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Application of Guar Gum as Edible Coating to Prolong Shelf Life of Red Chilli Pepper (*Capsicum frutescens L.*) Fruit during Preservation

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Abstract.

Fruits of red chilli pepper (Capsicum) contained capsaicinoids, a family of compounds that give them the characteristic pungent taste. Red chilli pepper contains lycopene, a red carotenoid pigment that has strong antioxidant properties. Red chilli pepper is highly perishable and loses its freshness and flaccidity soon after harvest, reducing not only the visual appeal of the bell pepper fruit but also the quality. Edible coatings are an attractive strategy to protect vegetables during postharvest. Edible coatings are widely used for extension of shelf life of fruits and vegetables by reduction of moisture loss and gas exchange as well as reduction of the physiological disorders. The main problem of postharvest losses associated with Red chilli pepper is rapid loss of firmness, soluble dry matter, and carotenoid. The objective of the present study was to identify the effect of different guar gum concentrations (0.2%, 0.3%, 0.4%, 0.5%, 0.6%) and storage temperature (2 ^{o}C, 6 ^{o}C, 10 ^{o}C, 14 ^{o}C) to the weight loss, firmness, total soluble sugar and carotenoid in red chilli pepper (*Capsicum frutescens L.*) fruits during storage. Moreover, shelf life (0 day, 5 days, 10 days, 15 days and 20 days) of red chilli pepper (*Capsicum frutescens L.*) fruit in storage also clarified. Results demonstrated that Guar gum 0.5% and storage temperature 6 ^{o}C could maintain red chilli pepper (*Capsicum frutescens L.*) fruit quality for 20 days without any deterioration. This is an opportunity to develop value-added products reducing the postharvest losses, improving nutritional value and generating additional revenue for red chilli pepper growers. Coating fruits with substances that form semi-permeable film is another method used to delay ripening and prolong the storage life of produce.

Keywords: *Red chilli pepper, guar gum, coating, firmness, carotenoid, shelf life, storage*

I. INTRODUCTION

Capsicum frutescens is an annual or short-lived perennial herb. The stem of *Capsicum frutescens* almost striate, glabrous, highiet between 1-4 feet depending on climate and growing conditions. The leaves are elliptical, slightly leathery, dark green and smooth. The flowers are typically conical or funnel form with five petals, usually fused and color is white. The fruits are erect, ellipsoid-conical to lanceoloid, 10-20 mm long, 3-7 mm in diameter. These fruits have range in color from green when immature to purple, red, orange or yellow when ripe (Menichini F et al., 2009). The plant grows in tropical climates, because it needs a warm, humid climate to survive (Barham P et al., 2010; Anthony OE et al., 2013). Capsicum is a tropical and an important agricultural crop and one of the popular vegetables, not only because of its economic value, but also for the combination of color, taste and nutritional values of its fruit (Nadeem M et al., 2011; Kouassi KC and Koffi NR, 2012). Capsicum was used as a colourant, flavourant, and/or as a source of pungency. The main source of pungency in peppers is the chemical group of alkaloid compounds called capsaicinoids. The red colour of mature pepper fruits is due to several related carotenoid pigments, including capsanthin, capsorubin, cryptoxanthin, and zeaxanthin, which are present as fatty acid esters. Capsicum frutescens was also used traditionally as an external therapy in painful muscle spasms in areas of shoulder, arm and spine; for treating arthritis, neuralgia, lumbago and chilblains. In addition, it also used for the treatment of diabetes, blood pressure [high/ low], bronchitis, burning feet, to increase circulation, relieve rheumatic pain, treat mouth sores and infected wounds, reduce blood clots, and aid digestion by stimulating saliva and gastric juice flow (Sunil P et al., 2012; Anthony OE et al., 2013). Many bioactive compounds were isolated from Capsicum frutescens including essential oils, alkaloids, glycosides, phenolic compounds, flavonoids, ester, terpenoids, noncarotenoids, lipoxygenase derivatives, carbonyls, alcohols, hydrocarbons, hydroxybenzoic acid, hydroxycinnamic acid, ascorbic acid, tannins, steroids, capsaicin, dihydrocapsaicin, capsiconinoid, capsinoid.

