The Application of *Nata de coco*-based Coatings to Fresh-cut Jackfruits during Refrigerated Storage

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Abstract. Jackfruit (*Artocarpus heterophyllus* Lam) is in high demand by Asians. It is large and difficult to peel, therefore, consumers prefer to buy jackfruit as a ready to eat product. Jackfruit is highly perishable. It ripens faster during the shelf life, and soon become unfit for eating. Development of colour, texture, and volatile compounds which contribute to flavour and aroma takes place during the ripening process. At present, edible coatings are becoming populer among consumers to preserve the parameters quality of foods. The aim of this study was to investigate the effect of application of *nata de coco*-based edible coatings on retention of fresh-cut jackfruit quality during a shelf life under refrigerated conditions (10 ^{0} C). The *nata de coco*-based coating was developed by dissolving *nata de coco* and glycerol in distilled water. $CaCl_2$ was used as a cross-linking agent. The fresh-cup jackfruit quality could be preserved under refrigerated temprature for 3 days by applied *nata de coco* coatings made from 3 weeks *nata.*

Keywords: edible coating, jackfruit, nata de coco, shelf life

1 INTRODUCTION

Deterioration of fresh-cut produce occurs gradually during storage and its cumulative effect renders unacceptable to consumers. Fresh-cut processing induces chemical and biochemical changes besides increasing product respiration rate leading to a reduction of storage time [1]. Fresh fruit and vegetable moisture loss after harvest represents a serious problem causing shrinkage and weight decrease of the products, and this phenomenon is more prominent in processed and ready-to-eat samples.

Jackfruit is classified into climacteric fruit with CO_2 production rate at 5^{o}C is 10 – 20 mg.kg^{-1}.h^{-1}. Jackfruits stored at temperature below 12^{o}C before transfer to higher temperature exhibit chilling injury symptoms including dark-brown discoloration of the skin, pulp browning, and deterioration in flavor and increase susceptibility to decay [2].

Edible coatings are an eco-friendly technique, which slows deterioration of fruits and vegetables by controlling gas exchange, moisture transfer, and oxidation. Major advantage of these coatings is to improve nutritional and sensory quality of food by incorporating active ingredients into the polymer matrix that are consumed with food products [3].

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Carboxymethyl cellulose (CMC) has been widely used in edible coatings for fresh fruits and vegetables [4], [5]. A cellulose derivative using the bacterial cellulose nata de coco has also been synthesized [6], [7]. The derivative is herein referred to as carboxymethyl nata (CMN). The CMN coatings reduced the rate of ripening of bell pepper fruits [7]. An edible natural biodegradable coating could be used to replace commercial synthetic waxes as coatings for citrus fruits [8][9]. The CMC coating had the least weight loss and adequate gloss and a CMC/chitosan bilayer coating improved fruit quality [9]. A CMC coating containing a crude extract of Moringa oleifera applied on oranges and stored at ambient temperature was effective in extending the shelf life of the fruits [10].

The objective of the study was to investigate the effect of nata de coco-based coating formulation on the quality of fresh-cut jackfruit at 10°C of temperature storage.

2 MATERIALS AND METHODS

2.1 Materials

Nata de coco at different time of incubation were purchased from a small scale industry of *nata de coco* at Mataram, jackfruit at ripe stage was collected in Gunungsari village of west Lombok regency. Other materials were used such as CMC, distilled water, NaOH, HCl, citric acid, cling wraps, PVC bag. Lab utensils and equipments included refrigerator, pH meter, refractometer, digital balance, hotplate, magnetic stirrer, thermometer, fruit penetrometer and glassware.

2.2 Preparations of *Nata de coco* Pulp

Nata de coco was heated with 1% NaOH for 60 minutes. This suspension then washed with water and followed by boiling for the second time in water. The *nata de coco* soaked in water for one night. Pulping was done by smoothing *nata de coco* using a blender and used for the manufacture of edible coating.

