International Journal of Agricultural Technology 2017 Vol. 13(7.1): 1449-1457
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Effect of Carboxymethyl Cellulose as Edible Coating on Postharvest Quality of Rambutan Fruit under Ambient Temperature

Kasinee Saowakon[1] Rujira Deewatthanawong[2] and Lampan Khurnpoon[1*]

[1]Department of Plant Production Technology, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand. [2]Thailand Institute of Scientific and Technological Research, Khlong Luang, Pathum Thani 12120, Thailand.

Kasinee Saowakon, Rujira Deewatthanawong and Lampan Khurnpoon (2017). Effect of Carboxymethyl Cellulose as Edible Coating on Postharvest Quality of Rambutan Fruit under Ambient Temperature. International Journal of Agricultural Technology 13(7.1): 1449-1457.

Rambutan fruits are sensitive to water loss after harvest, because of the high density of stomata in the spinterns. Carboxymethyl cellulose (CMC) is one of polysaccharide edible coatings which can be extracted from plants. This research was to study the effects of commercial CMC and water hyacinth (*Eichhornia crassipes*) extracted CMC on postharvest quality of rambutan fruit cv. Rongrien. The experiment was performed under completely randomized design (CRD) with 3 treatments comprising of 0.5 % CMC_{com}, 0.5 % CMC_{wh}, and non-coated treatment. Each treatment was replicated 4 times, with 8 fruits per replicate. Treated fruits were placed in the plastic baskets and stored under ambient temperature for three days. The results showed that, fruits coated with 0.5% CMC_{com} and CMC_{wh} were not significantly different in weight loss and fruit firmness, but non-coated fruits tend to have higher weight loss and fruit firmness than coated fruits during storage. All treatments showed a decline in L*, a*, and b* values of the fruit pericarp which was negatively correlated with pericarp browning. On day 2 of storage, significant differences of browning were observed, the highest score (3) was found in non-coated fruits while the score of coated fruits was 1.5. The total soluble solids slightly decreased in all treatments to about 20 % at the end of storage, while the titratable acidity increased from 0.4 to 0.6 %. The sensory evaluation (score) of the fruits coated with 0.5% CMC_{com} and CMC_{wh}, and non-coated were 2.8, 2.5, and 1.5, respectively. Higher vitamin C content was found in coated fruits at the concentration of 4.5 mg/100g fresh weight. We conclude that, fruits coated with CMC could not effectively reduce weight loss, but could maintain eating quality and vitamin C content during storage.

Keywords: browning, edible coating, firmness, sensory, rambutan

Introduction

Rambutans (*Nephellium lappaceum*) is a non-climacteric fruit and one of the most popular tropical fruits in the Spindaceae family (O'Hare, 1995). The Rongrien rambutan is one of the best known and cultivated cultivar in

[*]**Corresponding author**: Lampan Khurnpoon; **E-mail address**: kplampan@gmail.com

Thailand with exotic flavour and sweet pulp. Currently, Thailand is the world's largest producer and exporter of Rongrien rambutan. However, pericarp browning is a major problem that leads to decrease in attractive appearance and shorten postharvest shelf life of rambutan (Peter and Suzanne, 2000).

Edible coatings are alternatives for extending the postharvest life of fresh fruits and vegetables. They form a semi-permeable barrier to gases and water vapor and thereby reduce respiration and weight loss (Adetunji *et al.*, 2013). In addition, edible coatings can potentially carry other natural active ingredients such as anti-browning agents, flavours, and nutrients (Dhall, 2013). The edible coating can be divided into 3 groups including lipid, protein, and polysaccharide (Bourtoom, 2008).

