EFFECT OF CARBOXYL METHYL CELLULOSE AND GUM ARABIC BASED EDIBLE COATING ON THE QUALITY OF SUGAR APPLE DURING STORAGE

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Abstract
The objective of this work is to evaluate the effect of carboxyl methyl cellulose (CMC) and gum arabic (G) that are used to make the edible coatings to extend the shelf-life of raw sugar apple fruits. Sugar apple fruits were washed, pre-treated with ultrasonic and then uncoated or coated by films with 1% of gel at the different ratio of CMC and G. These samples were kept in cold chamber at 10^0C for 5 weeks. The quality of sugar apples was evaluated through TA, TSA, TSS, firmness, and color as well as the weight loss. The results showed that CMC and G coatings can increase longer the shelf life of sugar apple fruit than these untreated samples. CMC coating had a significant effect on the quality of sugar apple fruits than the CMC combined G coating during cold storage. The weight losses of coating samples reduced slightly and its lower 43.35% and 80.49% to compare with the uncoated sample. TA, TSS, and respiration rate of coated fruits increased slightly and significantly different with uncoated fruit. The color of the uncoated sample (L^*, a^*, b^*) become a darkness and had less greenness than fruit coated. It was concluded that higher CMC and G used as a coating for sugar apple fruits could serve as an alternative to post-harvest chemical treatments.

Keywords*:* Carboxyl methylcellulose, Edible coatings, Sugar apple fruit, Gum arabic.

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1. INTRODUCTION

Sugar apple (Annona squamosa, L), a tropical fruit that is planted a popular in Thailand, is a highly appreciated fruit by the consumer because of its excellent taste. This fruit is usually consumed fresh or made into juice or juice drinks. The sugar apple fruit represents an important source of vitamins and minerals such as vitamin C, B_6, B_5, B_3, magnesium, calcium, phosphorus, and potassium (Onimawo et at., 2002). In addition, it is reported to be a rich source of insoluble dietary fiber with potential hypoglycemic effects (Antique et al, 1985). Sugar apple fruit poses postharvest problems due to the high degree of perishability and higher moisture content which lead to the extensive postharvest losses caused by chemical and microbial deterioration. Moreover, sugar apple is a high respiration. The increase of respiratory activity after post-harvest is accompanied by rapid modifications in its chemical composition, which alter the taste, aroma, firmness of the pulp and skin color. Therefore, the time for processing and storage is shorter especially at room temperature; the post- harvest of this fruit is only 4 or 5 days (Murray Clayton et al, 2010). For this reason, sugar apple is only for the commercialized local market (Sunil Pareek et al, 2011; Chunprasert et al, 2006). In order to rise of the sugar apple fruit price, it is necessary to develop a new technology which extends the sugar apple post-harvest shelf life such as modified atmosphere packaging (MAP), K_2MnO_4-amargosite and $KMnO_4$ or ultrasonic pretreatment and kept cool,..etc. (Ruelas-Chacon et al, 2017; Adetunji et al, 2012; Ghavidel et al, 2013, Chaves et al, 2009). Nowadays, green technologies are encouraged to be used on post-harvest, and edible coatings are a new technology satisfied the requirement. Edible coatings are thin films that can be used as a new trend in post-harvest. Edible coatings applied on many products to provide a barrier against external elements and therefore increase shelf life (Sunil et al, 2011; Chunprasert et al, 2006; Maftoonazad et al, 2005) by reducing gas exchange, loss of water, flavors and aroma and solute migration towards the cuticle via fruits respiration. Besides, the edible coatings were water–micro emulsions to help to the increase of the brightness and color fruits (Chunprasert et al, 2006; Maftoonazad et al, 2005). The main advantage of edible films over traditional synthetics is that it can be safely eaten as part of the product (Chunprasert et al, 2006; Athmaselvi et al, 2014; Santoso et al, 2013). Meanwhile, some packages do not dispose of even if the films are not consumed and they could still contribute to environmental pollution.

Today, an edible coating is made of polysaccharides, proteins and lipids and resins as well. Several previous researchers have studied the application of coatings such as alginate, carrageenan, WPC (Whey Protein Concentrate) and (SPI) Soy Protein Isolate to vegetables such as carrot, melon and fruits like blueberries, bananas, avocado, strawberries and kiwi. In this present work, the objective was to compare the effectiveness of 2 edible coatings (carboxyl methyl cellulose (CMC) and gum arabic (G)) to prolong shelf-life of sugar apple fruits.