2.3 *Nata de coco* as coating for fresh-cut jackfruit

Peeled jackfruit were sorted based on size, color and absence of external injury. The selected fruits were randomly divided into two groups, and each group was divided into different sets. In the first group, each set consisted of 3 fruits each serving as a replicate. A treatment was assigned a set of fruits. This group of fruits was used in monitoring weight loss and appearance. The second group, consisting of 2 fruits per set, was used for chemical destructive analyses.

The coating formulations prepared contained 97% ,97,5%,98% and 98,5% of nata filtrate from different incubation time (nata de coco harvested at 7, 14 and 21 days) mixed with some additives. The nata filtrate was dissolved in 20 ml of 10% NaOH and diluted with water to 100 ml together with the additives so that the final concentration of NaOH was 2% and the pH of the mixture was 6.2- 6.5. The additives consisted of an acidulant, an emulsifier, a plasticizer and a firming agent. The coating formulations were applied evenly on the fruit surface by immersing. The fruit samples were arranged in one layer in open plastic baskets and wrapped with cling plastic, then stored for 9 days at 10 0C. Changes in the physical and chemical characteristics of the fruits were monitored at 3-day intervals.

2.4 Statistical analyses

The Kruskal-Wallis test for *k*-independent samples with the pairwise mean rank comparison test was used to evaluate the result of sensory atributes such as colour, texture and aroma. The other parameters were analyzed using the analysis of variance f-test for a randomized complete block design with pairwise comparison using Honestly Significant Difference (HSD) test to determine significant differences at 5% level of significancy.

3 RESULTS AND DISCUSSION

Nata de coco has been used as a starting material for the preparation of carboxymethyl cellulose (CMC). The CMC produced from this raw material has been referred to as carboxymethyl-nata (CMN). CMC is considered the most important cellulose derivative for food applications. Many of the polysaccharide-based edible coatings for fruits and vegetables make use of CMC [11]. Edible coatings have been developed to improve food quality and shelf-life by providing a semi-permeable barrier to gases and water vapor [12].

CMC with a degree solubility (DS) of 0.7 is the most common type utilized in food systems [12]. A maximum DS of 0.95 carboxymethyl groups per monomeric unit of food-grade CMC is allowed by the Code of Federal Regulations of the USA [12]. A high DS is desirable because solubility and stability are increased and compatibility with other ingredients is greater [7]. Harvesting time had a significant effect on cellulose content of nata de coco. Therefore, the DS of CMN from different harvesting time will contribute to effectiveness of the quality of edible coating.

The effectiveness of nata de coco-based coating for fresh-cut jackfruits which different time of harvesting on physico-chemical characteristics of the produce were showed in Table 2, 3, 4, and their contribution to sensory attributes of fresh-cut jackfruit at different time of storage at refrigerated temperature (100C) in Tabel 6.

Table 1. The result of variance analyses of nata *de coco's* harvesting time (N) and storage time of coated fresh-cut jackfruits (T) at refrigerated temperature on the parameter.

Parameter	harvesting time of *nata de coco* (N)	storage time of coated fresh-cut jackfruit (T)	Interaction (NxT)
Weight loss (%)	S	S	NS

Firmness (kg.mm^{-1})	S	S	NS
Total soluble solids (°Brix)	S	S	S
pH	S	S	NS
Colour	NS	S	NS
Texture	NS	S	S
Aroma	NS	S	S

Note: the characters of NS and S (denoted above), the analyses of variance was not significant and significant (α = 5%), respectively.

There were interaction effect of harvesting time of nata de coco and time of storage at refrigerated temperature on total solids, texture, and aroma of coated fresh-cut jackfruits. However, there were no interaction found on weight loss, firmness, pH, and the preference of fresh-cut jackfruits colour (Tabel 1).