Polysaccharide-based coatings include starch, alginates, carrageenan, and cellulose derivatives. Carboxymethyl cellulose (CMC) is a derivative of cellulose and prepared by a reaction of cellulose with sodium hydroxide and chloroacetic acids (Biswal and Singh, 2004). Characteristics of CMC are generally odorless and tasteless, flexible, transparent, and non-toxic (Dhall, 2013). Nowadays, CMC is widely used in food and pharmaceutical industries. In addition, CMC can be produced from agricultural waste such as papaya peel (Rachtanapun *et al.*, 2007), *Mimosa pigra* (Rachtanapun and Rattanapanone, 2011), durian rind (Rachtanapun *et al.*, 2011), and pomelo peel. Water hyacinth (*Eichhornia crassipes*) is a plant that is considered as a weed with negative impact to ecosystems. Using water hyacinth as a new source of raw material for synthesis of CMC is another way to make use of this invasive plant species since it has high cellulose content. Many research have applied CMC for prolong shelf-life of fresh products such as avocado (Maftoonazad and Ramaswamy, 2005), peach and pear (Togˇrul and Arslan, 2004), mango (Rachtanapun *et al*., 2008), and cucumber (Adetunji *et al*., 2013).

This research aimed to study the effects of commercial CMC and CMC extracted from water hyacinth on postharvest quality of rambutan fruit cv. Rongrien under ambient temperature.

Materials and methods

Materials

Water hyacinth plants were obtained from canal in Thanyaburi Klong 6, Phathum Thani, Thailand. Chemicals used for synthesis of CMC from water hyacinth were Sodium hydroxide (AR grade), 90 % acetic acid, isopropanol, chloroacetic acid, absolute methanol, and 70 % ethanol.

Preparation of carboxymethyl cellulose from water hyacinth

The water hyacinth plants were washed, dried, and ground. The dried powder was then extracted with 1 % (w/v) sodium hydroxide (NaOH) solution at the ratio of cellulose to solvent being 1: 30 (w/v) at 90 °C for 3 h. The mixture was filtered, washed with water until neutral and dried at 80 °C. The dried cellulose was passed through 100 mesh sieves and kept in the polyethylene bags.

Fifteen grams of prepared cellulose was mixed with 450 ml of isopropanol, and 50 ml of 30 % NaOH solution in a beaker for 30 min. Then, 18 g of chloroacetic acid was added into the mixture and stirred for 1.5 h. The mixture was covered with aluminium foil and placed in an oven at 55 °C for 3.5 h. The obtained solid was neutralized with 90 % acetic acid, filtered, washed 5 times with ethanol and 1 time with methanol. The final product CMC_{wh} was obtained after drying at ambient temperature.

Rambutan fruit

Fruits of rambutan cv. Rongrien at commercial maturity (75 % red, and 25% reddish orange) were transported from Talaad Thai wholesale market (Pathum Thani, Thailand) to the laboratory within 1 h. Fruits were selected for uniformity of size, color, and free of diseases. Selected fruits were dipped in cool water (10 °C) and 500 ppm of chlorine followed by air drying at ambient temperature for 10 min.

CMC coating

The fruits were randomly divided into three groups. Each group consisted of 4 replicates of 8 fruits per replicate. The fruits were dipped for 5 min in solution of 0.5 % (w/v) of commercial carboxymethyl cellulose (CMC_{com}), and 0.5 % (w/v) of CMC_{wh} and non-coated as the control treatment. Treated fruits were placed in plastic baskets and stored under ambient temperature (25 °C) and relative humidity of 85 %. The fruits of each group were evaluated every day.

Quality measurements

Weight loss was determined and expressed as the percentage of the initial weight. Color of the peel was measured by a chromameter CR400 (Minolta, Osaka Japan) and shown as L* value represented the lightness, a* value represented the redness (+) or greenness (-) and b* value represented the yellowness (+) or blueness (-). Pericarp browning was evaluated using the following scale: 0, no browning: 1, up to 25 % browning: 2, 50 % browning: 3, 75 % browning and 4, 100 % browning (score greater than 3 is unacceptable). The fruit firmness was measured by Lloyd food texture analyzer (Model TA 500) using a 0.6 mm of probe diameter at speed 100 mm/min, depression limit 1 cm, and trigger 1 N. The data were expressed as Newton (N). The total soluble solids (TSS) content and the titratable acidity (TA) from rambutan juice was determined by pocket brix-acidity meter (ATAGO®) reported as % Brix and % TA, respectively. Vitamin C content was analyzed by titration with 2, 6-dichlorophenol indophenol (AOAC, 1990). And sensory evaluation of sweetness and acidity of each fruit was graded using a score of 0 = abnormal, 1 = poor, 2 = average, 3 = good, and 4 = excellent.