2. MATERIALS AND METHODS

2.1. Materials

Sugar apple (Thai Lessard) was obtained from Suranaree Fresh market (Capital District, Nakhon Ratchasima). 100kg samples were selected and separated on the basis of uniformity of size, color, devoid of physical damage and fungal infection, followed by manual sorting and grading in the laboratory. It was immersed in fresh water and pre-treated by ultrasonic to remove duty and bacteria. The treatment time and output amplitude of the transducer were 15 min, 0.25W/g (Arce-Garcia, 2002). Next step, sugar apple fruits will be removed water remained on the surface by an industrial fan before coating by CMC and G solution.

Table 1. The abbreviation of coating and non-coating sugar apple fruit with different ratios of CMC and G

Coating	C1	0.33%CMC, 0.67% G
	C2	0.5%CMC, 0.5% G
	C3	0.67%CMC, 0.33%G
	C4	1%CMC
	C5	1%G
Non-coating	U	-

CMC and G were dissolved in distilled water to obtain concentrations of 1% gel (Table 1). Coating solutions also contained glycerol (1.5% w/w). Solutions were placed in a water bath (Schwabachw, Germany) at 80°C and kept there for 15 min to dissolve totally CMC and gum. Finally, the film will be firmed by drying at 45^0C in 2 hours and then stored in a cardboard box at cooling room (10^0C±2^0C), 90-95%RH.

2.2. Chemicals

Methanol absolute (Mallinckrodt), ethanol and sodium hydroxide absolute value (<95%), glycerol (Merck &Co., USA) were purchased from Sigma–Aldrich at a local supplier and used without treatment

2.3. Methods

2.3.1. Total Acidity (TA)

TA of the sugar apple juice was determined by the method given by AOAC, 1984. Titratable acidity is determined by titrating diluted sugar apple product to pH 8.00 with 0.1N NaOH. Three readings for each treatment were recorded per sampled day and the means of these measurements were expressed as citric acid and then used for statistical analyzes.

$$\%TA = \text{ml NaOH (0.1N)} \times F \times \frac{100}{\text{gram samples}} \quad (1)$$

F: milliequivalent factor (citric acid= 0.064)

2.3.2. Weight loss percentage

The sugar apple samples, C1, C2, C3, C4, C5, and U, were weighted at days 0, 7, 14, 21, 28, and 35 during the storage period. The difference between initial and final fruit weight was considered as total weight loss during the storage intervals and calculated as percentages on a fresh weight basis (Ruelas-Chacon, 2017).

$$\%\text{Weight loss}=\frac{W1-W2}{W1} \quad (2)$$

Where: W1 is the initial weight (g); W2 is the weight loss under cold storage (g).

2.3.3. Total Soluble Solids (TSS)

TSS of the sugar apple fruit was determined by the method described by Dong et al. 2004 in ^{0}Brix by placing a juice drop on the lens of a handheld refractometer.

2.3.4. Total surface area (TSA)

Estimates of the area of sugar apple surface are often made by calculating that of a geometric shape which is considered to be representative of the commodity. The sugar apple samples were weighed and measured the diameter at days 0, 7, 14, 21, 28, and 35 during the storage period. The results were calculated as Banks equation following (1985).

$$x=4.38\times w^{0.667} \quad (3)$$

w: weight of sugar apple (gram)

2.3.5. Fruit firmness

The fruit firmness was measured as total firmness (skin) by a puncture test. For this purpose the Instron Universal Testing Machine (Instron Corp., Canton, Mass., USA) was used. The full-scale load was set at 5. The crosshead speed was 50 mm per min, and chart speed 100 mm per min (Dang et al, 2008).

