International Journal of Agricultural Technology 2020 Vol. 16(4):949-958
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Physicochemical quality improvement of ready cook baby corns using calcium propionate immersion

Promyou, S.[1], Chimsonthorn, V.[2], Kijka, C.[2] and Supapvanich, S.[2*]

[1]Faculty of Natural Resources and Agro-Industry, Kasetsart University, Chalermprakiate Sakhon-Nakhon Province Campus, Sakhon-Nakhon, Thailand; [2]Department of Agricultural Education, Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Ladkrabang, Bangkok, Thailand.

Promyou, S., Chimsonthorn, V., Kijka, C. and Supapvanich, S. (2020). Physicochemical quality improvement of ready cook baby corns using calcium propionate immersion. International Journal of Agricultural Technology 16(4):949-958.

Abstract The effect of calcium propionate (Ca-propionate) on physicochemical quality changes of ready cook baby corn (*Zea mays* L.) during storage was investigated. It was found that Ca-propionate treatment retarded the loss of texture which was concomitant with the lower EDTA-soluble pectin and higher Na_2CO_3 soluble pectin concentrations compared to untreated baby corns. Ca-propionate treatment did not obviously affect total sugars content, antioxidant activity and free radical scavenging activity compared to untreated samples. However, Ca-propionate treatment induced bioactive compounds such as total phenols, flavonoids and ascorbic acid contents of ready cook baby corns during storage. Therefore, Ca-propionate immersion is an alternative improving quality especially texture and nutritional values of ready cook baby corns during cold storage.

Keywords: Baby corn, Calcium propionate, Texture and nutritional value

Introduction

Baby corn (*Zea mays* L.) is one of important vegetable crops of Thailand and containing high nutritional values which rich in fibers, carbohydrates, protein, vitamins, amino acid, β carotene and ascorbic acid (Hooda and Kawatra, 2013). It is widely grown in the whole country for local market and exportation. The demand of ready to cook baby corns in the worlds market has continuous increased as a result of change in consumer behaviour. In 2017, the exports of baby corns were 40 million USD and increased to 41 million USD in year 2018 (Offices of Agricultural Economics, 2018). However, the exportation of baby corn is very limited due to many problems associated with postharvest quality during storage and transportation. The main postharvest problems of this product are texture losses, high respiration rate, rapid loss of sweetness and browning which leads to affecting in the quality and

[*]**Corresponding Author:** Supapvanich, S.; **Email:** suriyan.su@kmitl.ac.th

shelf life of ready to cook baby corn during storage (Bakry *et al*., 2015).The loss of texture on agricultural commodities is associated with the cell wall structure, composition and its changes during storage (Toivonen and Brummell, 2008). Pectin can be found abundantly in the cell wall of dicotyledonous and some of monocotyledonous of non-graminaceous plants. It presents in the primary cell wall as a polysaccharide and represents different biochemical properties of the cell wall (McCann and Carpita, 2008). Calcium treatment has been widely reported to maintain the qualities of fresh products in term of improved cell wall structures. Ca^{2+} ion binds with de-methylated pectin to form calcium pectate called egg box structure which polygacturonase cannot hydrolyte this form of pectin (Lara *et al*., 2004). Most of study found that Ca-chloride, Ca-lactate, Ca-ascorbate and Ca-gluconate have been successfully applied to maintain fresh-cut fruit and vegetables quality (Oms-Oliu *et al*., 2010). However, no reports have been mention on the Ca-propionate effect on ready to cook baby corn texture and physicochemical quality improvement. The main objectives of research was to determine the possible application of water soluble calcium salts in case of Ca-propionate form as a pre-treatment for improve physicochemical quality of ready cook baby corns during storage.

