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Implementation of alginate as edible coating to extend shelf life of baby corn (*Zea mays* L.)

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Baby corn (*Zea mays* L.) is a monoic annual plant which belongs to maideas tribe and the grass family of gramineae, a popular green food in Vietnam. There is a great demand of baby corn consumption in international market owing to its remarkable freshness, delicious taste, high nutrition, free from pesticide and multiuse. Baby corn is fresh at harvesting but quickly perishable due to its high respiration rate at ambient temperature under poor storage facilities. Preservation of baby corn for long shelf-life is very important to improve its commercial value. Edible coating is one of popularly innovative technologies to preserve vegetables for long stability. It extends shelf life of fruits and vegetables by reduction of moisture loss and gas exchange as well as reduction of the physiological disorders. The main postharvest damages in baby corn is rapid loss of firmness, soluble dry matter, and carotenoid. The purpose of the current study was to define the effectiveness of various alginate concentrations (0.30%, 0.35%, 0.40%, 0.45%, 0.50%) and storage temperature (4 ºC, 12 ºC, 20 ºC, 28 ºC) to the weight loss, firmness, total soluble solid, total phenolic and carotenoid in baby corns in preservation. Moreover, shelf life of baby corn was also monitored in 4 weeks. Results demonstrated that alginate 0.45% and storage temperature 20 ºC could extend baby corn quality for 3 weeks without any decomposition. Coating created semi-permeable film with more opportunities to delay ripening, minimize postharvest loss, maintain nutritional value, prolong the storage stability and generate surplus profit for farmers.

Keywords: Baby corn, alginate, coating, firmness, total soluble solid, total phenolic, carotenoid, shelf life

INTRODUCTION

Baby corn (*Zea mays* L.) or maize is very adaptable to different weather conditions. It is one of the most productive popular grains consuming as food at various developmental stages from baby corn to mature grain (AkramAhmadi and ParisaZiarati, 2015). The net income from baby corn is four to five times higher from a single crop than grain maize crop. Moreover, it can be multiplied by growing of 3-4 crops of baby corn in a year (Garima and Aaradhana, 2018). Baby corn is dehusked immature maize ear, harvested within 2-3 days of silking but prior to fertilization (Pandey et al., 1998). The desirable size of baby corn is 6-11 cm length and 1-1.5 cm diameter with regular row/ovule arrangement. The most preferred colour by the consumer is generally creamish to very light yellow (Pal, 2011). It is used in Asian cuisine and considered a specialty item outside of Asia (Poonam et al., 2010). Baby corn has unique profiles of nutrients and phytochemicals when compared with other whole grains. Corn nutrients and phytochemicals include vitamins (A, B, E, and K), minerals (Mg, P, and K), phenolic acids (ferulic acid, coumaric acid, and syringic acid), carotenoids and flavonoids (anthocyanins), and dietary fiber (Siyuan et al., 2018). Baby corn is highly nutritive as containing high content of fat, protein, carbohydrate, ash, calcium, phosphorus, ascorbic acid (Das et al., 2009). Its phosphorus level was higher than other vegetables (Carol et al., 1999). It is low in calories, high in fiber, and low in cholesterol. It is also free from residual effects of pesticides because it is harvested within a week of silk emergence and pesticide need not be applied during this time frame. Therefore it is also considered as a green food. Regular consumption of baby corn lowers the risk of developing chronic diseases such as cardiovascular disease, type 2 diabetes, and obesity and improves digestive health (Siyuan et al., 2018).

There were several researches mentioned to baby corn storage. The respiratory behavior of baby corn - whole and end-cut, under different temperatures and gas conditions was evaluated to study its respiratory dynamics based upon enzyme kinetics (Manpreet et al., 2012). Freezing is an effective processing technology to enhance the storage life of baby corn (Santosh and Asha, 2012). One study proposed to assess respiratory dynamics and also evaluate the effect of storage on quality of minimally processed baby corn by modified atmosphere packaging (Sushant et al., 2014). One research evaluated five corn varieties for baby corn yield and post-harvest quality under organic crop (Adelmary et al., 2016). The changes in the physicochemical characteristics of the baby corn stored at different temperatures and under controlled atmosphere were evaluated (Polyana et al., 2019).

During the post-harvest, there is significant damage due to microorganism, insect, respiration and transpiration (Raghav et al., 2016). Postharvest quality of baby corn is strongly affected by numerous varibles such as weight loss and chilling injury that deteriorate the quality of baby corn during postharvest handling. Major parameters in fresh vegetables were affected by colour, texture, appearance, flavour, nutritional and microbial indicators (Lin and Zhao, 2007). The babycorn must be properly harvested, handled, stored and transported in order to obtain quality produce in satisfactory condition at the place of destination. There was not any research mentioned to the application of edible coating to preserve baby corn. Therefore purpose of our study was to demonstrate the effectivenss of alginate concentrations (0.30%, 0.35%, 0.40%, 0.45%, 0.50%) and storage temperature (4 ºC, 12 ºC, 20 ºC, 28 ºC) to the weight loss, firmness, total soluble solid, total phenolic and carotenoid in baby corn during 4 weeks of storage.