2.3.6. Respiration rate

Respiration of samples was analyzed periodically in a closed and hermetic system. The samples (four sugar apples per jar) were randomly distributed in the glass containers with a capacity of 1.80 liters at ambient temperature (10 ± 2∘C). The ratio between container capacity and amount of sugar apple was 600:100 (mL-g). Teflon tubes (gas inlet and outlet) are linked to the flow system. Gas samples were taken from the jar and connected to CO_2/O_2 gas analyzer (PBI Dansensor Gas Analyzer, Checkmate II, Denmark). The results in percentage a CO_2 were used for calculation of the respiration rate (mL $kg^{-1}h^{-1}$), using the following equation:

$$\frac{\%CO_2}{\text{Weight of samples} \times \text{time incubated} \times \text{volume jar}} \quad (4)$$

2.3.7. The fruit color

Color measurement of sugar apple fruit was made using a portable CR-4000 tristimulus colorimeter (Konica Minolta Sensing, Inc., Japan). Color of nine fruits selected randomly from each treatment was checked. Color was measured using the CIE L^*, a^*, b^* coordinates. Illuminant D65 and 10° observer angle were used. The instrument was calibrated using a standard white reflector plate.

2.4. Statistical Analysis.

Statistical analysis was analyzed with the stagraphic centrution XVI. A t-test was used to determine the differences between two samples (coated and uncoated). Statistical differences with $P < 0.05$ were considered significant. The experiment was done at least six triplicates.

3. RESULTS AND DISCUSSION

The percentage of weight loss of sugar apple fruits with different edible coatings are presented in Figure 1 (a). Weight loss increased with the progression of storage period and reached the maximum in the 5 weeks. All the coating treatments exhibited less fruit loss than uncoated fruit and significantly different between coated and uncoated fruit. The lowest weight loss was observed in 3.55% with C3, C4. Meanwhile, the value for U in 5 weeks was 6.32%. Moreover, as a different percentage of gel concentration, the weight loss also changed. These samples were low CMC concentration such as C1, weight loss was 18.11%, 34.95% 35.14% higher to compare with C2, C3, and C4. The highest CMC concentration improved the weight loss via the decrease in the rate of respiration. The TSS observed similar trend with weight loss as increasing storage time. TSS fruit was significantly affected by coating treatments and storage period. TSS increased with increased storage period in both coated and uncoated fruit. After one week of storage, there was insignificant different in TSS between uncoated and coated fruit that was observed. However, from week 2 to week 5, TSS of U increased dramatically and 14.66%, 17.03%, 27.01% and 28.33% higher to compare with the C1, C2, C3, C4, C5 (Figure 1(b)). TSS of C4 increased slowly and insignificant different to C1, C2, and C3 that indicated the slower ripening occurred.

Similarly, TA of sugar apple fruit was significantly affected by coating treatments and storage interval. Among all coating treatments, C2, C3 and C4 exhibited a lower decrease in TA (0.21%, 0.23%, and 0.25%), while U showed a significantly higher decrease in TA (0.27%) during cold storage (Figure 2(a)). This phenomenon was linked to the fruit's respiration rate. The sugar apple fruit become soften due to the hydrolysis of sugar apple protopectin to pectin and the degradation of the polysaccharide of a cell wall (Chavas et al, 2009). Therefore during fruit ripening, hydrolyzed plant cell wall affected the hardness and total soluble solid of fruit.

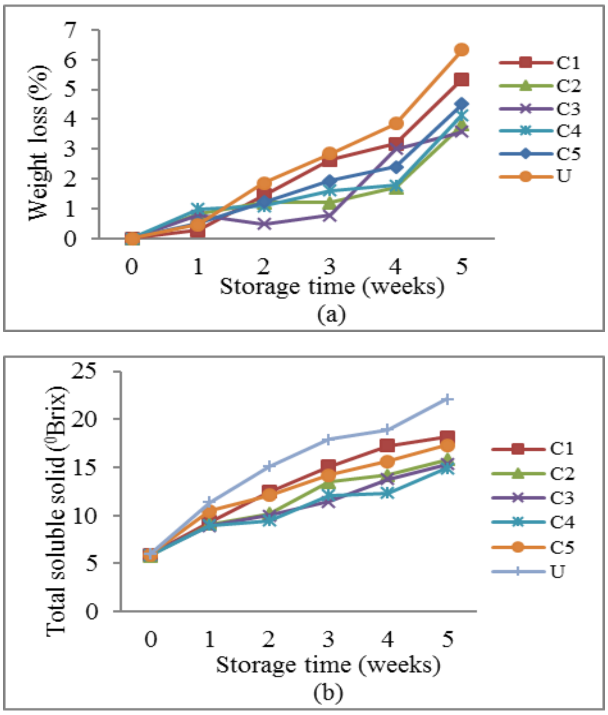

Fig. 1. (a) The weight loss and (b) the total soluble solid (TSS) response of sugar apple fruits uncoated and coated with CMC and G during a 5-week storage period at cooling room (10 ± 2^{0}C)