Results

Weight loss of rambutan fruit increased during storage and the percentage of weight loss after 3 days storage under ambient temperature in fruits coated with CMC_{com}, CMC_{wh}, and non-coated was 19.0 %, 19.1%, and 19.4 %, respectively, but there was no significant difference among the three studied groups (Table 1).

All treatments showed a decline in lightness (L*), redness (a*), and yellowness (b*) as the fruit developed more pericarp browning during storage. (Table 1 and Figure 2). Our results show that both CMC coatings could delayed pericarp browning (Table 1 and Figure 2).

Non-coated fruits showed an increase in firmness during storage while firmness of coated fruits declined on day 1 and slightly increase afterward. The non-coated fruits had the highest firmness value of 38.0 N on day 3. Fruit firmness of fruits coated with CMC_{com} and CMC_{wh} was 31.7 N and 35.0 N, but they were not significantly different. (Figure 1a).

During a 3-day storage period, total soluble solids of non-coated fruits and fruits coated with CMC_{com} and CMC_{wh} decreased from 21.8 to 20.2, 21.3 and 20.8 %Brix, respectively (Table 2). At the beginning of the experiment, titratable acidity was 0.4 % and remained relatively unchanged in the first 2 days. The titratable acidity slightly increased on day 3 to a value of 0.6 % (Table 2). Eating quality as shown by TSS/TA ratio decreased during storage. At the end, the fruits coated with CMC_{wh} had the highest eating quality of 36.2, while the TSS/TA ratio was 34.4 in CMC_{com} coated fruits and 32.9 in non-coated fruits (Figure 1b). The sensory evaluation of the non-coated fruits decreased from 4.0 to 1.5 on day 3 and coated fruits showed higher score of 2.8 and 2.5 in fruits coated with CMC_{com} and CMC_{wh}, respectively (Table 2).

Vitamin C content of non-coated fruits declined from 4.1 mg/100gFW to 3.1 mg/100gFW while vitamin C levels in fruits coated with CMC_{com} and CMC_{wh} slightly increased to 4.4 mg/100gFW and 4.5 mg/100gFW, respectively (Figure 1c).

Table 1. Effect of CMC edible coating on weight loss, color change, (L*, a*, and b*), and pericarp browning of Rongrien rambutan stored under ambient temperature for 3 days.

Parameters		Treatments	Storage time (Days)			
			0	1	2	3
Weight loss (%)		Control	-	7.8±1.1[a]	13.4±0.4[a]	19.4±0.9[a]
		0.5 % CMC_{com}	-	6.7±1.6[a]	13.6±0.9[a]	19.0±1.4[a]
		0.5 % CMC_{wh}	-	7.7±0.7[a]	13.4±0.7[a]	19.1±0.5[a]
Color	L* value	Control	30.6±1.4[a]	29.5±2.3[a]	28.3±1.6[a]	26.0±1.6[a]
		0.5 % CMC_{com}	30.6±1.4[a]	30.7±1.1[a]	28.5±2.1[a]	26.4±2.1[a]
		0.5 % CMC_{wh}	30.6±1.4[a]	27.7±1.3[a]	26.9±2.0[a]	27.0±2.0[a]
	a* value	Control	28.6±6.5[a]	28.0±2.7[a]	29.6±2.0[a]	27.0±3.1[a]
		0.5 % CMC_{com}	28.6±6.5[a]	24.2±6.2[a]	29.6±2.3[a]	24.4±6.2[a]
		0.5 % CMC_{wh}	28.6±6.5[a]	29.8±2.0[a]	28.7±3.8[a]	27.1±3.9[a]
	b* value	Control	23.4±2.1[a]	17.5±2.9[a]	16.7±0.4[a]	13.4±0.9[a]
		0.5 % CMC_{com}	23.4±2.1[a]	17.5±1.1[a]	16.7±1.7[a]	15.0±2.1[a]
		0.5 % CMC_{wh}	23.4±2.1[a]	19.9±1.7[a]	16.4±2.5[a]	15.1±0.8[a]
Pericarp Browning (score)		Control	0.0±0.0	1.5±0.6[a]	3.0±1.5[a]	3.8±0.6[a]
		0.5 % CMC_{com}	0.0±0.0	1.3±0.5[a]	1.5±0.6[b]	3.0±0.8[a]
		0.5 % CMC_{wh}	0.0±0.0	1.3±0.5[a]	1.5±0.6[b]	2.8±0.5[a]

Mean with the same letter in the same column for each quality parameters are not significantly different at $p<0.05$.