Materials and methods

Baby corn were obtained from commercial farm in Thailand and prepared by cleaning, peeling and removeing corn silk. The baby corns were screened for uniformity, i.e. shape, length and size, and then dipped with 200 $\mu L\ L^{-1}$ of sodium hypochlorite for 2 min to reduce the contaminated microorganisms. The baby corns were separated into 2 groups; in the first group, the baby corns were immersed in distilled water for 5 min and in the second group, the baby corns were dipped in 1 % (w/v) calcium propionate (Ca-propionate) for 5 min then stored at 4 $\pm$ 1 °C for 6 d. Each replication in the experiments was consisted of a foam tray contain five baby corns and wrapped with LDPE cling film.

The data were recored as follows: the cutting force of the ready to cook baby corns was measured using a TA Plus Texture Analyzer (Lloyds, England) with a blade probe. The maximum force of measurement was recorded. The unit of cutting force was presented as newton (N).

Total sugar concentration was determined using the method described by DuBois *et al*. (1956). The baby corns was extracted with distilled water and stirred for 1 h. The extract was reacted with 5 % phenol and conc. H_2SO_4. The reaction was incubated at room temperature for 30 min. Absorbance at 490 nm wavelength was recorded. Data were expressed in g glucose per kg fresh weight ($g\ kg^{-1}$).

Pectin Substances Assay was used method which described by Seymour, *et al*. (1987). The acetone insoluble solid (AIS) of baby corns were prepared. The total soluble pectin, EDTA-soluble pectin and Na_2CO_3 soluble pectin contains were determined following method described by Supapvanich and Tucker (2013). The hydrolyzate was used to assay uronic acid and the data were expressed as µg uronic acid per g fresh weight (µg kg^{-1}).

Antioxidant and free radical scavenging activities assay were investigated. Baby corn was extracted with 60 % (v/v) ethanol. The filtrate was used to determine both antioxidant and free radical scavenging activities and the concentrations of total phenols and flavonoids. Ferric reducing antioxidant potential assay as described by Benzie and Strain (1996) was used to determine antioxidant activity of the baby corn. The extract was reacted with 2.9 mL FRAP reagent, consisting of acetate buffer pH 3, 10 mM 2,4,6-tripyridyl-1,3,5-triazine (TPTZ) and 20 mM ferric chloride hexahydrate in the ratio of 10:1:1 (v/v/v), and incubated at room temperature for 30 min. The absorbance at 630 nm wavelength was recorded. The data were presented as µmole Trolox equivalents per g fresh weight (µmol g^{-1}). DPPH free radical scavenging activity was determined according the method of Brand-Williams *et al*. (1995) with slight modification. A 0.1 mL of the extract was mixed with 2.9 mL of 1 mM DPPH in 95 % ethanol. The absorbance at 517 nm wavelength was recorded at 0 min (A_0) and then measured again at 5 min (A_1). The percentage of free radical scavenging activity was calculated compared with A_0. Total phenols concentration was assayed using the method described by Slinkard and Singleton (1977). One mL of the extract was reacted with 1 mL of 50 % (v/v) Folin–Ciocalteu reagent followed by the addition of 2 mL of concentrated Na_2CO_3 solution. The reaction was incubated for 30 min at room temperature and then the absorbance at 750 nm wavelength was recorded. The data were presented as mg gallic acid per g fresh weight (mg g^{-1}). Flavonoids concentration was determined according the method of Jia *et al.* (1999). One mL of the extract was reacted with 3 mL of distilled water, 225 µL of 0.5 % $NaNO_2$ and then incubated for 6 min. After that, 450 µL of 10 % $AlCl_3.6H_2O$ was added and again incubated for 5 min before 1.5 mL of 1 M NaOH was added. The absorbance at 510 nm wavelength was recorded and data was expressed as µg catechin equivalent per g fresh weight (µg g^{-1}).

Ascorbic acid assay was extracted with 5 % methaphosphoric acid at 5 °C. The extract was determined the concentration of ascorbic acid by using the method of Hashimoto and Yamafuji (2001). The extract was reacted with 2 % di-indophenol, 2 % thiourea and 1 % dinitrophenol hydrazine. The mixture was incubated at 35 °C for 3 h and then 85 % of sulphuric acid was added. After incubation for 30 min, the absorbance at 540 nm wavelength was measured. The data was expressed as mg ascorbic acid per kg (mg kg^{-1}).

