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การคงคุณภาพของพริกหวานสีแดงขายปลีกโดยใช้การเคลือบผิวสองชั้นด้วยไคโตซาน-แชลแลค
Retaining the Quality of Red Bell Peppers at Retail using a Chitosan-shellac Bilayer Coating

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Abstract

Bell pepper (*Capsicum annuum* L.) experiences a rapid loss of fresh weight, leading to shriveling and decay during postharvest handling. The aim of this study was to examine the impact of fruit coatings on the quality retention of bell peppers. Red bell peppers at the commercial stage were coated with a single layer of 1% chitosan (CH) or 10% shellac (SH) and a 1% chitosan–10% shellac bilayer composite coating (CH-SH), compared with a non-coated control during retail at 25±1°C, and 60–70% RH. Red bell peppers had a moderate respiration rate of 50-60 mg CO_2/kg/h, while ethylene was negligible. The respiration rates declined during retail without significance between treatments. As a result of the reduced hue angles, the surface colors of the fruit were more intense, while the L* value of the uncoated control rapidly decreased. From day 3 to day 12, CO_2 concentrations in the cavity of coated fruits were 5-6%, whereas O_2 concentrations ranged from 12 to 15%, compared to 2% CO_2 and 16-17% O_2 in the control. The accumulation of acetaldehyde was less than 4 ppm, and ethanol was not detected in all coated fruits. When the shearing forces of flesh slightly increased in coated fruits during retail, the flesh-soluble solids and phenolics in fruits were rarely altered. DPPH in coated fruits at final day was ranged from 81 to 123 µg TEA/g FW. Both single and double coatings with Shellac on bell peppers effectively reduced weight loss, which was correlated with withered scores. Chitosan-shellac bilayer coating significantly decreased fruit shriveling during storage, whereas non-coated fruit displayed an above-average withered score of 2 (out of 4) starting from day 6 of retail.

Keywords: *Capsicum annuum* L., non- climacteric, shriveling, coatings

บทคัดย่อ

พริกหวานมีการสูญเสียน้ำอย่างรวดเร็วซึ่งนำไปสู่การเหี่ยวและการเน่าเสียในระหว่างการจัดการหลังการเก็บเกี่ยว วัตถุประสงค์ของการศึกษานี้คือการใช้สารเคลือบผิวรักษาคุณภาพผลพริกหวาน โดยเคลือบผลพริกหวานสีแดงวัยทางการค้าแบบชั้นเดียวด้วยไคโตซานเข้มข้น 1% หรือแชลแลคเข้มข้น 10% และการเคลือบผิวแบบ 2 ชั้นด้วย 1% ไคโตซาน ตามด้วย 10% แชลแลค เปรียบเทียบกับผลที่ไม่ได้เคลือบผิว ในการจำลองวางจำหน่ายที่ 25±1°ซ ความชื้นสัมพัทธ์ 60-70% ผลพริกมีอัตราการหายใจอยู่ในระดับกลาง (50- 60 mg CO_2/kg/h) และผลิตเอทิลีนที่ต่ำมาก โดยมีอัตราการการหายใจลดลงระหว่างการวางจำหน่ายโดยไม่มีความแตกต่างระหว่างชุดทดลอง สีผิวอิ่มตัวมากขึ้นซึ่งสัมพันธ์กับ Hue angle ที่ลดลงในทุกชุดการทดลองโดยผลที่ไม่ได้เคลือบผิวมีค่า L* ลดลงอย่างรวดเร็ว ค่า CO_2 ในโพรงของผลที่เคลือบผิวเพิ่มอยู่ในช่วง 5-6% และ O_2 ในช่วง 12-15% ตั้งแต่วันที่ 3 ไปจนถึงวันที่ 12 (2% CO_2 และ 16-17% O_2 ในผลที่ไม่เคลือบ) ส่วนอะซีลตัลดีไฮน์สะสมมีค่าน้อยกว่า 4 ppm และไม่พบเอทานอลในผลที่เคลือบผิว ค่าของแข็งที่ละลายน้ำได้และสารประกอบฟีนอลในเนื้อแทบจะไม่มีการเปลี่ยนแปลงในทุกชุดทดลองและ ค่าแรงเฉือนเมิแนวโน้มเพิ่มขึ้นเล็กน้อยในผลที่เคลือบผิว ส่วนค่า DPPH ของผลอยู่ในช่วง 81-123 µg TEA/g FW นอกจากนี้ผลที่เคลือบด้วยแชลแลคทั้งแบบชั้นเดียวและ 2 ชั้น สามารถชะลอการสูญเสียน้ำได้ดี ซึ่งสัมพันธ์กับค่าคะแนนการเหี่ยว

