Edible Coating Effects on Postharvest Quality of Green Bell Peppers

SIRICHIT LERDTHANANGKUL and JOHN M. KROCHTA

ABSTRACT

Green bell pepper fruits (Capsicum annuum L., cv. “Jupiter”) were coated with a mineral-oil-based coating or a cellulose-based coating. Three different milk-protein-based edible coatings (whey protein isolate, sodium caseinate, and sodium caseinate beeswax emulsion) plasticized with glycerol were also tested. The effects of these coatings were fol-

owed by measurement of changes in respiration, internal gases, color, firmness, and water loss during storage at 10°C, 80-85% RH for 20 days. None reduced respiration or affected color. Only the mineral-oil-based coating significantly reduced moisture loss, thus maintaining fruit firm-

ness and thereby prolonging fruit freshness.

Key Words: green peppers, edible coatings, respiration, texture, firmness

INTRODUCTION

FLACCIDITY, shriveling, wilting and decay are major problems that reduce marketability and consumer acceptance of bell pep-

per fruit after harvest. Flaccidity directly correlated with loss of water during storage (Showalter, 1973; Ben-Yehoshua et al., 1983; Lownds et al., 1993; Lownds et al., 1994). Respiration as well as diffusion through the cuticle on the skin are both in-

volved in fruit water loss. Since bell pepper fruit is a non-cli-

matic fruit (Hallseth, 1977), its respiration is minor in water loss. Loss of water also leads to shriveling and wilting if it is as high as 5% (Buszel and Kemigisberger, 1975). Therefore, reduction of water loss, especially diffusion through the cuticle, should help maintain textural quality and external appearance and thus im-

prove bell pepper storage life. Establishment of water-saturated atmosphere around the fruit by individual-seal, shrink-wrap or modiﬁed-atmosphere packaging (MAP) minimized water loss in several kinds of fruits and vegetables (Hardenburg, 1949; Ben-

Yehoshua, 1985; Paull and Chen, 1989). Bell peppers individ-

ually wrapped in plastic film showed marked reduction in weight loss and softening, which extended shelf-life (Hughes et al., 1981; Ben-Yehoshua et al., 1983; Miller et al., 1986; Otma, 1989; Brackett, 1990; Gonzalez and Tamado, 1991).

Although individual-seal and MAP appeared to reduce bell pepper fruit moisture loss, some limitations have inhibited com-

mercial use. One problem is development of aerobic microor-

ganisms due to water condensation caused by temperature fluctuations during storage or transportation. Miller et al. (1984) noted that ﬁlm wrapping increased the incidence of bacterial soft rot in bell pepper compared to nonwrapping. Brackett (1990) also showed that shrink-wrapped pepper developed higher pop-


Another limitation involved environmental concerns about us-

ing plastic materials. Replacement of plastic films with edible or biodegradable materials is desirable from an environmental perspective. The application of edible coatings and films in fruits and vegetables has received attention worldwide for improve-

ment of postharvest life, in combination with temperature and relative humidity management. Edible coatings on fruits could serve either as gas or moisture barriers. They could help lessen moisture loss, and/or reduce fruit oxygen uptake from the en-

vironment and thus slow respiration (Dohnowske and Fenema, 1994). McHugh and Krochta (1994) found oxygen barrier prop-

erties for whey protein-based ﬁlms which suggested potential use with fruits and vegetables. Edible coatings have been re-

ported to be effective on various kinds of fruits and vegetables (Smith et al., 1987; El Ghaouth et al., 1991b; Niuppon-Carriedo, et al., 1991; Avena-Bustillos et al., 1994a, b; Hageman and Baker, 1994; Park et al., 1994). Chitosan coating reduced weight loss, respiration rate, loss of color, wilting, and fungal infection for bell pepper during storage at 13°C and 20°C at 85% RH (El Ghaouth et al., 1991a).

Our specific objectives were to coat bell pepper fruit with several types of edible coatings (protein-, cellulose- and oil-
based) and investigate their effects on respiration rate, internal gases, texture, color, and weight loss of the fruit during storage.

