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Minimally Processed Jackfruit: Opportunity for the Foodservice Industry

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Abstract

Jackfruit is found in abundance in Malaysia. However the use of jackfruit as fresh dessert or in fruit platter has not been fully utilized in the foodservice industry due to the short shelf life of fresh jackfruit. The aim of this paper is to compare two simple calcium-infusion methods in ripe jackfruit pulps. Calcium is infused into the jackfruit pulps through immersion and vacuum-infusion techniques. The addition of calcium into the jackfruit enhanced the firmness and textural integrity of the fruit, thus prolonging the shelf life to 10 days. The minimally processed jackfruit exhibit fresh-like quality and longer shelf stability. It provides a variation in the fruits offered in foodservice establishment.

Keywords: jackfruit, calcium, minimal processing, shelf life, texture

1. Introduction

The consumption of fresh fruits and vegetables are growing as consumers become more aware about its health benefit (Allende, Tomás-Barberán, & Gil, 2006; Bennik, Vorstman, Smid, & Gorris, 1998). However, the current condition where people eat more meals outside their homes have increase the demand for convenient foods that retain as much fresh characteristics as possible (Ahvenainen, 1996; Corbo, Campaniello, Speranza, Bevilacqua, & Sinigaglia, 2015). Jackfruit, a local fruit of Malaysia is rich in nutrients. It contains carbohydrate and is high in fibre, minerals, carotenoid and thiamine (Jagadeesh et al, 2007; Willet, 2002). It has a distinctive aroma with sweet crisp flesh that can be eaten raw or cooked in a variety of sweet or savoury dishes. However, marketing of jackfruit has been hindered by the size of the fruit and difficulty in handling. As the whole fruit usually weigh up to more than 45kg, currently the fruits are marketed whole or separated fruitlets packed in polyethylene bags.

As the edible portion only makes up 30-35% of the fruits, the jackfruit is highly potential for minimal process. Pre-cut fruits lose some of its textural integrity due to the release of enzymes that disintegrate the cell wall. This presents an opportunity for the foodservice industry to cater to this increasing demand.

Jackfruit tree is an evergreen tree, easily grown in Asia (Jagadeesh et al., 2007). Every part of the tree can be used, either as food (Ismail & Kaur, 2013), medicine (Jagtap & Bapat, 2010) or building materials (Haq, 2006). The Malaysian Department of Agriculture has identified jackfruit as one of the Entry Point Projects for premium fruits in the Malaysian Economic Transformation Programme for export to the Middle East and Europe

Minimally processed jackfruit has a short shelf life as it remains in respiratory condition and physiologically active (Saxena, Bawa, & Raju, 2009). Various methods to prolong the keeping-quality of jackfruit have been proposed (Jayaprahash, 2013; Saxena, Bawa & Raju, 2012; Saxena, Saxena, Raju & Bawa, 2013). The market for fresh cut fruits has grown rapidly in recent years. Ohlsson (2002) suggested that minimal processing is replacing more traditional preservation methods as minimally processed products are better in term of sensorial quality and nutritional aspects. The foodservice industries are also focusing on getting more pre-prepared ingredients to minimize handling and to reduce operating cost (Ahvenainen, 1996). The International Fresh-cut Produce Association (IFPA) defines fresh-cut products as fruit or vegetables that have been trimmed and/or peeled and/or cut into 100% usable product that is bagged or pre-packaged to offer consumers high nutrition, convenience, and flavour while still maintaining its freshness (Lamikanra, 2002). The treatment done on minimally processed produce resulted tissue wounding, which cause deleterious effect on the produce (Silva, Bastos, Wurlitzer, Barros and Mangan, 2002). The minimally processed fruits are generally evaluated based on colour, texture, physicochemical characteristics and sensory attributes (Rico, Martín-Diana, Barat, & Barry-Ryan, 2007). In minimally processed products, the greatest hurdles is the changes in the physical attributes of the fruits (Soliva-Fortuny & Martín-Belloso, 2003; Toivonen & Brummell, 2008). Some of the methods currently employed in the fresh cut industry include modified atmosphere packaging (Saxena, Bawa, & Srinivas Raju, 2008), mild heat treatment (Son & Usol, 2001), edible coating (Dávila-Aviña et al., 2011) and calcium infusion (Gras, Vidal, Betoret, Chiralt & Fito, 2003).