Fruit firmness is an important criterion for fruit quality of sugar apple fruit. A gradual increase in fruit weight loss was the decreased fruit firmness during the cold storage period. Our results showed that the firmness of coated and uncoated sugar apple fruit was significantly different in 5 weeks storage. Fruit firmness did not show any significantly different between coated and uncoated samples in the first week but it decreased substantially as increase storage time and was the lowest on the fifth week for all coatings treatment. Coatings sugar apple fruit with CMC and G gel significantly prevented the firmness loss. The maximum loss of firmness was found in U, whereas minimum loss of firmness in C2, C3, and C4 (Figure 2 (b)). As our results, edible coatings with high CMC concentration on the C2, C3 and C4 can prevent the water loss was related to influence on the turgidity of the cells and subsequent stiffness of sugar apple fruit.

The effect of coatings on the respiration rate of sugar apple stored at ambient temperature (10 ± 2∘C) showed in Figure 3. All samples increased the respiration rate during storage, which indicates an increase in the fruit metabolic activity. After 5 weeks, the C4 had the lowest CO_2 production (6.1 mL kg^{-1}h^{-1}) and increased significantly respiration rate in C1 (8.1 mL kg^{-1}h^{-1}), C2 (7.4 mL kg^{-1}h^{-1}), C3 (7.1 mL kg^{-1}h^{-1}). There was significant to compare C1, C2, C3 with U (11.5 mL kg^{-1}h^{-1}), indicating that coating might have modified the internal atmosphere and significantly delayed respiration rate of sugar apple fruit. Respiration rate in fresh fruit and vegetables is considered good index for determination of storage life (Fagoni et at, 2001). The effect of polysaccharide-based coatings on respiration of horticultural products is related to their ability to create a barrier to oxygen diffusion through the coating (Fagoni et al, 2001; Dang et al, 2008).

Fruits size changed during storage time, TSA of fruits reduced as the same trend with the weight loss. TSA of U decreased 7.69% in 5 weeks, whereas these samples coated with gel decreased slightly about 0.8 to 1.5% of total area surface (Table 2). According to Banarus, (1994) the weight and size of fruits changed with the increase of storage time are usually due to the loss of water through transpiration. The water content of fruits was evaporated while it was kept cooling, and then the surface of fruits was dried. Our results are in agreement with those of Gavlheiro et al., (2003) and Banarus et al., et al. (1994) who concluded that coatings and/or films significantly conserved water content and the water content of fruit.

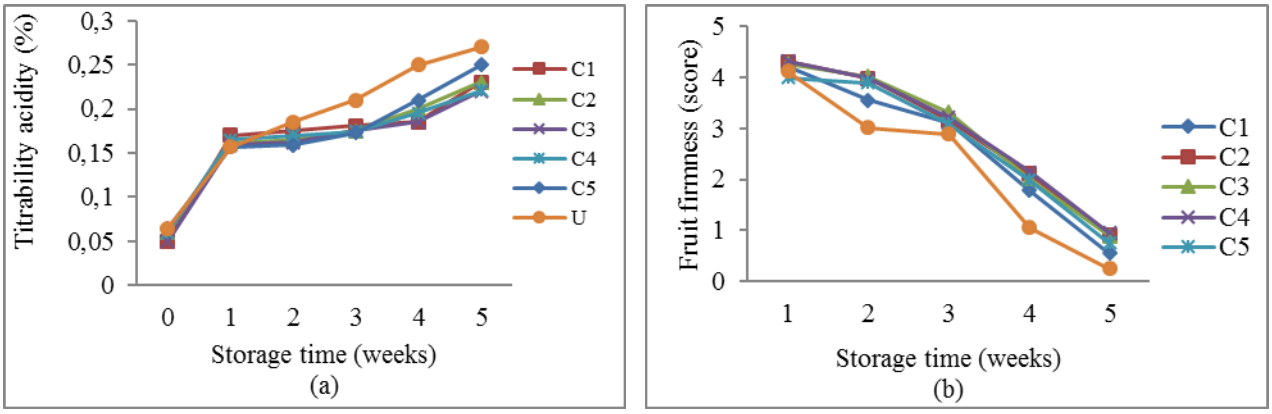

Fig. 2. (a) The TA and (b) the firmness response of sugar apple fruits uncoated and coated with CMC and G during a 5-week storage period at cooling room (10 ± 2^{0}C)