There were several researches mentioned to Red chilli pepper (*Capsicum frutescens L.*) preservation using edible coating. The effect of chitosan coating (1.0 and 1.5% w/v) on the storability of bell pepper stored at 13 and 20^{o}C (RH 85%) was determined by monitoring the weight loss, respiration and qualily (Ahmed El Ghaouth et al., 1991). 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 (Sirichit Lerdthanangkul and John M. Krochta, 1996). Shellac-based coatings were developed in combination with starch, EDTA and sodium alginate and were evaluated for shelf-life extension of fresh green chillies during storage at ambient temperature (26 ± 2 °C, RH 68 ± 4%) for 12 days

(K.Chitravathi et al., 2014). Effects of combining packaging and temperature preservation on cayenne pepper quality was examined (Nguyen Thi Hong Tham, Nguyen Phuoc Minh, 2014). Shellac-based surface coating was used in combination with passive modified atmosphere (MA) packaging for shelf life extension of fresh green chillies. Shellac coating along with the passive MA packaging resulted in restriction of metabolic activities (respiration) and delayed senescence and was found most effective in maintaining the postharvest quality of green chillies during low temperature storage (K. Chitravathi et al., 2016). Polyvinyl acetate-covinyl alcohol coating reduced weight loss, preserved fruit firmness, modified color, increased citric and ascorbic acid concentrations, reduced pectin methylesterase and polygalacturonase activity as well as respiration rate (Ortiz-Hernández et al., 2017). A study was carried out to investigate the influence of food grade coatings on fruit quality and storage life of bell pepper at 8±1∘ C with 90–95% RH for 24 days (Abad Ullah et al., 2017). Green chillies were coated with a composite edible coating composed of gum arabic (5%), glycerol (1%), thyme oil (0.5%) and tween 80 (0.05%) to preserve the freshness and quality of green chillies and thus reduce the cost of preservation (Sreejit Valiathan and K.A. Athmaselvi, 2018).

During the post-harvest, there is massive damage due to microbes, insects, respiration and transpiration (Raghav et al., 2016). Postharvest quality of red chilli pepper is influenced by various factors like moisture loss and chilling injury (CI) that deteriorate the quality of bell pepper fruit during postharvest operations (K. Maalekuu et al., 2002). The important excellence factors of fresh product that influence marketability consist of colour, texture, appearance, flavour, nutritional quality and microbial safety (Lin and Zhao, 2007). The objective of the present study was to identify the effect of different Guar gum concentrations (0.2%, 0.3%, 0.4%, 0.5%, 0.6%) and storage temperature (5 ^{o}C, 10 ^{o}C, 15 ^{o}C, 20 ^{o}C) to the weight loss, firmness, total soluble sugar and carotenoid in red chilli pepper (*Capsicum frutescens L.*) fruits during preservation. Moreover, shelf life (0 day, 5 days, 10 days, 15 days and 20 days) of red chilli pepper (*Capsicum frutescens L.*) fruit in storage also clarified.

II. Materials And Method

2.1 Materials

We collected red chilli pepper (*Capsicum frutescens L.*) fruits in Vinh Chau district, Soc Trang province, Vietnam. They were cultivated following VietGAP to ensure food safety. After harvesting, collected nuts were stored at a temperature of 8˚C and they were conveyed to laboratory within 8 hours for experiments. These fruits were tumbled thoroughly under turbulent moving to remove dirt, dust and adhered unwanted material. Beside red chilli pepper we also used other materials during the research such as Guar gum, ethyl alcohol, propylene glycol. Lab utensils and equipments included digital weight balance, penetrometer, refractometer, biuret, and refrigerator.

Figure 1. Red chilli pepper (*Capsicum frutescens* L.**)**

2.2 Methods

2.2.1 Preparation of edible coatings

Guar gum (0.2%, 0.3%, 0.4 %, 0.5%, 0.6%) was prepared by dissolving 0.4g, 0.6g, 0.8 g, 1.0 g, 1.2g of guar gum powder in 200 ml of water ethyl alcohol mixture (4:1) at 75 ^{o}C and stirred for 15 min using magnetic stirrer. Ethyl alcohol was added in order to reduce drying time and obtain a transparent and shiny coating. 1% volume of propylene glycol was also added in the formulation as plasticizer. Red chilli pepper (*Capsicum frutescens L.*) fruits were dipped in the film forming dispersions for 2 min. After that, they were hung up and dried at room temperature with natural convection for 2.5 h and then stored in refrigerator for further experiments.

2.2.2 Fruit quality assessments

The physical and chemical compositions including weight loss (%), firmness (N), total soluble solid (^{o}Brix), and carotenoid (mg/ml) in fresh and coated Red chilli pepper (*Capsicum frutescens L.*) were analyzed.