MATERIALS & METHODS

Fruit

Green bell peppers, Capsicum annuum, L. (cv. “Jupiter”), were hand harvested at Christopher Ranch ( Hollister, CA), placed in plastic boxes or perforated paper boxes, and transported directly to the Mann Laboratory, Univ. of California, Davis. All peppers were precooled overnight at 7°C and later sorted according to size, color, shape, maturity stage, and absence of external injuries. The next day, each individual fruit was washed with 0.5% sodium hypochlorite solution prepared from 5% com-

mercial bleach and subsequently rinsed with sterile deionized water, air dried, and stored overnight at 1°C with 80-85% RH. Before coating the next morning, a total of 217 fruits were divided into two groups. Twenty-one fruits were used for respiration measurement in triplicate on seven treatments. The remainder were subdivided into 28 groups of seven for use in seven treatments in which each group was a replicate of two groups of fruits. All peppers were coated on the third morning after harvest.

Coating materials

Whey protein isolate (WPI) and sodium caseinate (SC) coating solu-

tions and sodium caseinate-beeswax (SCB) coating emulsion were pre-

pared using previous protocols (Avena-Bustillos and Krochta, 1993). McHugh and Krochta, 1994). All solutions consisted of 10% (w/w) total solids and were plastici-

zated with 30% glycerol by weight to reduce the water activity of protein in the solution. For SCB emulsion, the ratio of protein to lipid was 3:1. This ratio had been reported to give the lowest water vapor permeability (Avena-Bustillos and Krochta, 1993). Adding more bees-

wax did not further reduce water vapor permeability. WPI was provided by Le Sueur isolates (Le Sueur, MN), while SC was supplied by New Zealand Milk Products (Santa Rosa, CA). White, bleached beeswax was purchased from Aldrich Chemical Co., Inc. (Milwaukee, WI). Glycerol was purchased from Fisher Scientiﬁc, Inc., (Fair Lawn, NJ). In addition to an uncoated control (Ctrl), an aqueous solution of 4% (v/v) glycerol was prepared as a second control (Gly) for coating solutions in which glycerol was a plasticizer.

The mineral-oil-based (MO) coating was a commercial product (Parafilm™ Durafresh) provided by EcoScience Produce Systems Division of American Machinery Corp. (Orlando, FL). The cellulose-based (CL) coating was also a commercial product (Nature Seal® 2000) provided

Author Lerdthanangkul, formerly with the Dept. of Food Science and Technology, Univ. of California, Davis, is afﬁliated with the Dept. of Food Science & Technology, Faculty of Agro-Industry, Kasetsart Univ., Bangkok, 10900, Thailand. Author Krochta is with the Dept. of Food Science & Technology and Dept. of Biological & Agricultural Eng., Univ. of California, Davis, CA 95616. Address inquiries to Dr. Krochta.

176—JOURNAL OF FOOD SCIENCE—Volume 61, No. 1, 1996

176—JOURNAL OF FOOD SCIENCE—Volume 61, No. 1, 1996

176—JOURNAL OF FOOD SCIENCE—Volume 61, No. 1, 1996

176—JOURNAL OF FOOD SCIENCE—Volume 61, No. 1, 1996

176—JOURNAL OF FOOD SCIENCE—Volume 61, No. 1, 1996
Respiration

Effects of edible coatings on respiration of bell pepper fruits during storage at 10°C, 80–85% RH were compared (Fig. 1). No bell peppers showed significant changes in CO₂ production rates with time. This supported previous results from Salventi (1977), who classified bell peppers as a non-climacteric fruit-vegetable. Bell peppers coated with WPI and SC resired at higher rates than controls. For day 18, no results are shown for WPI-coated fruits since all samples were spoiled. Addition of glycerol as a plasticizer to WPI and SC coatings probably influenced respiration elevations, since those fruits coated with glycerol had higher respiration rates than uncoated controls for the first four days. Addition of beewax seemed to have an opposite effect on respiration. Bell peppers coated with SCB resired at substantially lower rates than SC-coated fruits. However, they were not different compared to uncoated controls. Bell pepper fruits coated with MO and CL coatings showed insignificant increases in respiration rates compared to control.