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โดยผลที่เคลือบแบบ 2 ชั้นด้วยไคโตซาน-แชลแลคลดการเหี่ยวได้ดี ส่วนผลที่ไม่เคลือบผิวมีคะแนนการเหี่ยวเกิน 2 (จาก 4 คะแนน) ตั้งแต่วันที่ 6 ของการวางจำหน่าย

คำสำคัญ: *Capsicum annuum* L., non- climacteric การเหี่ยว การเคลือบผิว

Introduction

Sweet capsicums (*Capsicum annuum* L.), also known as bell or sweet peppers, are a member of the Solanaceae family originating in South America and now an important food crop internationally (O'Donoghue *et al*., 2018). Bell pepper has been receiving a lot of attention recently due to its suspected linkages to cardiovascular disease prevention, atherosclerosis, cancer, haemorrhage prevention, retardation of the ageing process, avoidance of cholesterol, and enhancement of physical resistance (Tiamiyu *et al*., 2023). Bell pepper fruit, due to its short shelf life, is susceptible to flaccidity, wilting, shriveling, fungal diseases, and decay. Shriveling, associated with quick water loss and decay, are the two major factors limiting storage life of bell peppers. The application of edible coating is a novel concept to enhancing postharvest shelf life of the horticulture produces by reducing the microbial infestation, respiration rate, lipid peroxidation, ethylene production and enzymatic reaction (Kumar *et al*., 2021). Coating materials may be made of proteins, lipids, polysaccharides, resins, or nature alone or in combination (Vaishali *et al*., 2019). Chitosan is a versatile biopolymer (poly[β-(1-4)-D-glucosamine]) and has a broad range of applications in fruit and vegetables because of its film-forming, biochemical properties, antimicrobial activity and elicitation of defense responses in plant tissues (Xing *et al*., 2011). On the other hand, Shellac is a natural polymer refined from a resinous substance excreted by an insect, *Laccifer lacca*, which is parasitic on certain trees, especially in India, Burma, Thailand, and southern China (Yuan *et al*., 2021). Shellac is non-toxic and physiologically harmless; therefore, it is listed as a GRAS (generally recognized as safe) substance by the FDA (Chitravathi *et al*., 2014). This study aimed to examine the impact of chitosan-shellac bilayer coating on the quality retention of red bell peppers.

Materials and methods

Red bell peppers at the commercial stage were bought from a local market and selected according to color, with no blemishes or visible signs of infection or decay. The selected fruits were washed with tap water, dipped in 200ppm Clorox for 3 minutes, and dried. The 1% chitosan coating solution was prepared by dissolving chitosan flakes (high molecular weight) in 1% glacial acetic acid. The 10% shellac coating was prepared by dissolving Shellac in 0.81% ammonia solution. Tween 20 (0.05%) was added to both solutions. The selected red bell peppers were divided into four groups: non-coated fruits (control),1% chitosan coating (CH), 10% shellac coating (SH) and chitosan-shellac bilayer coating (CH-SH). Surface coating was done by dipping the fruits into the solution for a minute and allowed to air dry. All bell peppers were stored at 25°C (60-70% RH) for 12 days. Some quality parameters and sensory were evaluated. The experiment was carried out in a completely randomized design (CRD) with 3 replications. All data measured was subjected to analysis of variance.

Results

Non-coated red bell pepper fruits only had a shelf life of 9 days, while coated fruits were able to reach 12 days. Weight loss was higher in control, reaching 13.96% on day 9, with other treatments observing no significant difference. At day 12 of storage, the bilayer coating showed 10.89% weight loss compared to 12.24% and 7.51% weight loss of chitosan and Shellac-coated fruits, respectively (Fig.1a). Wilting was also severe in control. However, no significant difference was observed between other treatments except at days 9 and 12 (Fig.1b). Respiration rates declined with storage period. No significant difference was observed between treatments (Fig.1c). Lightness decreased rapidly in control, while the slight changes occurred in coated fruits, but no significant difference was observed in all treatments (Fig.1e). The ΔE value increased with storage time (Fig1f). O_2 composition in the cavity showed a highly significant difference between treatments on days 3 and 9. Initially, O_2 levels were 16.01%, and on the final day, it was ranged between 13-15% (Fig.2a). CO_2 concentrations ranged between 2-6% on day 3 and day 12 between 2.7 and 6.7%, with bilayer-coated fruits having high CO_2 concentrations (Fig.2b). CH-SH bilayer showed more accumulation of acetaldehyde in fruit pulp than individual coatings (Fig.2c). Individually coated fruits showed more phenolic contents and antioxidant activity than the bilayer coated fruits at last day of storage. In contrast, there was a non-significant difference between treatments in total soluble solids (results not shown). Shellac-coated fruits had a total phenolic content of 90.76 µg/g FW followed by chitosan and bilayer coating with 84.82 µg/g FW at day 12 of storage (Fig.2.d). Antioxidant activity (DPPH) was lower at the final day of storage, showing a significant difference between the bilayer-coated and individually coated fruits (Fig. 2e).