Weight loss (%): To evaluate weight loss, separate samples in 3 replicates of each treatment were used. The same samples were evaluated for weight loss each time at weekly intervals until the end of experiment. Weight loss was determined by the following formula: Weight loss (%) = [(A−B)/A] x 100 where A indicates the fruit weight at the time of harvest and B indicates the fruit weight after storage intervals (A.O.A.C., 1994).

Firmness (N): Firmness was measured as the maximum penetration force (N) reached during tissue breakage, and determined with a 5 mm diameter flat probe. The penetration depth was 5 mm. Red chilli pepper (*Capsicum frutescens L.*) was cut into halves and each half was measured in the central zone.

Total soluble solids (^{o}Brix): Total Soluble Solids (TSS) of the red chilli pepper was determined by the method described by L. Dong et al. (2001) in ∘ Brix by placing a juice drop on the lens of a handheld refractometer.

Carotenoid (mg/ml): Carotenoid content was measured by near infrared spectroscopy (Elena Tamburini et al., 2017)

2.2.3 Effect of different Guar gum concentrations to weight loss, firmness, total soluble solid, carotenoid of Red chilli pepper (Capsicum frutescens L.) fruit

Effect of different guar gum concentrations (0.2%, 0.3%, 0.4%, 0.5%, 0.6%) to weight loss (%), firmness (N), total soluble solid (^{o}Brix), carotenoid (mg/ml) was assessed. All samples were preserved in 6^{o}C for 5 days.

2.2.4 Effect of storage temperature to shelf life of Red chilli pepper (Capsicum frutescens L.) fruit

After finding the appropriate Guar gum coating concentration (%), shelf life of red chilli pepper (*Capsicum frutescens L.*) fruit was also evaluated by the effect of different storage temperature. Red chilli pepper (*Capsicum frutescens L.*) fruits which were set in trays in were divided into four groups (2 ^{o}C, 6^{o}C, 10 ^{o}C and 14 ^{o}C). Weight loss, firmness, total soluble solid, carotenoid values were assessed during preservation (5 days) to demonstrate the appropriate storage temperature.

2.2.5 Shelf-life of Red chilli pepper (Capsicum frutescens L.) fruit during preservation

After finding the appropriate guar gum concentration, storage temperature; shelf life of red chilli pepper (*Capsicum frutescens L.*) fruit during preservation was also evaluated by sampling at different intervals (0, 5, 10, 15, 20 days). Weight loss, firmness, total soluble solid, carotenoid values were assessed.

2.3 Statistical analysis

The Methods were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Statgraphics Centurion XVII.

III. RESULTS & DISCUSSION

3.1 Physical and chemical characteristics in fresh Red chilli pepper (*Capsicum frutescens L.*) fruit

The physical and chemical compositions in fresh Red chilli pepper (*Capsicum frutescens L.*) fruit were analyzed. Resuts were mentioned in table 1.

Table 1. The chemical compositions in fresh Red chilli pepper (*Capsicum frutescens L.*) fruit

Parameter	Firmness (N)	Total soluble solid (^{o}Brix)	Carotenoid (mg/g)
Value	1425.38±14.7	12.36±0.01	29.30±0.02

3.2 Effect of different Guar gum **concentrations to weight loss, firmness, total soluble solid, carotenoid of Red chilli pepper (*Capsicum frutescens L.*) fruit**

Effect of different Guar gum concentrations (0.2%, 0.3%, 0.4%, 0.5%, 0.6%) to weight loss (%), firmness (N), total soluble solid (^{o}Brix), carotenoid (mg/ml) was assessed. All samples were preserved in 6^{o}C for 5 days. Results were depicted in table 2. As clearly shown in table 2, all edible coatings significantly (P< 0.05) retard the changes in red chilli pepper (*Capsicum frutescens L.*) weight loss, firmness, total soluble solid and carotenoid as compared to control samples. 0.5% Guar gum coating was appropriated for further experiments.

