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RESEARCH ARTICLE

Carboxy Methyl Cellulose (Cmc) As Edible Coating to Extend Shelf Life of Duku (*Lansium Domesticum)* During Storage

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Abstract

Duku fruit **(***Lansium domesticum* Corr.**)** is a tropical fruit which contains a variety of nutrients especially vitamins and minerals that are health beneficial. It has a sweet sour taste, fresh, a little seed and has a thin skin. Duku fruit contains several phytochemicals that possess high antioxidant activities. Severe pericarp browning, fruit drop, moisture loss, off-flavor and chilling injury are the predominant problems in harvested longkong fruit during handling and storage. The postharvest handling of duku fruit aims to prolong its quality and value, but it is not yet adequately developed. It is necessary to use postharvest techniques for the extension of duku shelf life. Application of carboxy methyl cellulose (CMC) as edible coating could be considered as a useful approach to maintain its product quality during preservation. Ojective of the present study focused on the effect of carboxy methyl cellulose (CMC) coating on some physicochemical, microbial and sensory characteristics of duku during preservation. Optimal results showed that weight loss, pH, total soluble solids, titratable acidity and ascorbic acid; total plate count; sensory characteristics could be maintained at appropriate levels by coating duku with 1.5% carboxy methyl cellulose (CMC). The present study attempted to investigate some of the most significant findings to extend the shelf life of duku fruit.

Keywords: *Duku, Carboxy methyl cellulose, Coating, Preservation, Physicochemical, Microbial, sensory*

Introduction

Lansium domesticum Corr. is a fruit tree species belongs to the family Meliaceae. There are numerous forms of the species and grouped into two main types: Duku and Langsat [1]. The duku (*Lansium domesticum*) fruit an ellipsoid or globose berry, up to 2-4(-7) cm x 1.5-5 cm, yellowish pubescent, calyx persistent with reflexed lobes; fruit-wall thin (1-1.5 mm) or thick (up to 6mm) [2].

It has a sweet taste, fresh, a little seed and has a thin skin. The edible portion of longkong fruit is fleshy and juicy, with five fragments of uneven white translucent adhering aril [3]. Duku fruit pericarp can be easily removed from the raceme end with slight applied pressure [7]. Duku fruit has been reported to be a rich source of bioactive compounds, especially polyphenolics, flavonoids and vitamins [9]. A fully matured longkong fruit provides a higher level of phenolics than an immature fruit. The content of phenolic compounds in duku fruit increases with fruit maturity.

Also, matured longkong fruit pulp contains a large variety of vitamins such as thiamine, niacin, and vitamins A, B1, B2 and C. It has a wide range of pharmacological activities such as antimalarial, antitumor, anticancer, antibacterial, antimelanogenesis, antimutagenic and antioxidant [10, 11].

Extract from the duku fruit was found to be more successful in inhibiting the proliferation of human colorectal adenocarcinoma cell [12, 13]. Extracts of freeze-dried duku and langsat could stimulate the growth and stability of *Bifidobacteria* spp in skimmed milk [1]. Its botany and phytochemistry as well as its medicinal, nutritional and cosmeceutical value, which include antioxidant, moisturizing, whitening and lightening effects, are mentioned [2]. *Lansium domesticum* vinegars nutritional value were shown to contain the same carbohydrate, protein and fat value with the apple cider [14].

The seeds of the Duku fruit (*Lansium domesticum*) contain Octadecadienonic acid (linolik acid) [10]. Duku is a tropical fruit that undergoes postharvest deterioration rapidly. It's a highly perishable fruit and easily damaged, softens very rapidly during ripening, and becomes mushy and difficult to consume fresh. Duku fruit is highly susceptible to enzymatic browning that is catalyzed by oxidoreductase enzymes such as PPO and POD. Pericarp browning is one of the most significant problems in marketing and export of longkong fruit. Pericarp browning leads to the loss of economic value of longkong fruit, although it does not affect its flavor and nutritional contents [15]. Temperature (low and high) and environmental conditions are the key factors that cause the majority of quality losses in duku fruit, followed by postharvest decay [16]. Application of carboxy methyl cellulose (CMC) as edible coating could be considered as a useful approach to maintain its product quality during preservation. Ojective of the present study focused on the effect of carboxy methyl cellulose (CMC) coating on some physicochemical, microbial and sensory characteristics of duku during preservation.