The experimental design was conducted with a two-group analysis of covariance (ANCOVA). Experimental data were the average of four replications and standard deviation (S.D.) bar. A variance analysis using t-test was performed to determine differences between means of the treatments, at a significance level of $P \leq 0.05$.

Results

Texture and total sugars content

The results showed the cutting force of ready cook baby corn decreased during storage and the force of Ca-propionate treated baby corns had higher than control over time in storage (Figure 1). It is indicated that Ca-propionate immersion could maintain the texture of ready cook baby corns during storage. The total sugars content of ready cook baby corns appeared to be constantly storaged and Ca-propionate immersion did not affect total sugars content in the baby corns when compared to the control.

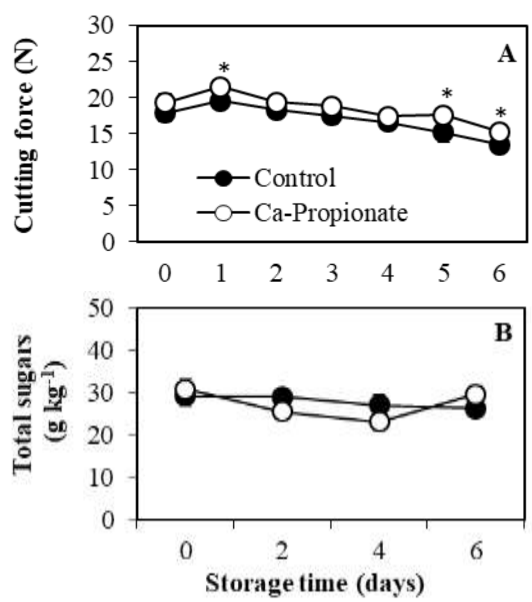

Figure 1. Cutting force (A) and total sugars concentration (B) of ready cook baby corns treated with Ca-propionate and control during storage at 4 ℃ for 6 d. The data are presented as mean (n = 4) with SD bar. Significant differences between treatments are indicated with asterisks [** ($P < 0.01$); * ($P < 0.05$)]

Pectin substances contents

The change in pectin substances is associated with texture of fruits and vegetables. The changes in EDTA-soluble and Na_2CO_3-soluble pectins contents in ready cook baby corns during storage as seen in Figure 2. It was found that EDTA-soluble pectin content of control sample was significantly higher longer storage than that of Ca-propionate treated baby corns ($P< 0.05$). EDTA-soluble pectin content in both control and Ca-propionate treated baby corns were increased during storage and higher than baby corns at initial day of storage. Na_2CO_3-soluble pectin content in control sample was significantly decreased which lower than Ca-propionate treated baby corns during storage ($P < 0.05$). The third day of storage, the increased in Na_2CO_3-soluble pectin content was found in Ca-propionate treated baby corns and declined afterward. These indicated that Ca-propionate immersion delayed the increment of EDTA-soluble pectin content and reduced the loss of Na_2CO_3-soluble pectin content of ready cook baby corns during storage.