MATERIALS AND METHODS

Material

Baby corn was harvested in Hau Giang province, Vietnam. They were cultivated following VietGAP to ensure food safety. After harvesting, it was stored at 28˚C and conveyed to laboratory as soon as possible for experiments. It was loaded carefully in plastic crates to avoid any mechanical injury during transportation. It was then manually graded and cleaned to sort out any damaged and diseased. Apart from baby corn we also used other materials during the research such as alginate, ethyl alcohol, propylene glycol.Lab utensils and equipments included digital weight balance, penetrometer, refractometer, biuret, and refrigerator.

Method

Preparation of edible coatings

Alginate (0.30%, 0.35%, 0.4 %, 0.45%, 0.50%) was prepared by dissolving 0.6g, 0.7g, 0.8 g, 0.9 g, 1.0g of alginate powder in 200 ml of water: ethyl alcohol mixture (4:1) at 75 ºC and stirred for 20 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. Baby corns were sprayed by alginate solution, dried at ambient room temperature for 30 minutes and then kept in different temperature (4 ºC, 12 ºC, 20 ºC, 28 ºC) to monitor the quality indicators for 4 weeks.

Effect of different alginate concentrations to physico-chemical characteristics of baby corn

Effect of different alginate concentrations (0.30%, 0.35%, 0.40%, 0.45%, 0.50%) to weight loss (%), firmness (N), total soluble solid (ºBrix), total phenolic (mg/100g), carotenoid (mg/ml) was assessed. All samples were preserved in 30ºC for 1 week.

Effect of storage temperature to shelf life of baby corn

After finding the optimal alginate coating concentration, quality of baby corn was also evaluated under different storage temperature. It was set in trays in four groups (4 ºC, 12ºC, 20 ºC and 28 ºC). Weight loss, firmness, total soluble solid, carotenoid values were assessed during 1 week to demonstrate the appropriate storage temperature.

Shelf-life of baby corn during preservation

After finding the optimal alginate concentration, storage temperature; stability of baby corn was also monitored in 4 weeks by 1 week-interval. Weight loss, firmness, total soluble solid, total phenolic, carotenoid values were assessed.

Fruit quality assessments and statistical analysis

The physico-chemical characteristics like weight loss (%), firmness (N), total soluble solid (ºBrix), and carotenoid (mg/ml) in fresh and coated baby corn (*Zea mays L.*) were evaluated. Weight loss (%) was estimated by comparison weight before and after coating in storage intervals (A.O.A.C., 1994). Firmness (N) was measured as penetrometer. Total soluble solids (ºBrix) was determined by a handheld refractometer. Carotenoid (mg/100g) was measured by near infrared spectroscopy (Elena et al., 2017). Total phenolic (mg/100g) was determined as per using FolinCiocalteu reagent (McDonald et al., 2011). The Methods were run in triplicate with three different lots of samples. Statistical analysis was performed by the Statgraphics Centurion XVI.

RESULTSAND DISCUSSION

Physico-chemical characteristics of fresh baby corn

The physico-chemical compositions in fresh baby corn were analyzed. Results were mentioned in table 1. Baby corn is a delicious, decorative and nutritious vegetable, without cholesterol. It is a low caloric vegetable which is rich in fibre content (Reena et al., 2017). Baby corn contains carotenoids, these are the substances that help prevent coronary artery disease, certain cancers and cataracts (Ravneet et al., 2009).

Effect of different alginate concentrations to physico-chemical quality of baby corn

Babycorn is a perishable commodity and has high respiration rate, so it cannot be stored for longer duration under ambient conditions and cannot be transported to distant places. The shelf life may be extended, thereby maintaining quality of the produce by appropriate production and harvesting practices, proper on farm handling, and post harvesting practice such as pre cooling, packaging, storage and transportation (Sushant Mehan et al., 2014). In our research, different alginate concentrations (0.30%, 0.35%, 0.40%, 0.45%, 0.50%) to weight loss (%), firmness (N), total soluble solid (ºBrix), total phenolic (mg/100g), carotenoid (mg/100g) was assessed. Results revealed in table 2. As clearly shown in table 2, all edible coatings significantly (P< 0.05) retard the changes in baby corn (*Zea mays L.*) weight loss, firmness, total soluble solid, total phenolic and carotenoid as compared to control samples. 0.45% alginate coating was appropriated for further experiments.

Effect of storage temperature to physico-chemical quality of baby corn

Mechanical stress, at the cut surface, cells and membranes reduces the life of freshly cut produce mainly due to damaged leading to alterations in tissue metabolism such as increase in water loss, CO_2, and ethylene evolution, alterations in flavor, aroma, and volatile profiles, increase in activity of enzymes related to enzymatic browning. Various techniques like packaging and low temperature storage need to be adopted to extend its post-harvest life (Sushant et al., 2014). In our research, after finding the optimal alginate coating concentration (%), physico-chemical quality of baby corn was also evaluated by the effect of different storage temperature. Results were elaborated in table 3. Storage temperature for baby corn (*Zea mays L.*) should be stored under 20ºC. In another research, the shelf life of baby corn were found to be packaging in 25 micron LDPE packages with 2 perforations followed by storage at 12.5°C (Sushant et al., 2014). The best storage condition to maintain the main quality characteristics of the spikelets at post-harvest was observed at the temperature of 16 ºC with controlled atmosphere (Polyana et al., 2019).