Table 2. Effect of CMC edible coating on total soluble solids (TSS), titratable acidity (TA), sensory of Rongrien rambutan stored under ambient temperature for 3 days.

Quality parameters	Treatments	Storage time (Days)			
		0	1	2	3
TSS (%Brix)	Control	21.8±0.1[a]	20.2±0.2[ab]	18.5±0.1[c]	20.2±0.1[c]
	0.5 % CMC_{com}	21.8±0.1[a]	19.9±0.1[b]	20.4±0.0[a]	21.3±0.1[a]
	0.5 % CMC_{wh}	21.8±0.1[a]	20.5±0.3[a]	19.2±0.2[b]	20.8±0.1[b]
TA (%)	Control	0.4±0.1[a]	0.5±0.1[a]	0.5±0.1[a]	0.6±0.1[a]
	0.5 % CMC_{com}	0.4±0.1[a]	0.4±0.1[a]	0.5±0.1[a]	0.6±0.1[a]
	0.5 % CMC_{wh}	0.4±0.1[a]	0.5±0.1[a]	0.5±0.1[a]	0.6±0.1[a]
Sensory evaluation (score)	Control	4.0±0.0	3.0±0.8[a]	1.5±1.7[a]	1.5±0.6[a]
	0.5 % CMC_{com}	4.0±0.0	2.8±1.0[a]	2.3±1.3[a]	2.8±1.0[a]
	0.5 % CMC_{wh}	4.0±0.0	3.3±1.0[a]	2.5±0.6[a]	2.5±1.3[a]

Mean with the same letter in the same column for each quality parameters are not significantly different at $p<0.05$.