Materials and Method

Material

Duku fruits were collected in Binh Duong province, Vietnam. They must be cultivated following VietGAP to ensure food safety. After harvesting, they must be conveyed to laboratory within 8 hours for experiments. Fruits were thoroughly rolled to remove dirt, dust and adhered unwanted material. Besides duku fruits we also used other materials during the research such as carboxy methyl cellulose (CMC), distilled water, NaOH, 2,6-dichlorophenolindophenol**,** Petrifilm - 3M, Tween 80, glycerol, PVC bag. Lab utensils and equipments included colony counter, refrigerator, pH meter, refractometer, digital balance, grinder, centrifugator.

Figure 1: Duku (*Lansium domesticum*)

Researching Procedure

Preparation of Coat Forming Solution

The coating solution was prepared by dissolving 0, 5, 10, 15, 20 g of carboxy methyl cellulose (CMC) powder in 1000 ml of distilled water for 10 h at 20°C to dissolve carboxy methyl cellulose (CMC) to prepare 1 L of 0%, 0.5%, 1.0%, 1.5%, and 2.0% carboxy methyl cellulose (CMC) solutions. Then, Tween 80 and glycerol were added in the carboxy methyl cellulose (CMC) solution [17].

Coating Application

The surface of the fruits were disinfected with 2% peracetic acid for 1 min and gently rinsed with distilled water, then air-dried. Fruits were separated into three groups in triplicate; each group of the fruits was quoted as control (without treatment) 0% and 0.5%, 1.0%, 1.5%, and 2.0% carboxy methyl cellulose (CMC) coating. Each group of duku was divided into 20 batches in triplicate (60 batches) each containing 1000±5g of whole duku.

They were dipped in the carboxy methyl cellulose (CMC) coating solution of 0%, 0.5%, 1.0%, 1.5%, and 2.0% for 1 min and the samples were air dried for 15 min at room temperature (about 28°C). The coated fruits were packed in PVC wrap and kept at 4°C in a refrigerated condition for a period of 30 days to study the shelf life and physicochemical and microbial parameters.

Determination of Weight Loss

Three batches of duku containing 1000±5g of whole duku were taken at an interval of three days for total storage period. The duku fruits were weighed regularly to determine weight loss, which was calculated cumulatively by comparing the weights of the sample with the electronic weighing balance at an interval of 5 days for the total 30 days storage period and the results were expressed as percentages.

Measurement of PH, Total Soluble Solids, Titratable Acidity and Ascorbic Acid

5g duku pulp was homogenized in 25 ml of distilled water. Then the mixture was filtered using muslin cloth. An aliquot of 25 ml was used to measure pH with a pH meter. The TSS was measured directly from the filtered residue using a hand refractometer and expressed as brix. The titratable acidity was determined with 0.1 N NaOH. Duku pulp (5g) from fruit was homogenized using a grinder and then centrifuged at 5000 rpm for 4 minutes; the supernatant phase was collected and analyzed to determine ascorbic acid content by 2,6-dichlorophenolindophenol titration.

Measurement of Microorganism Load

The total colony forming units (CFU) was enumerated during the storage period by Petrifilm - 3M.

Sensory Evaluation

The acceptability of the samples was evaluated through the standard sensory evaluation techniques.
The sensory attributes such as visual appearance, color, taste, flavor and acceptability was carried out by selected panel of judges (9 members) rated on a five point hedonic scale.

Statistical Analysis

The experiments 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 XVI.

Result & Discussion

Nutritional Composition in Duku Fruit

Table 1 Nutritional composition in duku fruit

Table 1: Major nutrient compositions in pulp of duku (*Lansium domesticum*)

Parameter	Moisture (g/100g)	Protein (g/100g)	Total soluble solid (°Brix)	Fibre (g/100g)	Total phenolics (mg/100g)	Vitamin C (mg/100g)
Value	23.41±0.02	8.19±0.02	15.38±0.02	20.37±0.01	2128.40±0.01	40.67±0.01

In a research reported, the edible fruit portion of duku is 68% of the fruit weight. In 100 g, it contains 84 g of water, 14.2 g of carbohydrates, 0.8 g of fiber, 0.6 g of ash, 19 mg of Ca, 275 mg of K, and some protein, fat, vitamin B1, B2, and vitamin C. The fresh peel contains 0.2% of the light-yellow volatile oil, brown resin and reducing acids. From the dried peel, it contains dark semiliquid oleoresin composing of 0.17% volatile oil and 22% resin [18].