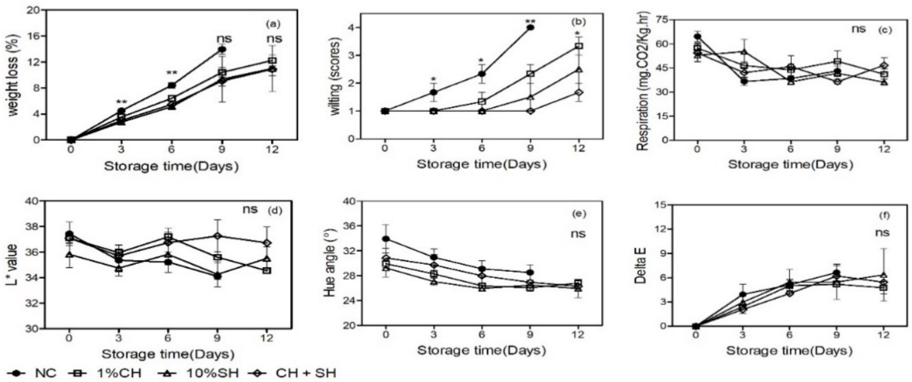

Figure1 Changes in weight loss(a), wilting score(b), respiration rate(c), L*values(d), hue angle(e) and ΔE(f) of red bell peppers retailed at 25°C, 60-70%RH for 12 days.

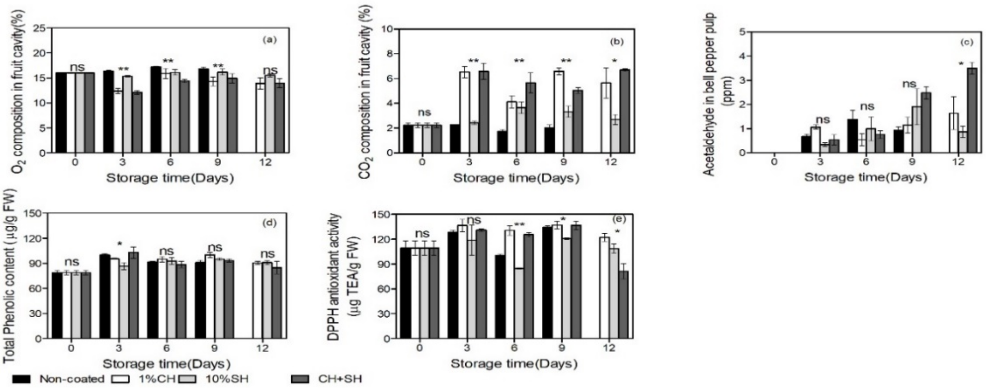

Figure 2 Changes in O_2(a) and CO_2(b) in fruit cavity, acetaldehyde in bell pepper pulp (c), total phenolic content(d) and antioxidant activity(e) of red bell peppers retailed at 25°C, 60-70%RH for 12 days.