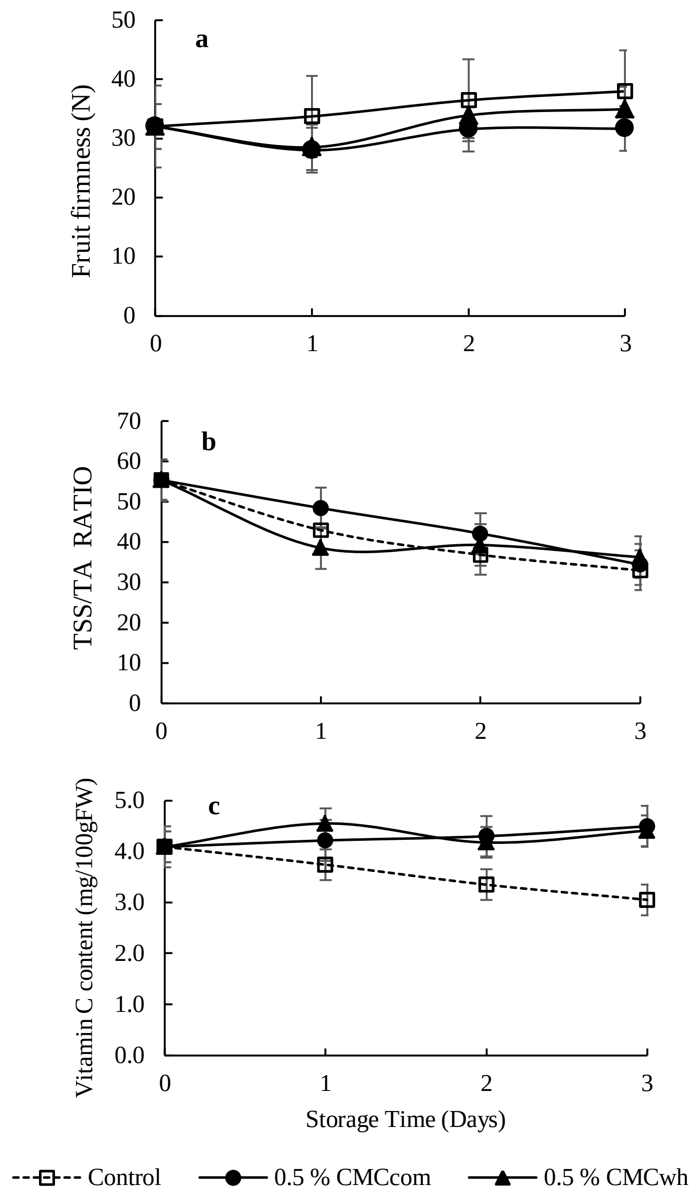

Figure 1. Effect of CMC edible coating on fruit firmness (a), TSS/TA ratio (b), and vitamin C content (c) of Rongrien rambutan stored under ambient temperature for 3 days.

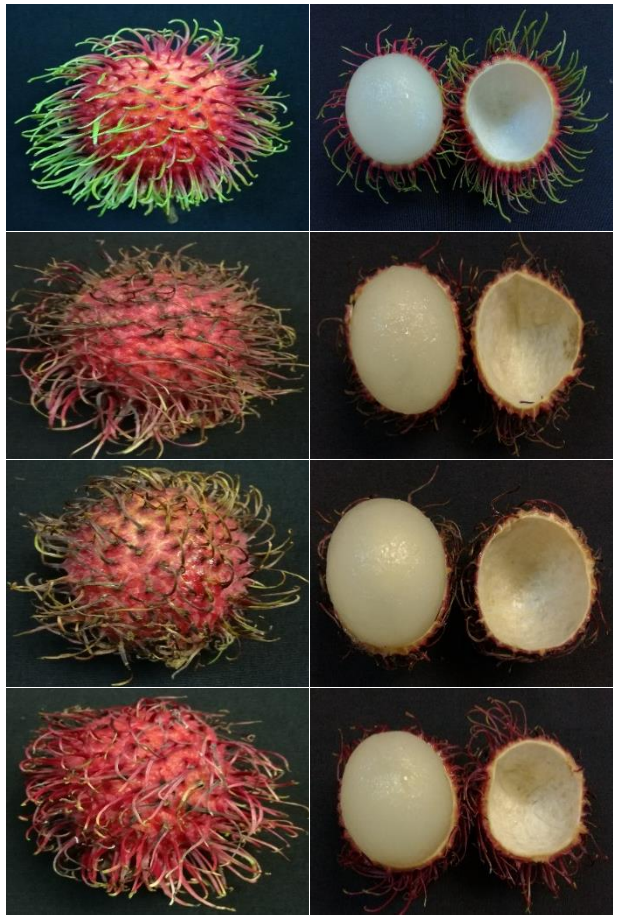

Figure 2. The appearance of Rongrien rambutan before and after storage under ambient temperature for 3 days.

Discussion

Rambutan fruits stored under ambient temperature for 3 days showed a decrease in vitamin C content, while fruit coated with CMC_{com} and CMC_{wh} had significantly higher vitamin C concentrations. Similar results have been reported in the previous study in strawberries in which a decline in vitamin C was delayed in cellulose coated strawberries. The edible coating helped regulating gas permeability resulting in lower oxygen, which in turn decreased an oxidation of vitamin C (Fakhouri *et al.*, 2014). During storage in TSS was observed possibly due to the respiration of the fruits. In addition, a dramatic decrease of organic acids was normally observed in climacteric fruits due to the consumption in the process of respiration and conversion to sugar at ripening stage, while organic acids remain relatively constant in non-climacteric fruits (Siriphanich, 1998).

In this study, water loss, fruit firmness, and peel color were not significantly different among treatments. CMC could not prevent water loss effectively because CMC is a hydrophilic compound (water-soluble) with moderate moisture transmission (Bourtoom, 2008). Generally, fruit firmness is affected by water content or turgor and cell wall components (Sam, 1999). Moreover, water loss was positively correlated with pericarp browning after harvest as desiccation causes cell membrane breakdown and oxidation of phenolic compounds (Landrigan *et al.*, 1996). Continuous water loss causes shrivelling that affect fruit firmness and browning leading to changes in L*, a*, and b* values.