As calcium has been associated in the maintenance of texture in various fruits, its inclusion in the bulbs is expected to retain the crispness of the jackfruit. This paper will look at two different methods of calcium infusion into the bulbs of ripe jackfruit. The methods evaluated were immersion and vacuum-infusion in 1% calcium solution. This paper would emphasise on the textural characteristics of jackfruits bulbs stored at 8 ^{o} C.

2. Method

2.1 Jackfruit

Jackfruits *Artocarpus heterophyllus* var CJ1 were obtained from the Crystal Fruit Farm in Gopeng, Perak. The fruits were harvested 123 days after anthesis and ripen at room temperature between 3 - 5 days. The fruits were ripe when its skin becomes soft to slight pressure and emits a sweet aroma. Chemical characteristics of ripe jackfruit is discussed by Ong, Nazimah, Osman, Quek, Voon, Mat Hashim, Chew and Kong (2006) The ripe fruits were cut and the fruitlets removed and deseeded. The control and treated samples were kept at 8^{o} C before further tests was conducted.

2.2 Calcium-infusion

Two infusion methods were used to introduce calcium into the jackfruit. These were immersion in the calcium solution at 8 ^{o} C and vacuum-infusion for 15 minutes. These methods were evaluated as it can be easily done in any foodservice establishment. The calcium solution was prepared by dissolving calcium chloride at 1% concentration in distilled water. For the immersion method, the deseeded fruitlets were arranged in a shallow plastic trays and the solution was added until all the fruitlets were immersed completely. The trays were covered and placed in the chiller at 8 ^{o} C between 18 - 24 hours. The solution was discarded and the fruitlets were drained.

The vacuum-infusion method requires a vacuum chamber that can accommodate a tray and connected to a vacuum pump. In this study, the tray containing deseeded jackfruit fruitlets were arranged in a tray filled with calcium chloride solution and placed in a laboratory size desiccator. The desiccator was attached to a vacuum pump and vacuum was applied for 15 minutes until no bubbles were observed in the solution. Jackfruits from both treatments were placed in polystyrene trays, cling-wrapped and kept in the chiller.

2.3 Physicochemical Characteristics

Several tests were conducted to evaluate the effects of calcium infusion in fresh cut jackfruit. The tests conducted include texture analysis, ascorbic acid content, and colour.

2.4 Texture

Texture analysis was done using Texture Analyzer (Stable Micro System version 1.05, UK). Samples were separated from the seeds and cut length-wise to 1 cm width strips. A total of 10 replicates were done for firmness test.

2.5 Ascorbic Acid Content

The ascorbic acid content of the ripe jackfruit pulps was determined by the AOAC method (AOAC Official Method Number 967.21, 1995). Analysis was done in triplicate.

2.5 Colour Evaluation

The colour of the jackfruit pulps were assessed using the Minolta Colorimeter Spectrophotometer CM 3500 (Minolta Co. Ltd., Japan). Jackfruit samples were cut into 2 cm x 2 cm squares. Values of L and b* were recorded. L value indicates the lightness of the sample, with 100 being very light and 0 black. A positive b* denotes the sample to be yellow, while a negative b* means blue. Data is an average of six different samples.

2.6 Statistical Analysis

Analyses of variance on data in this study were conducted using the SPSS 11.0 Window software. The one way analysis of variance (ANOVA) was done to determine if there was any significant difference and Games-Howell test was performed with level of significant of $p \leq 0.05$.

