore, it cannot take full advantage of low temperature storage to slow metabolic activity and preserve produce quality.

Although fresh tomato after harvest are usually handled at relatively high temperature, 12.7–15.5 °C (Jones, 1999), in many countries of the world, producers are still not able to handle it with refrigeration because of lack of availability and/or cost of refrigeration systems. The development of an alternative technique is desirable for extending the shelf life and maintaining quality of fruit and vegetables at least a short period of time during produce transport.

Currently, a number of postharvest techniques have been extensively studied to prolong shelf life of fruit and vegetables such as UV-C/UV-B irradiation, high temperature treatment, 1-methylcyclopropene (1-MCP), CA/MA, ozone, etc. (Liu et al., 2009, 2011; Lu et al., 2010; Tzortzakis et al., 2007; Wills and Ku, 2002). Although these techniques have proven to be beneficial in extending storage life of fruit and vegetables, they are limited in practice due to their complicated operation, high cost and negative effects on maintenance of storage taste and quality (Wang et al., 2008). Most importantly, they must be accompanied by refrigeration to obtain full benefits (Kader and Saltveit, 2003), which are not suitable for onsite operations in areas lacking technology and access to stable power supply.

Recently, hyperbaric storage, an application of air pressure ($0.1 < P_{abs} < 1.0$ MPa) to a fruit or vegetable during storage, has shown promising results in extending storage life of some fresh fruit and vegetables (Goyette et al., 2007). It has been shown to reduce respiration rate, ethylene production and the ripening process as well as probably extend the synthesis of certain biochemicals of fruits (Baba and Ikeda, 2003; Eggleston and Tanner, 2005; Goyette et al., 2012a) and reduce produce susceptibility to pathogens (Baba et al., 1999). Nevertheless, to date, only limited studies on pressure storage have been reported, none of which was carried out on postharvest storage of fresh produce without refrigeration at ambient temperatures.

In this study, the potential of hyperbaric treatment in extending shelf life of tomato fruit was investigated during storage and ripening periods at 20 °C (ambient temperature). Its effects on the respiration rate (RR) and quality attributes i.e., weight loss, color, firmness, soluble solid and titratable acidity were examined. The results obtained were also compared to simulated commercial storage conditions at 0.1 MPa (1 atm) at 13 °C.

2. Materials and methods

2.1. Raw material

Tomato fruit (*Lycopersicon esculentum* Mill. cv. DRK 453) was harvested at a commercial greenhouse (Saint Damase, QC, Canada), and was transported immediately to Agriculture and Agri-Food Canada's Horticulture R&D Centre in St-Jean-sur-Richelieu, Canada, within two hours. An average fruit weight with standard deviation (SD) was 196 ± 5 g. All tomatoes were sanitized in 100 ppm sodium hypochlorite solution for 5 min, then rinsed with water for another 5 min, and finally dried with a soft cloth. Initial parameters of tomato were determined, including color, firmness, soluble solids and titratable acidity.

2.2. Hyperbaric system

Fig. 1 shows the schematic of the dynamic hyperbaric respirometer (flow-through) system used during the tests. It was designed to measure RR of the produce continuously, consisting mainly of a compressed air tank, three low pressure vessels, three high pressure vessels and an infrared gas analyzer. The low pressure vessels were made from painted steel apparatus (PRO-TEK, Mirabel, Quebec, Canada), 220 mm in height and 265 mm inside diameter;