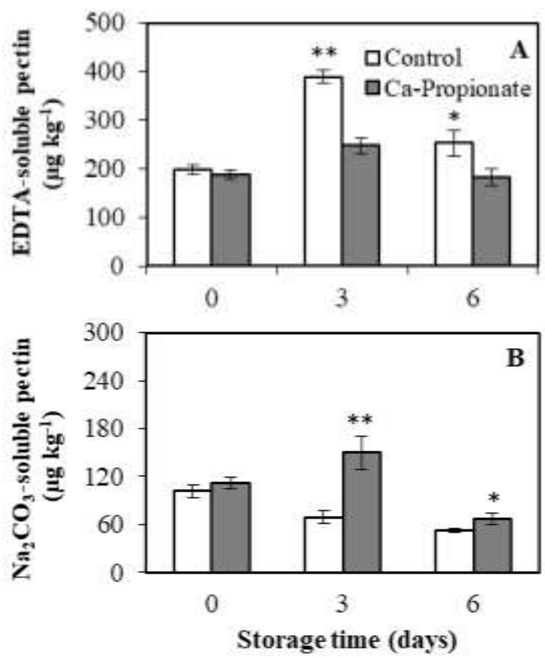

Figure 2. EDTA-soluble pectin (A) and Na_2CO_3-soluble pectin (B) of ready cook baby corns treated with Ca-propionate and control during storage at 4 ℃ for 6 d. The data are presented as mean (n = 4) with SD bar. Significant differences between treatments are indicated with asterisks [** (*P* < 0.01); * (*P* < 0.05)]

Antioxidant activity and free radical scavenging activity

The antioxidant activities in control and Ca-propionate treated baby corns was increased after storage for 2 d and decreased. Free radical scavenging activity in both treatments of baby corns increased after storage for 2 d and declined. After the fourth day storage, the increased in free radical scavenging activity was observed in the both treatments. It was not significantly differed in both antioxidant and free radical scavenging activities that found in all treatments during storage, those of Ca-propionated treated baby corns trended to be slightly higher storaged than the control treatment (Figure 3).

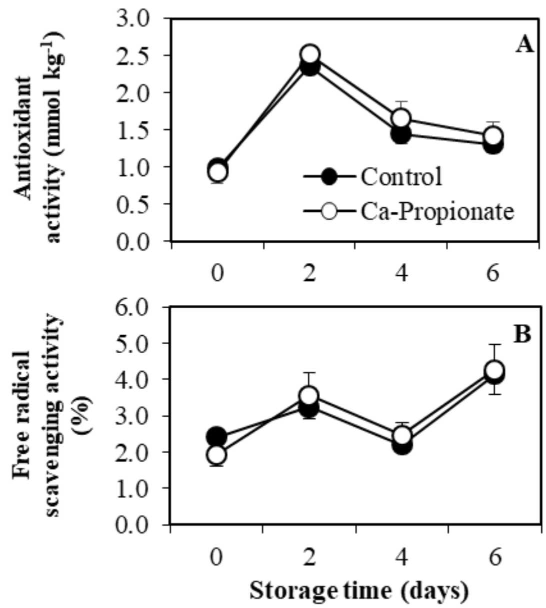

Figure 3. Antioxidant activity (A) and free radical scavenging activity (B) of ready cook baby corns treated with Ca-propionate and control during storage at 4 ℃ for 6 d. The data are presented as mean (n = 4) with SD bar. Significant differences between treatments are indicated with asterisks [** ($P < 0.01$); * ($P < 0.05$)]

Bioactive compounds contents

The total phenols contentin control and Ca-propionate treated baby corns remained constantly condition during storage for 4 d and then increased afterward. The sixth day storage, total phenols content of Ca-propionate treated baby corns was significantly higher than control (P < 0.05) (Fig. 4A).

Flavonoids content of Ca-propionate treated baby corns was continuously increased during the storage while the control sample appeared constantly over storage. The flavonoids content of Ca-propionate treated baby corns was obviously higher than control samples (Fig. 4B). Ascorbic acid content in control and Ca-propionate treated baby corns remained constantly during storage for 2 d. After that, the ascorbic acid content of the both treatments increased over the storage. Ca-propionate immersion could induce ascorbic acid content in ready cook baby corns which higher than in control samples (Fig. 4C). It is suggested that Ca-propionate immersion could induce bioactive compounds, especially flavonoids and ascorbic acid contents of ready cook baby corns during storage.