Discussion

In this experiment, the efficacy of the CH-SH bilayer coating was examined. Our results show that edible coatings were able to lower moisture loss, ultimately delaying shriveling. This shows that coatings effectively reduced moisture loss and delayed shriveling by creating a partial barrier to gases and moisture. Chitosan was found to be effective in reducing water loss in cucumber and bell pepper (El Ghaouth *et al*.,1991). Shellac was applied to orange fruits (Khorram *et al*., 2017), effectively reducing water loss. Compared to individual coatings, the bilayer coating was not very effective in slowing down the respiration rate, and this could be attributed to the presence of coating cracks seen after drying, which alter coating permeability. The decline in *L** values and hue angle were due mainly to fruits turning to dark red color of the senescence (Kabir *et al*., 2019). An increase in CO_2 concentration in the fruit cavity and acetaldehyde in the pulp was observed following the application of coatings. The coatings did not promote excessive accumulation of CO_2 and acetaldehyde, leading to anaerobic respiration. The same results regarding CO_2 concentration inside fruit were also found by Poverenov *et al*. (2014) in red bell peppers. Acetaldehyde accumulation in coated bell peppers was less than 4 ppm, which is acceptable as it did not induce any off-flavors or ethanol accumulation. TPC and antioxidant activity were higher in individual coated fruits than in the bilayer coating at the end of retail. Higher TPC in individual coatings might be due to a higher metabolism leading to the degradation of certain phenolic compounds (Safari *et al*.,2021). At day 9 of storage, all coated fruits exhibited higher TPC than the control, with no significant difference between treatments. These results agreed with those found by Poverenov *et al*. (2014). Chitosan-coated peppers showed more antioxidant activity throughout the storage period. Poverenov *et al*. (2014) also found that chitosan-coated red bell peppers had higher antioxidant activity than CH-GL composite-coated ones.

Conclusions

The application of chitosan-shellac bilayer coating proved to have high potential in maintaining the quality of red bell peppers by reducing weight loss and retarding shriveling. The 1% CH- 10% SH bilayer extended the retail shelf life of red bell peppers at room temperature from 6 to 9 days, maintaining their quality and freshness. As such, further studies on the applications of this bilayer should be researched**.**

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References

Chitravathi, K., O.P. Chauhan and P.S. Raju.2014. Postharvest shelf-life extension of green chilies (*Capsicum annuum* L.) using shellac-based edible surface coatings. Postharvest Biology and Technology 92: 146–148.

El Ghaouth, A., J. Arul and R. Ponnampalam. 1991. Use of chitosan coating to reduce water loss and maintain quality of cucumber and bell pepper fruits. Journal of Food Processing and Preservation 15: 359-368.

Kabir, N.S., M. Chowdhury, W. Lee, Y. Hwang, S. Cho and S. Chung.2019. Influence of delayed cooling on quality of bell pepper (*Capsicum annuum* L.) stored in a controlled chamber. Emirates Journal of Food and Agriculture 31(4): 271-280.

Khorram, F., A. Ramezanian and S.M.H. Hosseini.2017. Shellac, gelatin, and Persian gum as alternative coating for orange fruit. Scientia Horticulturae 225: 22-28.

Kumar, N., Pratibha, Neeraj, A. Ojha, A. Upadhyay, R. Singh and S. Kumar.2021. Effect of active chitosan-pullulan composite edible coating enrich with pomegranate peel extract on the storage quality of green bell pepper. LWT - Food Science and Technology 138: 110435.

O’Donoghue, M.E., D.A. Brummell, J.M. McKenzie, D.A. Hunter and R.E. Lill. 2018. Sweet capsicum: postharvest physiology and technologies, New Zealand Journal of Crop and Horticultural Science 46(4): 269-297.

Poverenov, E., Y. Zaitsev, H. Arnon, R. Granit, S. Alkalai-Tuvia, Y. Perzelan, T. Weinberg and E. Fallik.2014. Effects of a composite chitosan–gelatin edible coating on postharvest quality and storability of red bell peppers. Postharvest Biology and Technology 96: 106–109.

Safari, Z.H., P. Ding, A.A. Sabir, A. Atif, A. Yaqubi and F.S. Yussoff. 2021. Maintaining antioxidants in tomato fruit using chitosan and vanillin coating during ambient storage. Food Research 5 (5): 274 – 286.

Tiamiyu, O.Q., S.E. Adebayo and N. Ibrahim. 2023. Recent advances on postharvest technologies of bell pepper: A review. Heliyon 9: e15302.

Vaishali, S., H.P. Sharma, Samsher, V. Chaudhary, Sunil and M. Kumar.2019. Importance of edible coating on fruits and vegetables: A review. Journal of Pharmacognosy and Phytochemistry 8(3): 4104-4110.

Xing, Y., X. Li, Q. Xu, J. Yun, Y. Lu and Y. Tang. 2011. Effects of chitosan coating enriched with cinnamon oil on qualitative properties of sweet pepper (*Capsicum annuum* L.). Food Chemistry 124:1443–1450.

Yuan, Y., N. He, Q. Xue, Q. Guo, L. Dong, M.H. Haruna, X. Zhang, B. Li and L. Li. 2021. Shellac: A promising natural polymer in the food industry. Trends in Food Science and Technology 109: 139–153.