Table 2. Weight loss (%) of fresh-cut jackfruits coated with *nata de coco* from different time of harvesting and length of storage at 10^{0}C

Storage (days)	*Nata de coco* harvesting time (weeks)		
	1	2	3
3	12.20a	10.47a	7.29b
6	13.89a	11.69a	8.35b
9	15.51a	12.82a	8.58b
HSD $_{0.05}$	**3.46**	**3.46**	**3.46**

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. Firmness (kg.mm^{-1}) of fresh-cut jackfruits coated with *nata de coco* from different time of harvesting and length of storage at 10^{0}C

Storage (days)	*Nata de coco* harvesting time (weeks)		
	1	2	3
3	3.07b	2.6c	2.01c
6	1.81a	1.98a	1.83a
9	1.03a	1.32a	0.79a
HSD $_{0.05}$	**0.65**	**0.65**	**0.65**

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. Total soluble solids (° Brix) of fresh-cut jackfruits coated with *nata de coco* from different time of harvesting and length of storage at 10^{0}C

Storage (days)	*Nata de coco* harvesting time (weeks)

	1	2	3
3	3.55a	3.79a	5.50b
6	6.90bc	6.35b	7.55c
9	7.60bc	7.70bc	8.15c
HSD 0.05	**0.88**	**0.88**	**0.88**

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 5. pH of fresh-cut jackfruits coated with *nata de coco* from different time of harvesting and length of storage at 10^0C

Storage (days)	*Nata de coco* harvesting time (weeks)		
	1	2	3
3	6.1c	5.6c	5.9c
6	4.9b	4.5b	5.0b
9	3.5a	3.8a	3.4a
HSD 0.05	**0.68**	**0.68**	**0.68**

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 6. Sensory score of colour of fresh-cut jackfruits coated with *nata de coco* from different time of harvesting and length of storage at 10^0C

Storage (days)	*Nata de coco* harvesting time (weeks)		
	1	2	3
3	3.25a	4.08b	4.10b
6	2.85a	2.65a	2.65a
9	2.45a	2.45a	2.45a
HSD 0.05	**1.17**	**1.17**	**1.17**

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 7. Sensory score of texture of fresh-cut jackfruits coated with *nata de coco* from different time of harvesting and length of storage at 10^0C

Storage (days)	*Nata de coco* harvesting time (weeks)		
	1	2	3
3	2.65b	3.10c	3.33b
6	2.55a	3.60bc	3.45b
9	1.95a	2.00a	2.85b
HSD 0.05	**0.62**	**0.62**	**0.62**

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 8. Sensory score of aroma of fresh-cut jackfruits coated with *nata de coco* from different time of harvesting and length of storage at 10^0C

Storage (days)	*Nata de coco* harvesting time (weeks)		
	1	2	3
3	2.53a	3.15b	2.55b
6	2.75ab	2.40a	3.15b
9	2.30a	2.25a	2.65ab
HSD $_{0.05}$	**0.67**	**0.67**	**0.67**

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%).

3.1 Change in physical attributes of coated jackfruits

Weight loss. A major factor in fruit deterioration is water loss. Fruits and vegetables continue to respire and lose water after harvest. Water loss greatly reduces fruit quality. resulting in pronounced economic loss expressed as weight loss. The hollow nature of the jackfruit limits its water reservoir capacity and therefore small amounts of water loss consequently decrease freshness and firmness. thereby reducing fruit quality. shelf-life and market value. Selective films are applied to fruits and vegetables to reduce weight loss.

Generally, no significant differences in weight loss were observed among all of the treatments (Table 2). These indicated that the nata coatings at different time of harvesting did not retard weight loss. Similar results were reported for bell pepper by Lerdthanangkul and Krochta [12]. Polysaccharide films are not effective in retarding water loss because of their hydrophilic character. a consequence of the presence of numerous hydroxyl groups in the polymer[14] . Such films provide only minimal water barriers [15].

The relative humidity of the storage unit where the fruits were stored may have contributed to water loss. The large surface-to-volume ratio of jackfruit makes these fruits susceptible to water loss. Water migration in fruits is accelerated when the relative humidity is low. consequently enhancing weight loss. A high relative humidity is preferred to prevent water diffusion. However. a high relative humidity at room temperature would favor microbial growth. It is therefore imperative that a fruit coating acts as a gas and moisture barrier.