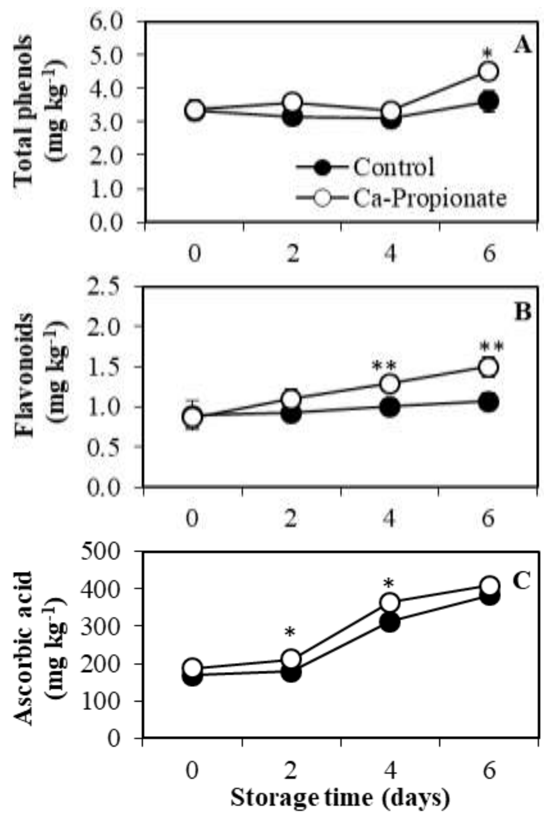

Figure 4. Total phenols (A), flavonoids (B) and ascorbic acid (C) concentrations of ready cook baby corns treated with Ca-propionate and control during storage at 4 ℃ for 6 d. The data are presented as mean (n = 4) with SD bar. Significant differences between treatments are indicated with asterisks [** (*P* < 0.01); * (*P* < 0.05)]

Discussion

Visual appearance, texture and taste are the main organoleptic factors that limiting quality of ready cook baby corn during storage. Brummell (2006) addressed that the modification of cell wall structure including pectin depolymerisation is a major factor affecting the change in texture characteristic of fruits and vegetables. The recent work in these experiment revealed that Ca-propionate had hight effecency to maintain the texture of ready cook baby corns during storage which associated with the maintenance of pectin substance structures. The increase in EDTA-soluble pectin content was concomitant with the decrease in cutting force which the higher EDTA-soluble pectin content, the lower cutting force as shown in control treatment. Supapvanich and Tucker (2013) suggested that the increment of chelating soluble pectin concentration is related to increase depolymerisation of long chain polyuronides resulting to firmness loss. The immersion of Ca-propionate maintained the texture of ready to cook baby corn according to the retardation of increased EDTA-soluble pectin and induced Na_2CO_3-soluble pectin content that recognised as insoluble pectin form. The increased Na_2CO_3-soluble pectin content of Ca-propionate treated baby corn in the third day storage might be caused by the formation calcium pectate leading to increase insoluble pectin concentration. It is commonly recognised that calcium is improved texture of fresh commodities by strengthening cell wall structure. Ca^{2+} ion binds with de-methylated pectin to form calcium pectate called egg box structure which polygacturonase can not hydrolyte this form of pectin (Lara *et al*., 2004). The results in the experiment also showed that Ca-propionate immersion did not influence on total sugars content of the ready cook baby corn. It is indicated that Ca-propionate did not affect the taste, especially sweetness of the baby corn during storage. Similarly, the Ca-propionate treatment was not affected in the antioxidant and free radical scavenging activities of the ready cook baby corns when compared to control. However, the trends of antioxidant and free radical scavenging activities of Ca-propionate treated baby corn were slightly higher than control. It is widely addressed that antioxidant activity of fresh products relies on various factors, such as environmental conditions, preharvest practice and nutrient treatment (Lurie, 1998). Moreover, we found that Ca-propionate immersion induced total phenols, flavonoids and ascorbic acid contents in the ready cook baby corn during cold storage. These data were similar to Madani *et al*. (2016) reported that 2 % calcium chloride immersion induced antioxidant activity and total phenols concentration in papaya fruit during storage. Supapvanich *et al*. (2012) also reported that calcium immersion stimulated antioxidant activity and bioactive compounds such as total phenols, flavonoids and ascorbic acid contents and antioxidant enzyme activities in sweet leaf bush during cold storage. It is concluded that Ca-propionate immersion at 1 % (w/v) was a positive effect to maintain the eating quality, especially texture and nutritional values of ready cook baby corns during cold storage.