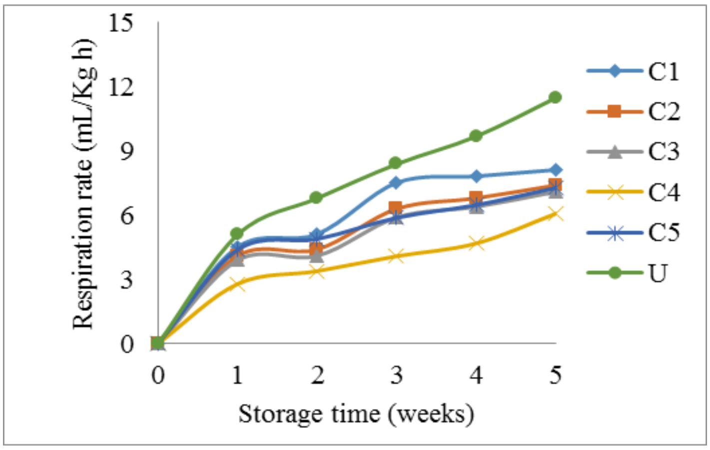

Fig. 3: Influence of CMC and G coatings on the respiration rate of sugar apple during a 5 week storage period at ambient temperature (10± 2∘C)

Table 2. The relationship between actual surface area and the storage time of different sugar apple fruits coatings$^{(*a)}$

Week	C1	C2	C2	C4	C5	U
0	1.210^{a}±0.02	1.290^{a}±0.010	1.260^{a}±0.010	1.230^{a}±0.010	1.220^{a}±0.01	1.300^{a}±0.03
1	1.210^{a}±0.01	1.288^{ab}±0.011	1.257^{ab}±0.010	1.227^{ab}±0.02	1.217^{b}±0.02	1.299^{a}±0.01
2	1.210^{a} ±0.01	1.288 ^{ab}±0.012	1.257^{ab}±0.011	1.225^{b}±0.012	1.212^{c}±0.02	1.297^{b}±0.01
3	1.204^{b} ±0.02	1.287^{ab}±0.011	1.252^{b}±0.014	1.223^{bc}±0.013	1.212^{c}±0.08	1.280^{c}±0.01
4	1.202^{b}±0.015	1.270^{b}±0.010	1.250^{c}±0.012	1.220^{c}±0.010	1.196^{d}±0.01	1.260^{d}±0.009
5	1.184^{c} ±0.020	1.270^{b}±0.010	1.250^{c}±0.03	1.220^{c}±0.009	1.196^{d}±0.09	1.200^{e}±0.010

^{a,ab,b,bc,c,d,e} Different letters within the column denote statistically significant differences between treatments (P≤0.05). Each value is the mean of six replications.

^{*a} Total surface area of sugar apple fruits (dm^{2}).

Table 3. Effect of CMC and gum arabic film on color *L, color *a**, and color *b** of sugar apple during cold storage**

Sample	Weeks	L^*	a^*	b^*
C1	0	40.7[a]	-7.9[a]	14.6[a]
	1	40.5[ab]	-7.8[b]	14.6[a]
	2	40.4 [ab]	-7.7[b]	14.5[a]
	3	37.9[b]	-5.9[c]	14.5[ab]
	4	35.9[c]	-5.8[d]	14.3[b]
	5	33.5[d]	-5.8[d]	14.2[c]
C2	0	39.6[a]	-7.8[a]	13.5[a]
	1	39.5[ab]	-7.8[a]	13.2[b]
	2	39.4[b]	-7.8[b]	13.2[b]
	3	37.8[c]	-6.1[b]	13.2[b]
	4	35.4[d]	-5.8[c]	13.1[b]
	5	34.5[e]	-5.7[d]	13.0[c]
C3	0	39.8[a]	-7.6[a]	13.6[a]
	1	39.7[a]	-7.6[a]	13.6[a]
	2	39.7[a]	-7.5[a]	13.5[a]
	3	38.0[b]	-7.5[a]	13.5[ab]
	4	37.8[b]	-6.9[b]	13.3[b]
	5	37.6[c]	-6.0[c]	13.1[c]
C4	0	40.2[a]	-7.9[a]	13.8[a]
	1	4.02[a]	-7.9[a]	13.8[a]
	2	40.2[a]	-7.8[a]	13.5[b]
	3	39.1[b]	-6.9[b]	13.5[b]
	4	38.9[c]	-6.8[bc]	13.4[bc]
	5	37.5[d]	-6.8[bc]	13.4[bc]
C5	0	39.9[a]	-7.8[a]	13.1[a]
	1	39.8[ab]	-7.8[a]	13.1[a]
	2	39.7[ab]	-7.6[ab]	13.0[a]
	3	37.8[b]	-6.5[b]	12.7[b]
	4	35.6[c]	-6.0[c]	12.4[c]
	5	34.1[d]	-5.5[d]	12.4[c]
U	0	40.5[a]	-7.9[a]	13.8[a]
	1	39.7[b]	-7.7[b]	13.0[b]
	2	38.5[b]	-7.2[c]	12.7[c]
	3	36.4[c]	-5.5[c]	12.5[de]
	4	33.7[d]	-5.1[d]	12.0[d]
	5	33.5[d]	-5.0[d]	11.9[d]