Firmness. Firmness is a major quality factor that greatly plays a role during the selection of a fruit by a consumer. Decrease of firmness in fruits occurs after harvest through loss of moisture. starch breakdown and cell-wall degradation. Cell wall components are held together by pectin that serves as a cementing substance. As fruit ripens. pectic substances breakdown through the action of enzymes. resulting in fruits that are less succulent. less tender and more fibrous [16].

A decrease in firmness was observed in all fruit samples during storage (Table 3). However. just like weight loss. no significant differences were observed among the treatments of 6 days and 9 days storage at refrigerated temperature, but the nata-coated fruits with 3 weeks of nata de coco harvesting time exhibited a slower rate of decrease in firmness. The higher firmness values of the coated fruits may indicate that the nata de coco coating had retarded ripening to a slight extent. This would parallel the observation that the nata-coated fruits exhibited delayed ripening based on color change (Table 4). Similarly, data found in bell peppers coated with an edible coating based on CMC and stearic acid that it showed less firmness deterioration in comparison with control fruits [17]. The firmness of bell peppers coated with lipid-based coatings during storage had no significant differences [18].

These researchers reported that pectin content decreased significantly in coated fruits stored for 9 days at 10 0C with 80-85% relative humidity. It may be said that the slower rate of decrease in firmness of the nata-coated fruits may be attributed to a decrease in pectin content with storage. However, the loss of pectic substances may not appear to be the main factor that accounts for the decrease in firmness but may also be attributed to the cleavage of linkages of the cell wall components and hydrolysis.

3.2 Changes in some chemical characteristics of coated jackfruits during storage

Total Soluble Solids. The Total soluble solids (TSS) estimates the sugar content of a fruit. In this study. the TSS of the jack fruits increased up to the 9th day of storage (Table 4). The TSS of fresh-cut jackfruit coated with *nata de coco* of 3 weeks had the highest value compared to 1 and 2 weeks, but the TSS of jackfruits coated with 3 weeks of *nata de coco* was not significant when stored for 6 and 9 days, although the TSS increased during 9 days of storage. The increase in TSS during storage may be attributed to the sugars that form during ripening. It has been reported that different kinds of sugars are formed as jackfruit ripens. One such sugar is glucose. a precursor of vitamin C. Hence. sugar formation in the coated fruits may not have occurred to the same extent as that of the control and blank fruits. This could also mean that the rate of ripening of the coated fruits was slower than that of the blank and control fruits. The increase in TSS suggests that citric acid may have been utilized in the synthesis of sugars [19]. The possible enzymatic degradation of polysaccharides may be another reason for the TSS increase. Brix readings increased upon action of cell wall digesting enzymes on citrus pulp due to the solubilization of reducing sugars [20]

pH. The pH of the juice extracts ranged from 3.4 -3 .8 after the 9-day storage period (Table 5). A decrease in pH relative to the initial pH was observed in juices extracted from 6 days fruits. The decrease in pH can be attributed to the high percentage of moisture loss in these treatments as inferred from their weight loss (Table 2). When water is lost. the concentration of the solvated hydrogen ions become more concentrated. thus making the juice more acidic. Also. the possible existence of active synthetic pathways producing soluble acids contributing hydrogen ions in fruits during storage would cause a decrease in pH. The nata harvesting time for coated formulation had not significant contribution to pH of jackfruits, but the storage time.

3.3 Sensory characteristic of coated jackfruit

The results indicated that no significant differences in sensory score were recorded among coated samples of different *nata de coco* harvesting time at the same days of storage. The sensory of coated jack fruit was significantlt affected by the length of storage. The sensory attributes of texture and aroma was affected significantly by the length of storage and *nata* harvesting time. Score of texture and aroma of coated jack fruit drop dramatically after 3 days storage of storage.