Conclusion

The CMC edible coating from commercial and water hyacinth could not maintain most of fruit qualities; however, the CMC coatings helped increase vitamin C levels and eating quality during storage. Future study is needed to optimize the formulation of CMC for better results in extending the shelf life and maintaining fruit qualities.

Acknowledgement

We thank the Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang and Expert Centre of Innovative Agriculture, Thailand Institute of Scientific and Technological Research (TISTR) for providing laboratory facilities. The author would like to gratitude thank to TISTR for the financial support.

References

Adetunji, C.O., Arowora, K.A., Fawole O.B, Adetunji, J.B. and Olagbaju, A.R. (2013). Effect of edible coating of carboxymethyl cellulose and corn starch on cucumber stored at ambient temperature. Asian Journal of Agriculture and Biology. 1(3):133-140.

AOAC (1990). Official methods of analysis of the Association of Official Analytical Chemists, 15th ed., Association of Official Analytical Chemists, Arlington VA. 1058-1059.

Biswal, D.R. and Singh, R.P. (2004). Characterisation of carboxymethyl cellulose and polyacrylamide graft copolymer. Carbohydrate polymers. 57: 379-387.

Bourtoom, T. (2008). Edible films and coating: characteristics and properties. International Food Research Journal. 15(3): 237-248.

Dhall, R.K. (2013). Advances in edible coatings for fresh fruits and vegetables: a review, Food science and nutrition. 53: 435-450.

Fakhouri, F.M., Casari A.C.A., Mariano, M., Yamashita, F., Innocnentini Mei, L.H., Soldi, V. and Martelli, S.M. (2014). Effect of a gelatin-based edible coating containing cellulose nanocrystals (CNC) on the quality and nutrient retention of fresh strawberries during storage. IOP Conf. Series: Materials Science and Engineering. 64: 1-6.

Landrigan, M., Moriris, S.C. and McGlasson, B.W. (1996). Postharvest browning of rambutan is a consequence of water loss. Journal of the American Society for Horticultural Science121(4): 730–734.

Maftoonazad, N. and Ramaswamy, H.S. (2005). Postharvest shelf - life extension of avocadosusing methylcellulose -based coating. LWT- Food Science and Technology. 38: 617–624.

O'Hare, T.J. (1995). Postharvest physiology and storage of rambutan. Postharvest Biology and Technology. 6: 189-199.

Peter, A.F. and Suzanne, S.S. (2000). Comparison of rambutan quality after hot forced-air and Irradiation quarantine treatments. Horticultural Science. 35(7): 1315-1318.

Rachtanapun, P., Kumthai, S., Yagi, N. and Uthaiyod, R. (2007). Production of carboxymethyl cellulose(CMC) films from papaya peel and their mechanical properties. Proceedings of 45th Kasetsart University Annual Conference: Agricultural Extension and Home Economics: Agro-Industry. 790-799.

Rachtanapun, P., Luangkamin, S., Tanprasert, K. and Suriyatem, R. (2011). Synthesis and characterization of carboxymethyl cellulose from durian rind. Proceedings of 49th Kasetsart University Annual Conference: Agro-Industry.

Rachtanapun, P. and Rattanapanone, N. (2011). Synthesis and characterization of carboxymethyl cellulose powder and films from *Mimosa pigra*. Journal of Applied Polymer Science. 122: 3218–3226.

Rachtanapun, P., Thanakkasaranee, S. and Soonthornampai, S. (2008). Application of Carboxymethyl cellulose from Papaya Peel for Mango (*Mangifera indica* L.) ‘Namdokmai’ Coating. Journal of Agricultural Science. 39(3): 74-82.

Sam, C.E. (1999). Preharvest factors affecting postharvest texture. Postharvest Biology and Technology. 15:249-254.

Siriphanich, J. (1998). Postharvest physiological of fruits and vegetables. 2th ed. Kasetsart University. Bangkok.

Tog˘rul, H., Arslan, N. (2004). Extending shelf-life of peach and pear by using CMC from sugar beet pulp cellulose as a hydrophilic polymer in emulsions. Food Hydrocolloids 18: 215-226.

(Received: 17 October 2017; accepted: 25 November 2017)