[a,ab,b,bc,c,d,e] Different letters within the column denote statistically significant differences between treatments ($P \leq 0.05$). Each value is the mean of six replications.

Storage duration significantly affected the color of sugar apple fruit. The changes in color parameters (L^*, a*, b^*) of coated and uncoated sugar apple fruits through-out the storage at cooling room (10 ± 2^0C) are shown in Table 3. Lightness (*L*∗) of sugar apple fruit was decreased during storage duration, irrespective of coatings. The results showed that aril L* and b* values significantly decreased the second week cold storage, however, no significant differences were found between coated and control fruits on the first week. Meanwhile, the L* and b* values significantly increased to the end of storage. Both L* and b*

values were significantly affected by coating treatments. The color of U changed from green, yellow to dark color at week 5, whereas coated samples still kept the special color of sugar apple, especially C3, C4. The coated film with low CMC concentration (C1, C2), fruit color changed faster than higher concentration (C3, C4).
Our results also suggested that during sugar apple fruits ripening, these coated samples still appeared the darkness but limited because of the enzymatic browning reactions and oxygen presence. The film forming coated on the sugar apple surface that reduced the oxygen level inner prevented the fruit respiration and enzymatic action. Our results agreed with findings of Athmaselvi et al. 2013 and Santoso and Rahmat et al., 2012 where the color values of apples became a darker untreated with Aloe vera based edible coating.

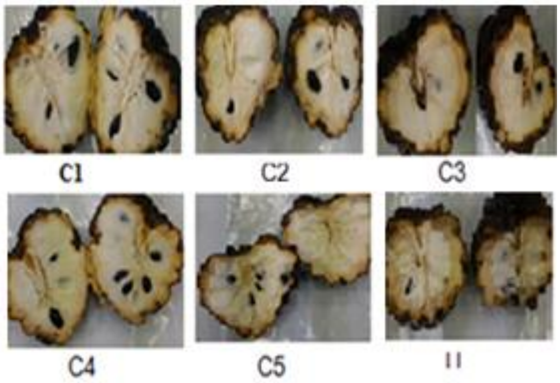

Fig. 4. The use of cut test method to check the ripening level of sugar apple fruits on 5 weeks

The results of the cut slice of sugar apple fruit also showed that the ripening level of sugar apple fruits increased when uncoated samples or coated with a lower level of CMC (Figure 4). With U or C5, sugar apple fruits are more soften than the coated. The flesh of fruit become juicy and changed the structure. The surface of a cut test of sugar apple fruits on the experimented U and C1 are discoloration that caused by bruising by water evaporate and over-ripening. Meanwhile, these samples C2, C3 and C4 the flesh is white and still hard. Maftoonazad and Ramaswamy, 2005 results were in agreement with our results and stated that retention of firmness could be explained by retarded degradation of insoluble protopectins to the more soluble pectic acid and pectin. CMC edible coatings prevent the respiration and the ripening level.