Colour. The results showed that the nata coatings had the tendency to retard peel color changes. This may further be implied from the observation that the formulation of nata from 3 weeks harvesting time exhibited lower colour than that with 1 weeks (Tabel 6). Color retardation may be attributed to the gas barrier property of polysaccharide coatings such as CMC. Polysaccharide-based coatings have been reported to extend the shelf-life of fruits and vegetables because of their reduced permeabilities to carbon dioxide. oxygen and ethylene [12]. CMC coatings in particular reduce oxygen uptake but do not cause an equivalent increase in carbon dioxide concentration in the internal atmosphere of fruits. thus preventing anaerobic fermentation [12]. The appearance of the yellow color in jackfruit is brought about by the degradation of chlorophyll induced by ethylene.

Texture. Texture is a sensation of pressure that can be felt by mouth or using palpation with the finger [15]. Table 7 showed that the most texture preferred was fresh-cut jackfruit coated with 2 weeks of nata harvesting time and stored for six days. The lowest score of texture was found on fruit of 1 weeks nata harvesting time and 9 days of storage. The preference of panelist drop when the fruits had juiceness characteristic and firmness decreased. The firmness change due to the cleavage of linkages of the cell wall components and hydrolysis [This characteristic indicated that the fruits pectin decrease in storage. made the fruits firmness decrease.

Aroma. According to the results given in Table 8, the aroma score of coated fresh-cut jackfruit were laid between 2,25 – 3,15 of 5 scale. The highest score were found on fruits coated with 2 weeks nata and 3 days of storage, however on 6 days of storage, the fruits aroma of 3 weeks nata got the highest. The score of aroma decreased after 3 days of storage and drop significantly after 6 days of storage. It was indicated that the aroma lost during storage due to nata-based coating was unable to be gas barrier. Ong, al [21] reported that jackfruit contain volatile compound such as ethyl isovalerate, 3-

methylbutyl acetate, 1-butanol, propyl isovalerate, isobutyl isovalerate, 2-methylbutanol, and butyl isovalerate [21].

4 CONCLUSIONS

Utilization of *nata de coco* for fruits coating depended on the harvesting time of *nata* cultivation. Interaction of harvesting time and the length of storage at refrigerated temperature affected the quality of fresh-cut jackfruits coated with *nata*-based edible coating for 9 days storage at refrigerated temperature. Coating with 3 weeks *nata* and stored at refrigerated temperature for 3 days preserved the quality of the fresh-cut jackfruits.

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References

1. N. Azarakhsh, A. Osman, H.M. Ghazali, C.P.Tan and N.M Adzahan,. Lemongrass essential oil incorporated into alginate-based edible coating for shelf-life extension and quality retention of freshcut pineapple. *Postharvest Biology and Technology* 88: 1–7. (2014)
2. ICUC (International Centre for Underutilized Crops),. *Handling Jackfruits after Harvest.* UK: Department for lnternational Development. Forestry Research Program. (2004)
3. P. Sharma. V. P. Shehin, N. Kaur. and P. Vyas. Application of edible coatings on fresh and minimally processed vegetables: *a review*. International Journal of Vegetable Science 2018; 10: 1-20. (2018)
4. A. Niazmand. H.B., Ghodusi, F. Shahidi. and R. Niazmand. Effects of three polysaccharide coatings on physiochemical and organoleptic properties of mushroom (*Agaricus bisporus*). *American-Eurasian Journal Agricultural & Environmental Science* 5: 740–744. (2009)
5. M.H. Bahri and M. Rashidi. Effects of coating methods and storage periods on some qualitative characteristics of carrot during ambient storage. *International Journal of Agriculture and Biology* 11: 443–447. (2009)
6. L.S. Manguiat, V.C. Sabularse, D.C. Sabularse. Development of carboxymethylcellulose from *nata de coco*. *ASEAN J Sci Technol Dev* 18:8596. (2001)
7. V.C. Sabularse, M.N.D.Montalbo, H.P. Hernandez and E.P. Serrano. Preparation of nata de coco-based carboxymethylcellulose coating and its effect on the post-harvest life of bell pepper (*Capsicum annuum* L.) fruits. *International Journal of Food Sciences and Nutrition*. 60 (7): 206–218. (2009)
8. H. Arnon.. Y. Zaitseva. R. Portat. and E. Poverenova. Effects of carboxymethyl cellulose and chitosan bilayer edible coating on postharvest quality of citrus. *Postharvest Biology and Technology* 87: 21–26. (2014)
9. H. Arnon, R. Granit, R. Porat and E. Poverenov. Development of polysaccharide-based edible coatings for citrus fruits: A layer-by-layer approach. *Food Chemistry* 166: 465–472. (2015)