RESULTS & DISCUSSION

Respiration

Internal CO₂ and O₂ concentrations of each sample were obtained by withdrawing 1 mL internal gas samples from the bell pepper cavity with a syringe while the fruit was submerged under water. The gas sample was then injected into an infrared gas analyzer (Model PB-2000, Horiba Instruments, Inc., Irvine, CA) equipped with an Omnistar™ chart recorder (Western Scientific Assoc., Danville, CA). Experiments were replicated three times for each treatment and observations were taken at 2-day intervals for 18 days.

Internal gases analysis

Internal CO₂ and O₂ concentrations of each sample were obtained by withdrawing 1 mL internal gas samples from the bell pepper cavity with a syringe while the fruit was submerged under water. The gas sample was then injected into an infrared gas analyzer (Model PB-2000, Horiba Instruments, Inc., Irvine, CA) equipped with an Omnistar™ chart recorder (Western Scientific Assoc., Danville, CA). Experiments were replicated three times for each treatment and observations were taken at 2-day intervals for 18 days.

Statistical analysis

Differences in quality characteristics were analyzed statistically by one-factor ANOVA and classified by Fisher’s PLSD test (α = 0.05). All analyses employed SuperANOVA v.1.11 (Abacus Concepts, Inc., Berkeley, CA).

Color evaluation

Both instrumental and sensory methods were employed to follow changes in color of bell pepper during storage. In the instrumental measurement, the color of each sample was measured in the L*a*b mode of CIE by a Minolta Color Meter CR200 (Minolta Camera Co., Japan). Prior to measurement, the instrument was calibrated with a green standard tile (L 64.96, a = 26.58, b = 117.43). Surface pigmentation variations for each sample were compensated by recording the average of five readings taken horizontally at the middle around the fruit. The hue angle value was later calculated by using the equations described by Shaw (1988).

In the sensory method, two trained test panels evaluated visual color of each sample by using the four-point scale (1 = green; 2 = breaking; 3 = red with some green; and 4 = red) as developed by Bussell and Kreuzberger (1973).

Texture analysis

Firmness of each fruit was first evaluated subjectively by using two trained test panels. The test panel determined firmness of bell pepper by recording the degree of pod yield to moderately-applied finger pressure and scoring on the following scale: 5 = very firm; 4 = firm; 3 = slightly firm; 2 = slightly firm; and 1 = flaccid, no resistance (Miller et al., 1986).

After subjective measurement, the stem of each fruit was trimmed off and covered with a thin layer of white silicon sealant to minimize gas diffusion of fruit during testing, since the fruit would be immediately subjected to internal gases analysis. An Instron Universal Testing Machine (Model 1122, Instron Engineering Corp., Canton, MA) equipped with a 500kg load cell was then used to conduct the nondestructive deformation test. Each fruit was compressed 6.2 mm using a crosshead speed of 30 mm/min and a chart speed of 200 mm/min. The full scale load on the chart recorder was 16 kg. The testing procedures followed the methods outlined by Hampshire et al. (1987).

Water loss

Seven bell pepper fruits for each treatment were placed on an individual fruit tray in a cold room at 10°C, with 80–85% RH. The weights of each fruit were recorded at the same time for each measurement within ±1 min on day 2, 6, 9, 12, 15, and 18 of storage. Percentage fresh weight loss per initial fruit weight for each sample was calculated.

Figure 1—Respiration changes of control and coated bell peppers during storage at 10°C, 80–85% RH.
Internal gases analysis
Effects of edible coatings on internal CO\textsubscript{2} (Fig. 2) and O\textsubscript{2} (Fig. 3) of bell pepper fruits during storage were also compared. In general, internal CO\textsubscript{2} increased with storage time, while internal O\textsubscript{2} decreased. CL and SC coatings appeared to be the most effective gases barriers to internal CO\textsubscript{2} and O\textsubscript{2} among all treatments. Fruits coated with these two solutions had higher internal CO\textsubscript{2} concentrations and lower internal O\textsubscript{2} concentrations than others. However, gas barrier efficiencies of the two coatings were not sufficient at the RH used (80–85%) to achieve optimum CO\textsubscript{2} and O\textsubscript{2} levels which result in reduction of respiration rates. Low O\textsubscript{2} (2–5\%) has retarded bell pepper ripening and respiration, while high CO\textsubscript{2} with maximum up to 5\% delayed loss of green color (Otma, 1989; Exama et al., 1993). Furthermore, too high CO\textsubscript{2} concentrations resulted in calyx discoloration (Hardenburg et al., 1990). Fruits coated with WPI and SCB, those coated with MO, and those coated with 4\% glycerol showed no differences in internal CO\textsubscript{2} and O\textsubscript{2} compared to controls. The high RH of this study reduced the gas barrier properties of the hydrophilic film coatings, which are better gas barriers at RH ≤ 50\% (McHugh and Krochta, 1994). Protein- and polysaccharide-based edible coatings are likely to function best to lower respiration when recommended low temperature and high RH storage conditions cannot be provided for fruits and vegetables.

