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Effect of Vacuum Packaging On Sensory and Texture Properties of Fresh Cut Jackfruit

Nurul Husna Asmady[1], Munira Zainal Abidin[1*]

[1]Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia (Pagoh Campus),
84600 Pagoh, Muar, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: Jackfruit, also known as *Artocarpus heterophyllus*, is a fruit from a tropical tree that is raised in South America, Africa, and Asia. Jackfruit is typically eaten raw in Malaysia. Vacuum packaging, on the other hand, describes the process of taking the air out of the packaging before closing them. Freshly cut jackfruit that is often packaged in plastic is vulnerable to tissue softening, surface browning, and flavor loss. As a result, the goal of this research is to examine how vacuum packaging affects the sensory and textural characteristics of freshly sliced jackfruit. There are three samples in this study which was control sample (jackfruit that has not been dipped with $CaCl_2$ solution but was vacuum packed), vacuum packed sample and unvacuum packed sample which were dipped in 1% $CaCl_2$ solution for 5 minutes. The sample then was stored for 15 days at temperature of 4 ^oC. The pH value for the vacuum packed sample on day 15 was 4.89 ± 0.01. The vacuum packed sample experienced the least moisture loss during storage among the three samples. The results for the experiment for the sample's brightness, chroma, and hue were not significant ($p>0.05$), however the results for the sample's firmness was significant since ($p<0.05$). According to the sensory study, the vacuum-packed sample is the most palatable of the three. Based on the results obtained, it can be concluded that, vacuum packaging is the best packaging to be used to pack the fresh cut jackfruit.

Keywords: Jackfruit Bulb, Vacuum Packaging, Calcium Chloride Treatment, Chilled Storage, Texture Properties, Sensory Properties

1. Introduction

Tropical tree fruit called jackfruit, also known as *Artocarpus heterophyllus*, is grown throughout Asia, Africa, and South America. There are a few types of jackfruit in Malaysia such as Tekam Yellow clone, Nangka Madu clone, Crystal clone and also Nangka Matura clone. However, some of these types of clones were not being registered with DOA. Jackfruit is typically eaten raw in Malaysia. The flavor of jackfruit is subtly sweet with a touch of sourness. Jackfruit has many health advantages in addition to its deliciousness. When compared to apples, apricots, avocado, bananas, and other fruits and

Corresponding author: muniraza@uthm.edu.my

vegetables, jackfruit may have more vitamins and minerals [2]. The fresh cut jackfruit bulb that is being packaged in a polystyrene container can also be found at the fruit store. In Malaysia, you can typically buy the jackfruit whole.

The process of vacuum packaging involves taking the air out of the package before closing the item. Vacuum packaging's primary goal is to stop a product's oxidation reaction when the product is exposed to oxygen [1]. By placing the packaging material in close proximity to the product, vacuum packaging primarily serves to eliminate oxygen from the product [3]. Adopting vacuum packaging techniques can reduce fruit browning and weight loss. The fruits' firmness can also be preserved.

Freshly cut jackfruit that is often packaged in plastic is vulnerable to tissue softening, surface browning, and flavor loss. Due to the high vitamin C content of jackfruit, it will react with the air and result in the browning effect, giving the fruit an unfavorable appearance. The regular plastic containers are unable to sustain the freshness of the fresh cut jackfruit bulb. This study aims to investigate how vacuum packaging affects the sensory and textural characteristics of freshly cut jackfruit. The effect of vacuum packaging on the jackfruit bulb will be studied in 15 days by a number of analysis, including moisture content, pH value, texture analysis, color analysis, and sensory analysis. The purpose of this study is to use vacuum packing to package fresh cut jackfruit bulbs and to examine how this packaging affects the physicochemical and sensory characteristics of the fruit and to compare the vacuumed packed jackfruit with the unvacuum packed jackfruit bulb.

2. Materials and Methods

2.1 Materials and method

The material used for this research was fresh cut jackfruit bulb, vacuum bag and calcium chloride ($CaCl_2$) food grade. The instruments involved in the analysis of this sample were oven, pH meter (HI-83141N), texture analyzer (Stable Microsystems Ta-XT2), and Hunter UltraScan - Pro spectrophotometer (HunterLab MiniScanEZ).