3. Results

3.1 Physicochemical Characteristics

Texture is a very important aspect in fresh cut fruits acceptance. According Saxena et. al. (2013), texture is one of the determining factors in the acceptability of fresh cut jackfruit. The firmness of jackfruit bulbs after 14 days of storage is shown in Table 1.

All the samples showed a decrease in firmness as storage days progressed. During immersion, the diffusion of immersion liquid into the ripe jackfruit matrix caused an increase in the turgor pressure. The increased turgidity and the effect of Ca^{2+} in the ripe jackfruit pulps were correlated by the apparent firmness at day 0. However, the firmness of the immersed ripe jackfruit pulps decreased after day 3 of storage, followed by increased texture data recorded on day 10 and 14.

Table 1. Changes in firmness of jackfruit during storage

Storage Day	Firmness (N)		
	Untreated Jackfruit	Immersed for 18 hours	Vacuumed-infused for 15 minutes
0	0.38	0.43	0.54
3	0.21	0.32	0.47
7	0.15	0.34	0.52
10	0.15	0.43	0.55
14	0.13	0.32	0.52

ANOVA and Games-Howell test revealed a significant difference between firmness of the pulps due to treatment at $P < 0.05$.

Table 2. ANOVA effect of treatment on the firmness of the jackfruit pulps

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.250	2	.125	25.314	.000
Within Groups	.059	12	.005		
Total	.309	14			

Table 3. Games-Howell test for effect of treatment on firmness of jackfruit pulps

(I) 1	(j) 1	Mean difference (i-j)	Std. Error	Sig.	95% confidence interval Lower bound	Upper bound
Control	Immersed	-.16400*	.05263	.045	-.3236	-.0044
	Vacuumed	-.31600*	.04802	.003	-.4757	-.1563
Immersed	Control	.16400*	.05263	.045	.0044	.3236
	Vacuumed	-.15200*	.02905	.004	-.2405	-.0635
Vacuumed	Control	.31600*	.04802	.003	.1563	.4757
	Immersed	.15200*	.02905	.004	.0635	.2405

*. The mean difference is significant at the 0.05 level.

The increase in texture data observed in immersed samples on day 10 and 14 were not due to increase in firmness of the pulps but rather due to stringiness of the pulps. On both days (day 10 and 14), the blade was not able to execute a clean cut on the pulps. The stringiness was brought about by the disintegration of the cell walls which caused the pulps to be fibrous. Therefore, the infusion of calcium into the ripe jackfruit pulps matrix through immersion method failed to maintain the firmness of the pulps during storage. The immersed ripe jackfruit lost its firmness by day 3

In vacuum-infused jackfruit, the firmness of the jackfruit pulps was maintained until day 14 of storage. According to Collins and Wiley (1967), vacuum treatment removes intercellular gases from the tissues, facilitating the penetration of calcium into the tissues.

In both immersed and vacuum-infused ripe jackfruit pulps, infusions were done at room temperature and 8 ^{o} C respectively. Therefore, the cell wall structures were undamaged. Lamikanra and Watson (2004) found at low temperature penetration of calcium into fruit cells were improved. Calcium-fortification of plant materials had been shown to modify the structural and mechanical properties of the products (Gras et al., 2003) through the formation of calcium pectate gels that strengthen the cell wall structures (Toivonen & Brummell, 2008). However, in this study, jackfruit immersed in calcium solution failed to maintain the structural integrity as proved by the declining firmness. The gases in the tissues of the immersed jackfruit may have expanded and rupture the tissues during storage, causing loss of firmness (Collins and Wiley, 1967).

Table 4 showed the ascorbic acid content of the jackfruit during. The untreated samples had a much higher ascorbic acid content compared to treated samples.