Table 1: The chemical compositions in fresh baby corn

Parameter	Firmness (N)	Total soluble solid (ºBrix)	Total phenolic (mg/100g)	Carotenoid (mg/100g)
Value	1562.71±0.23	13.78±0.03	26.83±0.01	31.45±0.00

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 2: Effect of different alginateconcentrations to physico-chemical quality of baby corn

Alginate concentration (%)	Weight loss (%)	Firmness (N)	Total soluble solid (ºBrix)	Total phenolic (mg/100g)	Carotenoid (mg/g)
Control	5.69±0.02[a]	1257.32±11.53[c]	10.76±0.02[c]	21.17±0.03[c]	25.07±0.00[c]
0.30	4.12±0.01[b]	1368.04±12.38[b]	12.03±0.01[b]	23.89±0.00[b]	28.74±0.01[b]
0.35	3.41±0.02[c]	1405.19±16.02[ab]	12.45±0.00[ab]	24.01±0.03[ab]	28.92±0.03[ab]
0.40	2.85±0.03[cd]	1478.65±10.05[ab]	12.78±0.03[ab]	24.12±0.02[ab]	29.08±0.01[ab]
0.45	2.03±0.01[d]	1503.29±12.04[a]	13.05±0.01[a]	24.49±0.00[a]	29.43±0.02[a]
0.50	2.00±0.02[d]	1512.06±11.33[a]	13.11±0.02[a]	24.52±0.01[a]	29.47±0.00[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 physico-chemical quality of baby corn

Storage temperature (ºC)	Weight loss (%)	Firmness (N)	Total soluble solid (ºBrix)	Total phenolic (mg/100g)	Carotenoid (mg/100g)
4 ºC	2.38±0.03[a]	1329.37±11.36[c]	11.49±0.03[c]	21.38±0.01[c]	26.62±0.01[c]
12 ºC	2.19±0.01[ab]	1451.25±10.83[b]	12.82±0.01[b]	23.91±0.03[b]	29.05±0.00[b]
20 ºC	1.85±0.00[b]	1534.03±12.36[a]	13.41±0.00[a]	25.76±0.02[a]	29.96±0.00[a]
28 ºC	2.03±0.01[ab]	1503.29±12.04[ab]	13.05±0.01[ab]	24.49±0.00[ab]	29.43±0.02[ab]

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 baby corn during preservation

Preservation time (weeks)	Weight loss (%)	Firmness (N)	Total soluble solid (ºBrix)	Total phenolic (mg/100g)	Carotenoid (mg/100g)
0	1.85±0.01[c]	1534.03±11.29[a]	13.41±0.00[a]	25.76±0.02[a]	29.96±0.00[a]
1	2.03±0.01[bc]	1504.27±13.41[ab]	13.14±0.03[ab]	25.23±0.00[ab]	29.42±0.03[ab]
2	2.49±0.02[bc]	1478.45±10.30[ab]	12.95±0.02[ab]	25.01±0.03[ab]	29.04±0.01[ab]
3	2.73±0.00[b]	1421.93±12.28[b]	12.67±0.00[b]	24.90±0.01[b]	28.85±0.00[b]
4	4.81±0.01[a]	1147.84±11.57[c]	11.06±0.02[c]	20.38±0.00[c]	22.24±0.02[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%)

Shelf-life of baby corn 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. In our research, after finding the potimal 0.45% alginate concentration, storage temperature at 20ºC; stability of baby corn also monitored within 4 weeks in 1 week-interval. Results were also mentioned in table 4, quality of baby corns could be maintained for 3 weeks. In another report, the maximum storage time of baby corn was two days and 12 hours, both at refrigerated temperature (16 °C) and under controlled atmosphere (Polyana et al., 2019). Ascorbic acid and beta-carotene content of frozen baby corn decreased significantly by 11.60 and 10.75%, respectively, by the end of 90 days of storage (Santosh and Asha , 2012).

CONCLUSION

Baby corn has a very wide range of usage than any other cereal. It can be used as staple food for human consumption, animal feed and for many industrial uses. Presently baby corn is gaining great attention in international market due to its short duration, freshness, taste, nutritive value, high market rate, free from pesticide and multiuse. Baby corn, 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 baby corn quality such as alginate coating concentration, storage temperature as well as extending product shelf life. The increase in shelf life of baby corn fruit would be an advantage to the growers. The results of this study could be used in baby corn industry to delay the loss in freshness and improve the storage life of baby corn during storage.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Minh Phuoc Nguyen arranged the experiments and also wrote the manuscript.

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