Vitamin C is predominant as compared with the other vitamins in duku fruit [16]. Duku is a digestive and nutritious fruit with an exceptional combination of sugar and acids [19]. The content of total soluble solids (TSS) is also used as a maturity indicator in duku fruit; the recommended TSS in longkong fruit pulp during harvesting is between 15.0−17.0 ◦Brix [4, 20]. In another research, duku fruit contents such as total soluble solids (15.0−19.0 ◦ Brix), total sugars (13.0−14.5%) and reducing sugars (2.78-5.00%) increase, whereas titratable acidity tends to decrease during fruit ripening [21, 22].

The primary sugars present induku are fructose, glucose and sucrose.23 A gradual increase in pH (3.99-4.51) was observed in longkong fruit during four weeks (13 to 16 weeks) of on-tree maturation.5 A research reported that fully matured longkong fruit had a decrease in total acidity (0.61%) as compared with immature fruit (0.95%) [20].

Effect of Carboxy Methyl Cellulose (CMC) Coating on Weight Loss of Duku

The weight loss of duku observed in control was due to the shrinkage of fruits by loss of moisture which was not observed in the coated fruits. The carboxy methyl cellulose (CMC) coating prevented the evaporation of moisture from coated duku fruits. There was a significant difference observed between the control and coated samples. Results were showed in Table 2.

Table 2: Effect of carboxy methyl cellulose (CMC) coating on weight loss (%) of duku stored at 4°C

Preservation time (days)	Carboxy methyl cellulose (CMC) concentration				
	0%	0.5%	1.0%	1.5%	2.0%
0	0	0	0	0	0
5	2.28±0.02^{a}	2.24±0.01^{ab}	2.04±0.01^{b}	1.49±0.01^{bc}	1.32±0.01^{c}
10	5.17±0.00^{a}	5.04±0.03^{ab}	4.78±0.02^{b}	4.40±0.02^{bc}	4.23±0.01^{c}
15	6.47±0.01^{a}	6.38±0.00^{ab}	6.20±0.01^{b}	6.07±0.01^{bc}	5.45±0.00^{c}
20	8.34±0.03^{a}	8.26±0.03^{ab}	8.15±0.01^{b}	8.11±0.03^{bc}	7.21±0.01^{c}
25	9.08±0.01^{a}	8.67±0.00^{ab}	8.49±0.00^{b}	8.35±0.02^{bc}	8.14±0.02^{c}
30	10.13±0.02^{a}	10.05±0.02^{ab}	9.50±0.03^{b}	9.44±0.00^{bc}	9.18±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%)

Rapid pericarp browning, softening and loss of freshness during transportation and in retail stores are the major problems in duku fruit [16]. Several reports stated that longkong fruit stored between 10 and 15 ◦C had chilling injury symptoms such as fruit drop, weight loss, pitting and brown scalding of the skin with a water-soaked appearance [24]. Normally, longkong fruit chilling injury symptoms appear after fruit are kept at ambient temperature for more than three hours.

Effect of Carboxy Methyl Cellulose (CMC) Coating on PH, Total Soluble Solids, Titratable Acidity and Ascorbic Acid of Duku

Carboxy methyl cellulose (CMC) coating could maintain the respiration at a minimal rate. Effect of carboxy methyl cellulose (CMC) coating on pH, total soluble solids, titratable acidity and ascorbic acid of duku was clearly illustrated in Table 3.