Table 2. Effect of different Guar gum concentrations to weight loss (%), firmness (N), total soluble solid (^{o}Brix), carotenoid (mg/g) of red chilli pepper (*Capsicum frutescens L.*) fruit during preservation (6^{o}C after 5 days)

Guar gum **concentration (%)**	Weight loss (%)	Firmness (N)	Total soluble solid (^{o}Brix)	Carotenoid (mg/g)
Control	4.06±0.01^{a}	1362.17±16.4^{c}	12.04±0.01^{c}	26.05±0.03^{c}
0.2	3.77±0.03^{ab}	1374.55±14.2^{bc}	12.74±0.03^{bc}	26.34±0.02^{bc}
0.3	2.89±0.01^{b}	1388.84±17.5^{b}	12.87±0.01^{b}	26.92±0.02^{b}
0.4	2.37±0.00^{bc}	1403.01±14.6^{ab}	13.03±0.01^{ab}	27.13±0.01^{ab}
0.5	**1.20±0.02^{c}**	**1415.07±15.9^{a}**	**13.40±0.03^{a}**	**27.32±0.03^{a}**
0.6	1.23±0.01^{c}	1418.05±13.8^{a}	13.42±0.00^{a}	27.39±0.02^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 3. Effect of storage temperature to weight loss (%), firmness (N), total soluble solid (^{o}Brix), carotenoid (mg/ml) of Red chilli pepper (*Capsicum frutescens L.*) fruit

Storage temperature (^{o}C)	Weight loss (%)	Firmness (N)	Total soluble solid (^{o}Brix)	Carotenoid (mg/ml)
2 ^{o}C	1.18±0.02^{b}	1410.85±15.6^{a}	13.43±0.02^{a}	27.29±0.03^{a}
6 ^{o}C	**1.20±0.02^{b}**	**1415.07±15.9^{a}**	**13.40±0.03^{a}**	**27.32±0.03^{a}**
10 ^{o}C	1.48±0.02^{ab}	1398.48±14.9^{ab}	12.91±0.01^{ab}	26.14±0.02^{ab}
14 ^{o}C	1.92±0.01^{a}	1354.33±13.7^{b}	12.30±0.02^{b}	25.98±0.01^{b}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 4. Shelf life of Red chilli pepper (*Capsicum frutescens L.*) fruit during preservation

Preservation time (days)	Weight loss (%)	Firmness (N)	Total soluble solid (^{o}Brix)	Carotenoid (mg/g)
0	0^{d}	1415.07±15.9^{a}	13.40±0.03^{a}	27.32±0.03^{a}
5	1.03±0.03^{c}	1403.38±10.1^{ab}	13.29±0.02^{ab}	26.89±0.00^{ab}
10	1.38±0.00^{b}	1397.46±10.2^{b}	13.05±0.01^{b}	26.32±0.03^{b}
15	1.84±0.01^{ab}	1388.29±10.0^{bc}	12.90±0.03^{bc}	26.01±0.02^{bc}
20	2.00±0.02^{a}	1374.57±10.1^{c}	12.71±0.01^{c}	25.79±0.03^{c}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

The effect of chitosan coating (1.0 and 1.5% w/v) on the storability of bell pepper stored at 13 and 20°C (RH 85%) was determined by monitoring the weight loss, respiration and quality. Chitosan coating markedly reduced the weight loss in both bell pepper at both temperatures. Increasing the concentration of chitosan from 1.0 to 1.5% (wh) resulted in a significantly greater weight retention in both fruits. In addition, coating bell pepper with chitosan reduced the respiration rate, loss of color; wilting and fungal infection (Ahmed El Ghaouth et al., 1991).

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 followed by measurement of changes in respiration, internal gases, color, firmness, and water loss during storage at 107C, 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 firmness and thereby prolonging fruit freshness (Sirichit Lerdthanangkul and John M. Krochta, 1996).

The green chillies were coated with shellac coating, packed in anti-fog film and kept at 8 ± 1 °C for storage along with uncoated control. The coated and MA packed chillies showed significantly lower respiration rates as compared to control. The physico-chemical characteristics showed significantly lesser variations in terms of physiological loss in weight, firmness, colour, pigments, ascorbic acid and antioxidant activity during storage. A shelf life extension of 48 days was observed for coated and MA packed chillies against uncoated and MA packed (28 days) and control (15 days) ones. Shellac coated chillies showed a shelf life of 30 days at 8 ± 1 °C (K. Chitravathi et al., 2016).

the chillies were coated with the composite edible coating using the dipping method with three dipping times (1, 3 and 5 min). The physicochemical parameters of the coated and control chillies stored at room temperature (28±2ºC) were evaluated at regular intervals of storage. There was a significant difference ($p \leq 0.05$) in the physicochemical properties between the control chillies and coated chillies with 1, 3 and 5 min dipping times. The coated green chillies showed significantly ($p \leq 0.05$) lower weight loss, phenolic acid production, capsaicin production and significantly ($p \leq 0.05$) higher retention of ascorbic acid, total chlorophyll content, colour, firmness and better organoleptic properties. The composite edible coating of gum arabic and thyme oil with 3 min dipping was effective in preserving the desirable physico-chemical and organoleptic properties of the green chillies up to 12 days, compared to the uncoated chillies that had a shelf life of 6 days at room temperature (Sreejit Valiathan and K.A. Athmaselvi, 2018).