2.2 Sample preparation

Fresh and ripe jackfruit which is known as Nangka madu was used in this study. This jackfruit was obtained from Muar, Johor. The bulb was separated from the rind and the core part of the fruit. About 200 grams of fresh cut jackfruit bulb were dipped into calcium chloride 1% solution for 5 minutes as the pre-treatment before being packed. After the sample were packed into the vacuum bag, the samples will undergo vacuum technique to remove all the air inside the bag. The vacuum machine that was used is vacuum chamber machine. For this study, there were a total of three samples. The first sample was the control sample which was jackfruit bulb that was not being dipped with $CaCl_2$ solution but being packed by using vacuum packaging technique. The second sample was the jackfruit bulb that has been dipped with 1% $CaCl_2$ solution for 5 minutes and been vacuum packed and the third sample was the jackfruit bulb that was dipped with 1% $CaCl_2$ solution but not being vacuum packed. The sample will be stored at 4°C temperature [4] which is a chilled temperature. The sample will be evaluated every 3 days for 15 days [5]. The fresh cut jackfruit was analyzed for sensory properties, texture properties, color of the jackfruit, pH value and moisture content.

2.3 Moisture content

The moisture content of the jackfruit was measured using an oven drying method for moisture determination at 105 ℃ for 24 hours [6].

2.4 PH analysis

Jackfruit bulb weighed around 50 grammes, and 50 ml of distilled water was added to make a homogeneous mixture. The pH analysis was performed using a portable pH meter, model HI-83141N. The sample was examined with the pH meter's probe, and the results were obtained [4].

2.5 Texture analysis

Using a texture analyzer (Stable Microsystems Ta-XT2) device on the jackfruit bulb, the subsequent force required to rupture the sample was measured. Warner Bartzler cylindrical probe (5mm) function at 0.5 mm/s test speed and some other minor modifications were used for the analysis [7].

2.6 Color analysis

A Hunter UltraScan - Pro spectrophotometer (HunterLab MiniScanEZ) was used to measure the jackfruit bulbs' color. The chroma meter measures accurate color almost instantaneously and displays the results using an 8 mm diameter (measuring area) diffused illumination and a 0° viewing angle. After the first calibration with a standard plate, the jackfruit bulb samples were used to measure the head of the meter in terms of L*a*b*[4]. Utilizing the following equations, one may determine the color and hue [8].

$$C* = a*^2 + b*^2 \qquad Eq.1$$

$$hue° = tan^{-1} . \sqrt{\frac{b*}{a*}} \qquad Eq.2$$

2.7 Sensory analysis

50 participants conducted sensory analysis of the jackfruits' color, appearance, flavor, texture and overall acceptability using a nine-point hedonic scale. The panelists assessed samples of vacuum-packed jackfruit as well as jackfruit that had not been so packaged. The samples are rated on a nine-point hedonic scale, where 0 is very dislike, 9 is very much dislike, 8 is very much dislike, 7 is moderately dislike, 6 is somewhat dislike, 5 is not sure, 4 is dislike slightly, 3 is dislike moderately, 2 is very much dislike, and 1 is exceedingly dislike.

2.8 Statistical analysis

The statistical programme SPSS was used to analyze the data that were received from the analysis. The experiment was set up in a random manner, and an analysis of variance (ANOVA) with a significance level of 0.05 was performed.

3. Results and Discussion

3.1 pH analysis

Table 1: pH value of the samples during storage

Day	0	3	6	9	12	15
Sample						
Control	4.79±0.12[a]	4.95±0.11[a]	5.15±0.04[a]	5.34±0.06[a]	5.60±0.04[a]	5.60±0.01[a]
Vacuum packed	4.34±0.06[b]	4.54±0.04[b]	4.42±0.02[b]	4.74±0.06[b]	4.84±0.04[b]	4.89±0.01[b]
Unvacuum packed	4.20±0.12[b]	4.35±0.10[b]	4.49±0.05[b]	4.65±0.02[b]	4.76±0.0[b]	4.74±0.22[b]

[Data represent mean ± standard deviation, means that did not share a letter are significantly different]

Note; Control sample (jackfruit bulb that has not been dipped with $CaCl_2$ solution but being vacuum packed), Vacuum packed sample (jackfruit bulb that was dipped with 1% $CaCl_2$ solution and being

vacuum packed, Unvacuum packed sample (jackfruit that was dipped with 1% $CaCl_2$ but not being vacuum packed).

3.2 Moisture content

From Table 2 we can conclude that the moisture content of all the samples decreases throughout the storage time. A study conducted by Prathibha (2020), showed that the moisture loss of the fresh cut jackfruit bulb increases during the storage time [10]. Due to respiration and increased susceptibility to wilting, the moisture loss rises. Moisture loss from the cut surface was accelerated by cutting and slicing, which was a significant contributor to quality loss. From Table 2, it can be seen that vacuum packed sample experience the least moisture loss during storage time followed by control sample and unvacuum packed sample respectively. This is because the vacuum packed sample has done not have any contact with oxygen after being packed. Thus, the sample can remain firm for a longer time. The samples did not significantly differ from one another ($p>0.05$) after being stored in various packaging conditions. This was due to the fact that two distinct jackfruits were used to produce the sample bulb throughout the experiment.