Table 4. Ascorbic acid content of control and treated jackfruit during storage

Storage Day	Ascorbic Acid (mg/100g sample)		
	Untreated Jackfruit	Immersed for 18 hours	Vacuumed-infused for 15 minutes
0	3.7	1.9	2.6
3	1.7	1.2	2.4
7	1.5	1.2	2.4
10	0.6	0.9	0.9
14	0.6	0.6	0.7

Table 5. ANOVA effect of treatment on the ascorbic acid content of the jackfruit pulps

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.089	2	.545	.609	.560
Within Groups	10.740	12	.895		
Total	11.829	14			

Table 6. Games-Howell test for the effect of treatment on the ascorbic acid content of the jackfruit pulps

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Immersed	.4600	.6066	.742	-1.495	2.415
	Vacuumed	-.1800	.7003	.964	-2.222	1.862
Immersed	Control	-.4600	.6066	.742	-2.415	1.495
	Vacuumed	-.6400	.4643	.408	-2.061	.781
Vacuumed	Control	.1800	.7003	.964	-1.862	2.222
	Immersed	.6400	.4643	.408	-.781	2.061

ANOVA and Games-Howell tests revealed there are no significance differences for ascorbic acid content of the jackfruit pulps due to treatment at $P < 0.05$. As ascorbic acid is water-soluble immersing the cut jackfruit pulps into the calcium solution may have caused the ascorbic acid to leach out. However, during storage, all the samples showed a decrease in the ascorbic acid content, recording a value of 0.6 mg ascorbic acid for both untreated and immersed jackfruits; and 0.7 mg per 100 gram samples for vacuumed jackfruit.

The ascorbic acid is sensitive to oxidation and a decline in its activity can be expected during storage (Ali, Masud, Abbasi, Mahmood, & Hussain, 2013). The wound caused by cutting the jackfruit released enzymes which brought about the reduction of the ascorbic acid content in the untreated jackfruit pulps (Bett et al., 2001).

The higher ascorbic acid content at day 0 in vacuumed-treated jackfruit may be attributed to the minimal amount of time in solution compared to immersion-treated jackfruit. However, the rate of ascorbic acid loss is higher in untreated jackfruit. Calcium had been proven to be effective in retaining ascorbic acid (Ali et al., 2013)

Table 7. Colour data of stored jackfruit

	Control after 14 days	Immersed after 14 days	Vacuumed after 14 days
ΔL	-5.34 ± 0.04	-6.04 ± 0.03	-9.38 ± 0.12
Δb*	-10.07 ± 0.08	-5.59 ± 0.02	-3.82 ± 0.08

n = 6

Colour is among the first attributes evaluated by the consumers (Toivonen & Brummell, 2008). Changes in the lightness coefficient, L* and b* values in the Hunter colour chart of the samples is tabulated in Table 7. The values reported are in reference to control sample at day 0. All the samples (untreated and treated with calcium) recorded a decrease in the L* and b* values. Negative L-values indicate darker colour as compared to the fresh sample after 14 days of storage at 8 ^{o}C. All the samples were also less yellow than the untreated jackfruit.

The changes in colour implied the jackfruit bulbs may have undergone browning reaction. The same was observed in dried jackfruit bulbs (Saxena, Maity, Raju, & Bawa, 2012), with decreasing L* and b* values. Saxena et al (2012) reported similar browning and degradation of carotenoid in air dried jackfruit. Thus, calcium treatment does not prevent browning in jackfruit pulps.

4. Conclusion

Consumer awareness about the health benefits of consuming more fruits have resulted an increase in fresh cut fruit demand. In this experiment, two calcium-infusion methods were evaluated to assess the changes in firmness, ascorbic acid content and colour of minimally processed jackfruit pulps. The result showed that infusions of calcium into the tissue of jackfruit pulps were able to retain the textural integrity of the fruit up to at least 3 days by immersion method and up to 10 days by vacuum infusion method. The ascorbic acid contents of jackfruits treated with calcium was comparable to untreated samples. A slight browning was detected in all the samples after 14 days of storage. Thus, in a foodservice application, where jackfruit can be minimally processed for the convenience of the consumer; introduction of calcium by vacuum infusion to retain its textural characteristics is achievable.

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