3.3 Effect of storage temperature to weight loss, firmness, total soluble solid, carotenoid of Red chilli pepper (*Capsicum frutescens L.*) fruit

After finding the appropriate Guar gum coating concentration (%), shelf life of Red chilli pepper (*Capsicum frutescens L.*) fruit was also evaluated by the effect of different storage temperature. Results were elaborated in table 3. Storage temperature for Red chilli pepper (*Capsicum frutescens L.*) should be 6°C which was appropriated for further experiments.

A study was carried out to investigate the influence of food grade coatings on fruit quality and storage life of bell pepper at 8±1∘ C with 90–95% RH for 24 days. Coating treatments were given to bell pepper fruits by dipping in aqueous solutions of gum arabic (6, 9, and 12%), Aloe vera gel (4, 5, and 6%), and cinnamon oil (0.5, 0.75, and 1%). Physicochemical characteristics as well as quality of bell pepper fruits improved in all coating treatments. Results revealed that 12% gum arabic coating exhibited significantly reduced weight loss, membrane leakage, chilling injury, and decay incidence with less increase in pH, total soluble solids, and sugar percentage, whereas appealing fruit color ($L*$, $a*$, and $b*$) along with higher values of ascorbic acid (1.84 mg/100 g), titratable acidity (0.19%), and firmness (4 N) was observed in cold storage environment. Their results clearly suggested that coating of bell pepper fruits with 12% gum arabic can maintain postharvest storage quality of bell pepper fruits (Abad Ullah et al., 2017).

3.4 Shelf-life of Red chilli pepper (*Capsicum frutescens L.*) fruit during preservation

The right edible coating formulation could reduce water loss and gas exchange rates as well as represent an excellent way of incorporating additives to control reactions that are detrimental to produce quality during storage and transport. Edible coatings are thin films that can be used as a new trend in post-harvest by reducing moisture and solute migration, gas exchange, respiration, and oxidative reaction rates, as well as by reducing physiological disorders. Edible coatings applied on many products to provide a barrier against external elements and therefore increase shelf life. After finding the appropriate 0.5% Guar gum concentration, storage temperature at 6°C; shelf life of Red chilli pepper (*Capsicum frutescens L.*) fruit during preservation also evaluated by sampling in different intervals (0, 5, 10, 15, 20 days). Results were also mentioned in table 4. Quality of Red chilli pepper (*Capsicum frutescens L.*) fruits which were coated by 0.5% Guar gum and stored at 6 °C was maintained for 20 days without any deterioration.

In another study, gum arabic coating reduced textural damage and decay of green bell pepper (E. Ochoa-Reyes et al., 2013), whereas gum arabic in combination with silver nanoparticles inhibited microbial growth and increased shelf life of green bell peppers (S. Hedayati and M. Niakousari, 2015). Previously, cinnamon oil in combination with chitosan reduced decay percentage in

sweet peppers (Y. Xing et al., 2011). Shellac-sodium alginate based coating was found to be the most effective in maintaining the quality of fresh green chillies during ambient storage as compared to other coatings (K.Chitravathi et al., 2014).

IV. CONCLUSION

Red chilli pepper is the most commonly used fruit of the solanaceous family with excellent nutritive value and a high content of ascorbic acid and vitamins such as vitamins A and E and whole range of vitamin B complex. Red chilli pepper fruit, due to its short shelf life, is susceptible to flaccidity, wilting, shriveling, fungal diseases, and decay. These problems reduce premium price in market and consumer acceptance after harvest. This research has successfully found out the appropriate conditions for maintaining Red chilli pepper (*Capsicum frutescens L.*) fruit quality such as Guar gum coating concentration, storage temperature as well as extending product shelf life. The increase in shelf life of Red chilli pepper fruit would, therefore, be an advantage to the growers. The results of this study could be used in red chilli pepper industry to delay the loss in freshness and improve the storage life of bell pepper fruits during cold storage.

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