4. CONCLUSION

Our present result shows that coating sugar apple fruit with CMC and G delayed the ripening process by inhibiting the respiration rate of this fruit. These results also proved that CMC coating is better than G on improvement the postharvest quality during storage at cooling temperature. The CMC and G coating, a polysaccharide is a biodegradable that is easy to apply in mass production, and less expensive. However, CMC and G film still have disadvantages such as the low ability to make film and low strengthen of film. For this reason the nearest studies, CMC and G are still necessary to improve its properties by adding specific hydrophobic components to fill in the break on the fill to increase the postharvest storage quality at ambient temperature and cold storage.

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6. References

[1]. Onimawo, I.A. 2002. Proximate composition and selected physicochemical properties of the seed, pulp and oil of soursop (*Annona muricata*). Plant Foods for Human Nutrition 57 (2), 165- 171.

[2]. Atique A, Iqbal M, Ghouse, A K M, 1985. Use of Annona squamosa and Piper nigrum against diabetes. Fitoterapia. 56 (3): 190-192.

[3]. AOAC, Official Methods of Analysis (2) 1984, Association of Official *Analytical Chemists, Arlington*, Tex, USA vol. 918,.

[4]. Bruno B.R.A, Rayane, C. 2016. Determination of cardinal temperatures for sugar apple (Annona squamosa L.), Ciência e Agrotecnologia 40(2):145-154.

[5]. Murray Clayton, Nevin D. Amos, 2010. Estimation of apple fruit surface area. New Zealand. *Journal of Crop and Horticultural Science*, 1175-8783.

[6]. Chunprasert A., Uthairatanakij C. Wongs-Are, 2006. Storage quality of Neang sugar treated with chitosan coating and MAP, IV International Conference on Managing Quality in Chains - The Integrated View on Fruits and Vegetables, 100-106.

[7]. Sunil Pareek, Elhadi M. Yahia, O.P. Pareek , R.A. Kaushik, 2011. Postharvest physiology and technology of Annona fruits, *Food Research International 44*, 1741–1751.

[8]. Ruelas-Chacon X., Contreras G.C, 2017. Guar Gum as an Edible Coating for Enhancing Shelf-Life and Improving Postharvest Quality of Roma Tomato (Solanum lycopersicum L.), *Journal of Food*, Volume 2017, pages 1-9.

[9]. Adetunji C. O , Fawole O.B , Arowora K.A, 2012. Effects of Edible Coatings from Aloe Vera Gel on Quality and Postharvest Physiology of Ananas Comosus (L.) Fruit During Ambient Storage. *Global Journal of Science Frontier Research Bio-Tech &* Genetics, Volume 12 Issue.

[10]. Ghavidel R.A, Davoodi M.G, 2013. Effect of selected edible cotaings to extend shelf life of fresh cut apples. *International Journal of Agriculture and Crop Sciences*, Vol., 6 (16), 1171-1178.

[11]. Chaves M. A., Bonomo, R. C. F. 2009. Use of potassium permanganate in the Sugar apple post haverst preservation, *Cienc. Tecnol. Aliment*. Vol (5) 346-351.

[12]. Athmaselvi, K.A., Sumitha, P., and Revathy, B. 2013. Development of Aloe vera based edible coating for tomato. *Int. Agrophys*., vol 27, 369-375.

[13]. Maftoonazad, N. and Ramaswaymy (2005). Postharvest shelf-life extension of avocados using methyl cellulose-based coating. Food *Sci. Technol-Leb 38*, 617–624.

[14]. Athmaselvi, K. A., Kumar, K. A. Thermal, 2014, Structural, and Physical Properties of Freeze Dried Tropical Fruit Powder. *Journal of Food Processing Volume 2014*, 10 pages.

[15]. Santoso, F., and V. A. Rahmat, 2012. Safety and quality assurance of tomato using aloe vera edible coating. *Acta Horticulturae,* vol. 1011, pp. 133–140, 2.

[16]. Arce-Garcia, Arce M., E. Palou, A. Lopez, 2002. Ultrasound treatments and antimicrobial agents effects on *Zygosaccharomyces rouxii*. IFT Annual Meeting Book of Session 91E-18.

[17]. Dong, H., L. Cheng, T. Jiahou, Z. Kunwang and J. Yueming. 2004. Effects of chitosan coating on quality and shelf life of peeled litchi fruit. *J. Food Eng.* 64 (3): 355–358.

[18]. Dang KT, Singh Z, Swinny EE, 2008. Edible coatings influence fruit ripening, quality, and aroma biosynthesis in mango fruit. *J Agric Food Chem*; 56(4) :1361-70.