Color evaluation
None of the coatings substantially influenced color changes during storage. Hue, as represented by average hue angle (tan \(\frac{1}{2}\) b/a), of all bell pepper fruits remained in the range 120° to 130° (data not shown). A hue angle of 0° represents pure redness, while a hue angle of 180° represents pure greenness. Similarly, visual evaluation results showed no color changes for all coated peppers compared to controls. They were all scored at 1, which represented green color (data not shown).

Texture analysis
Changes in firmness of controls and coated bell peppers during storage were also compared (Fig. 4). MO coating significantly slowed softening of bell pepper fruits during storage. All other coatings appeared to have no effect on loss of firmness. After 20 days storage, all except MO-coated fruits had average firmness levels < 24N, which was considered the minimum for commercial acceptability (Hampshire et al., 1987).

The results from sensory evaluation (data not shown) also showed the same trends. The MO-coated fruits always had the highest sensory scores throughout storage, except on day 2 when there were no significant differences in texture among treatments. At the end of storage, only uncoated control fruits showed signs of decay (14\% of the control sample). None of the coated fruits showed any decay. However, at the end of storage all except MO-coated fruits showed shrinkage, softening and shrivelling. Thus, only MO-coated fruits were still marketable after storage. After 20 days, only MO-coated fruits had the score of 4 (which indicated fruits were still firm). For all other coated fruits including controls, firmness ratings were about 2 or 3.

Water loss
Comparisons were made on water loss from controls and coated fruits during storage, represented by % weight loss relative to initial fresh fruit weight (Fig. 5). MO coating significantly reduced moisture loss from fruit throughout storage. After 18 days, MO-coated fruits lost only 3.2\% moisture. MO-coated fruits were free from wilting and shrivelling, while all others showed moderate to severe wilting and shrivelling. MO-coated fruits still looked fresh and remained firm enough for marketability.

CONCLUSIONS
Due to its nonclimacteric respiratory pattern as well as moderately low respiration rate, bell pepper fruit seemed not to benefit from edible coatings that provided gas barrier properties.
The coating which provided moisture barrier characteristics was more important for bell pepper fruits, which are susceptible to moisture loss. The mineral-oil-based coating was a desirable edible coating for commercial application for fresh bell pepper fruit. Its excellent moisture barrier property resulted in reduced moisture loss, and maintained fruit firmness and freshness.

REFERENCES


Avena-Bustillos, R.J., Krochta, J.M., Saltveit, M.E., Jr., Rivas-Villegas, R.J., and Sunceda-Perera, F.A. 1994b. Optimization of edible coating formula-


Brashetz, R.J. 1980. Influence of modified atmosphere packaging on the mi-

Bussel, J., and Kenigsohn, Z. 1975. Packaging green bell peppers in re-

Dantwala, G. and Pepperman, G. 1994. Edible Films and Coatings: Character-


Experiments were performed at the University of California, Davis, in the Department of Food Science and Technology. The authors are grateful to The Commercial Storage of Prune, Apricot, and Plum and Nectarine Strohe for financial support. This research was supported by the USDA’s NRI program.

Experiments were performed at the University of California, Davis, in the Department of Food Science and Technology. The authors are grateful to The Commercial Storage of Prune, Apricot, and Plum and Nectarine Strohe for financial support. This research was supported by the USDA’s NRI program.