Acknowledgements

This research work was financially supported by Kasetsart University Research and Development Institute (KURDI).

References

Bakry M. O., EL-Desuki, M., El-Behairy, U. A. and Huda A. I. (2015). Effect of Some Post Harvest Treatments on Sweet Corn (*Zea Mays* Var. Rugosa) Quality During Storage. Middle East Journal of Agriculture Research, 4:925-931.

Benzie, I. F. F. and Strain, J. J. (1996). The ferric reducing ability of plasma (FRAP) as a measure of “antioxidant power”: The FRAP assay. Analytical Biochemistry, 239:70-76.

Brand-Williams, W., Cuvelier, M. E. and Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. Food Science and Technology, 28:25-30.

Brummell, D. A. (2006). Cell wall disassembly in ripening fruit. Functional Plant Biology, 33:103-119.

DuBois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A. and Smith, F. (1956). Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28:350-356.

Hashimoto, S. and Yamafuji, K. (2001). The determination of diketo-L-gulonic acid, dehydro-L-ascorbic acid, and L-ascorbic acid in the same tissue extract by 2, 4-dinitrophenol hydrazine method. Journal of Biological Chemistry, 147:201-208.

Lara, I., Garcia, P. and Vendrell, M. (2004). Modifications in cell wall composition after cold storage of calcium-treated strawberry (*Fragaria ananassa* Duch.) fruit. Postharvest Biology and Technology, 34:331-339.

Lurie, S. (1998). Postharvest heat treatment. Postharvest Biology and Technology, 14: 257-269.

Madani, B., Mirshekari, A. and Yahia, E. (2016). Effect of calcium chloride treatments on calcium content, anthracnose severity and antioxidant activity in papaya fruit during ambient storage. Journal of the Science of Food and Agriculture, 96:2963-2968.

McCann, M. C. and Carpita N. C. (2008). Designing the deconstruction of plant cell walls. Current Opinion in Plant Biology, 11:314-320.

Offices of Agricultural Economics (2018). Total and export values of agricultural goods. Retrieved from http:www.oae.go.th/statistic/export/QVExp.xls.

Oms-Oliu, G., Rojas-Grau, M. A., Gonzalez, L. A., Varela, P., Soliva-Fortuny, R., Hernando, M. I. H., Munuera, I. P., Fiszman, S. and Martin-Belloso, O. (2010). Recent approaches using chemical treatments to preserve quality of fresh-cut fruit: a review. Postharvest Biology and Technology, 57:139-148.

Seymour, G. B., Harding, S. E., Taylor, A. J., Hobson, G. E. and Tucker, G. A. (1987). Polyuronide solubilization during ripening of normal and mutant tomato fruit. - Phytochemistry 26:1871-1875.

Slinkard, K. and Singleton, V. L. (1997). Total phenol analysis: Automation and comparison with manual methods. American Journal of Enology and Viticulture, 28:49-55.

Supapvanich, S. and Tucker, G. A. (2013). Cell wall hydrolysis in netted melon fruit (*Cucumis melo* var. reticulatus L. Naud) during storage. Chiang Mai Journal of Science, 40:447-458.

Supapvanich, S., Arkajak, R. and Yalai, K. (2012). Maintenance of postharvest quality and bioactive compounds of fresh-cut sweet leaf bush (*Sauropus androgynous* L. Merr.) through hot $CaCl_2$ dips. International Journal of Food Science and Technology, 47:2662-2670.

Toivonen, P. M. and Brummell, D. A. (2008). Biochemical bases of appearance and texture changes in fresh-cut fruit and vegetables. Postharvest Biology and Technology, 48:1-14.

(Received: 12 August 2019, accepted: 20 June 2020)