10. C.O. Adetunji, O.B. Fawole, K.A. Arowora, S.I. Nwaubani, J.K. Oloke, A.O. Adepoju, J.B. Adetunji, and A.O. Ajani. Performance of edible coatings from carboxymethylcellulose (CMC) and corn starch (CS) incorporated with *Moringa oleifera* extract on *Citrus sinensis*. *Agrosearch* 13: 77–85. (2013)
11. J.M. Krochta, De Mulder-Johnston. Edible and biodegradable polymer films: Challenges and opportunities. *Food Tech* 51:6174. (1997)
12. M.O. Nisperos-Carriedo. Edible coatings and films based on polysaccharides**. In** Krochta, J.M., Baldwin, E.A. and Nisperos-Carriedo, M.O. (Eds). *Edible Coatings and Films to Improve Food Quality*. Lancester: Technomic Publishing Co., Inc. (1994)
13. Fundador, E.O.V., Sabularse, V.C. and Revilleza, M.J.R. Immobilization of invertase on carboxymethylcellulose prepared from nata de coco for the inversion of sucrose. ASEAN *Journal of Science and Technology for Development* 20: 37–47. (2003)
14. T.H. McHugh, R.J- Avena-Bustillos and W. Du.,. *xtension of Shelf Life and Control of Human Pathogens in Produce by Antimicrobial Edible Films and Coatings*. **In** Microbial Safety of Fresh Produce. eds. X. Fan, B.A. Niemira, C.J. Doona, F.E. Feeheriy and R.B. Gravani. SingaPore: IFT Press and Wiley-Blackwell. (2009)
15. J.J. Kester and O. Fennema,. An Edible Film of Lipids and Cellulose Ethers: Performance in a Model Frozen-Food System. *Journal of Food Science* 54 (6) : 1390 – 1392. (1989)
16. F.D. Conforti and J.B. Zinck. Hydrocolloid-Lipid Coating Affect on Weight Loss, Pectin Content, and Textural Quality of green Bell Peppers. *Journal of Food Science* 67 (4) : 1360 – 1363. (2002)
17. C.E. Uquiche, T.M. Villaroel, and L. Cisneros-Zevallos. Edible coating effects on the sensory quality of green bell pepper fruits (*Capsicum annuum* L.). *Arch Latinoam Nutr* 52: 8490 – 8495. (2002)
18. M. Mohebbi, M. R. Amiryousefi, N. Hasanpour and E. Ansarifar. Employing an intelligence model and sensitivity analysis to investigate some physicochemical properties of coated bell pepper during storage. (2013)
19. R.B.H Wills, T.H. Lee, D. Graham, W.B/ McGlasson, and E.G. Hall. *Postharvest: An introduction to the physiology and handling of fruit and vegetables*. Westport, CT: AVI Publishing Co. Inc. (1981)
20. E. Echeveria, J.K. Burns, and L. Wicker. Effect of cell wall hydrolysis on Brix in citrus fruit. *Proceedings* of Florida State Horticultural Society. Florida: Florida State Horticultural Society. (1988)
21. B.T. Ong a , S.A.H. Nazimah, C.P. Tan, H. Mirhosseini , A. Osman, D. Mat Hashim, G. Rusul. Analysis of volatile compounds in five jackfruit (Artocarpus heterophyllus L.) cultivars using solid-phase microextraction (SPME) and gas chromatography-time-of-flight mass spectrometry (GC-TOFMS). *International Journal of Food Science and Technology* 47 : 299–305. (2012)