Table 3: Effect of carboxy methyl cellulose (CMC) coating on pH, total soluble solids, titratable acidity and ascorbic acid of duku stored at 4°C after 30th day of preservation

Duku treated with	Parameters			
	pH	Total soluble solids (o Brix)	Titratable acidity (%)	Ascorbic acid (mg/100g)
1.5% carboxy methyl cellulose (CMC) before preservation	5.48±0.01^{a}	15.38±0.02^{a}	9.57±0.01^{a}	40.67±0.01^{a}
1.5% carboxy methyl cellulose (CMC) after 30th day of preservation	5.50±0.02^{a}	15.33±0.00^{a}	9.55±0.02^{a}	40.51±0.01^{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%)

The prolongation of the shelf life of duku has not yet been accomplished due to its high susceptibility to decay and chilling injury under low temperature and higher relative humidity (RH) storage [5]. The sugar and organic acid contents in longkong fruit steadily decrease as the fruit storage life increases (Sirichote A.).

Duku fruit ascorbic acid content increased with time during storage at a low (13 ◦C) and high temperature (25 ◦C) and at high RH (80-90%)[24]. Storage conditions such as the temperature and packaging environment are the key factors influencing the acidity level of postharvest longkong fruits.

Effect of Carboxy Methyl Cellulose (CMC) Coating on Total Plate Count (TPC) of Duku

Contamination of the fruits and vegetables flesh can occur from the skin increasing the fruits and vegetables spoilage leading to biochemical deterioration such as browning, off flavour and texture break down, decreasing the fruits and vegetables quality and the risk to the consumers due to the presence of pathogenic microorganism [25].

Duku fruit is highly susceptible to decay as it is majorly affected by fungal and bacterial infections during postharvest storage. Sooty mould (*Meliola* spp.) and fruit rot

(*Cylindrocladium* spp.) are the most common types of decay in duku fruit.

Decaying organisms increased the rate of fruit drop, loss of firmness and pericarp browning in duku [7].

Table 4: Effect of carboxy methyl cellulose (CMC) coating on sensory characteristics of duku stored at 4°C after 30th day of preservation

Duku treated with	Total plate count (TPC)
1.5% carboxy methyl cellulose (CMC) before preservation	$1.4 \times 10^{2} \pm 0.01^{a}$
1.5% carboxy methyl cellulose (CMC) after 30th day of preservation	$0.3 \times 10^{1} \pm 0.02^{b}$

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%)

One study found that an increase in longkong fruit drop was influenced by *Cladosporium, Colletotrichum, Fusarium, Lasiodiplodia* and *Penicillium* [26]. One research reported that coating longkong fruit with 2% chitosan and then fumigating it with 5 µM MeJA could control mould growth during postharvest storage [27].

Effect of Carboxy Methyl Cellulose (CMC) Coating on Sensory Characteristics of Duku

Duku fruit during maturation had increasing activities of the pectin methylesterase and polygalacturonase and this could be the reason for decreasing fruit firmness during ripening [6].

Table 5: Effect of carboxy methyl cellulose (CMC) coating on sensory characteristics of duku stored at 4°C after 30th day of preservation

Duku treated with	Sensory score
1.5% carboxy methyl cellulose (CMC) before preservation	7.95 ± 0.02^{a}
1.5% carboxy methyl cellulose (CMC) after 30th day of preservation	7.89 ± 0.01^{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%)

Duku fruit harvested at 4, 7, 11, 14 and 17 days after fruit yellowing stage were monitored for changes in colour and chemical characteristics. Fruit yellowing (FY) is the stage at which all dokong fruit in a bunch have yellowish-green pericarp. The pericarp changed from yellowish green to intense yellow (higher b* and C* values) on the fourth day, dark yellow (lower L* value) on the seventh day, and light yellow (higher L* value) on the 11th day [28]. Storing duku fruit at low and high temperatures causes severe pericarp browning and decreases its shelf life [3].Storing longkong fruit at 18 ◦C and 85 to 90% RH could control the rapid browning, extending the shelf life for several weeks with minimal organoleptic changes [6, 29, 30].

Conclusion

Duku fruit is a typical tropical plant that has high economic value and health value. Duku fruit pulp has a pleasant aroma with a sweet and slightly sour taste. It has unique nutritional and organoleptic characteristics that contribute to fruit exports to numerous countries.

Therefore, the duku fruit should be preserved for a long shelf life without using chemical substances. We have successfully optimized some physicochemical, microbial and sensory characteristics of duku during preservation. By this study, there will be an alternative approach to prolong duku shelf-life during post-harvest.

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