Table 2: The moisture content (%) of the samples during storage

Day Sample	0	3	6	9	12	15
Control	82.34±5.45^{a}	79.28±1.27^{ab}	70.16±0.50^{a}	70.15±0.12^{b}	79.12±1.22^{a}	67.99±0.72^{a}
vacuum packed	77.94±1.20^{a}	78.04±0.80^{a}	70.46±2.82^{a}	75.20±2.09^{a}	76.20±7.02^{a}	74.48±4.44^{a}
Unvacuum packed	80.23±7.09^{a}	80.42±0.63^{b}	70.57±0.94^{a}	69.31±0.95^{b}	79.99±0.72^{a}	68.84±0.18^{a}

[Data represent mean ± standard deviation, means that did not share a letter are significantly different]

Note; Control sample (jackfruit bulb that has not been dipped with $CaCl_2$ solution but being vacuum packed), Vacuum packed sample (jackfruit bulb that was dipped with 1% $CaCl_2$ solution and being vacuum packed, Unvacuum packed sample (jackfruit that was dipped with 1% $CaCl_2$ but not being vacuum packed).

3.3 Color analysis

Table 3 displays the samples' lightness, whereas Table 4 displays their chroma and Table 5 displays their color. The fresh control sample on day 0 of storage is represented by the L* value of 61.67, followed by 62.19 and 76.28 for chroma and hue. It is evident from table 3 that the control sample's L* value increased, indicating that the bulb darkened during storage. On the other hand, the L* value for the control sample dropped from 75.95 to 56.27 on day 15 of storage. The color value for the control sample rose while it was in storage, but it abruptly fell on day 15 of storage.

On day 0 of storage, the vacuum-packed sample's L* value was 62.27, with chroma and hue values following at 64.3 and 78.28, respectively. The vacuum-packed sample's L* value grew throughout the storage period, but it fell on Day 9 before rising once more, then fell once more on Day 15 of storage. Day 0's L* value for the unvacuum packed sample was 63.18, followed by chroma and hue values of 60.61 and 78.81, respectively. The L* value for an unvacuum packed sample grew throughout storage and abruptly declined on day 15 of the storage period. The sample's higher lightness profile suggests that the bulb darkens during storage.

The chroma values of all three samples varied throughout storage, indicating that the saturation of the bulb color during storage is not constant, which may be due to the various colors of the samples' used bulbs. However, lower exposure of oxygen in the vacuum packaging can helped in preserving the appearance of the sample thus retaining its yellow-orange color. The data is not significant since the p-value obtained from the statistical analysis is more than 0.05 ($P>0.05$).

Table 3: The L* value for the three samples

Day Sample	0	3	6	9	12	15
Control	61.67±1.64[a]	60.72±0.27[b]	60.29±0.63[b]	62.23±1.36[a]	75.95±2.36[a]	56.27±0.23[a]
Vacuum packed	62.27±1.63[a]	62.57±1.08[ab]	66.05±2.71[a]	64.41±2.41[a]	79.48±1.38[a]	60.04±2.11[a]
Unvacuum packed	63.18±1.93[a]	63.86±0.96[a]	64.44±1.77[ab]	64.9±0.77[a]	78.43±1.92[a]	59.28±3.47[a]

[Data represent mean ± standard deviation, means that did not share a letter are significantly different]

Note; Control sample (jackfruit bulb that has not been dipped with $CaCl_2$ solution but being vacuum packed), Vacuum packed sample (jackfruit bulb that was dipped with 1% $CaCl_2$ solution and being vacuum packed, Unvacuum packed sample (jackfruit that was dipped with 1% $CaCl_2$ but not being vacuum packed).

Table 4: The chroma (C*) of the samples

Day Sample	0	3	6	9	12	15
Control	62.19±1.56[a]	61.13±1.81[a]	61.87±4.02[a]	58.49±1.83[a]	69.84±0.79[a]	52.49±4.12[a]
Vacuum packed	64.3±5.71[a]	59.28±1.44[a]	58.33±4.56[a]	61.65±5.59[a]	62.01±2.16[a]	49.16±5.03[a]
Unvacuum packed	60.61±2.92[a]	59.50±5.26[a]	61.93±3.19[a]	59.96±3.45[a]	63.23±9.33[a]	51.68±9.23[a]

[Data represent mean ± standard deviation], means that did not share a letter are significantly different]

Note; Control sample (jackfruit bulb that has not been dipped with $CaCl_2$ solution but being vacuum packed), Vacuum packed sample (jackfruit bulb that was dipped with 1% $CaCl_2$ solution and being vacuum packed, Unvacuum packed sample (jackfruit that was dipped with 1% $CaCl_2$ but not being vacuum packed).

Table 5: The hue (hue^o) of the samples

Day Sample	0	3	6	9	12	15
Control	76.28±3.46[a]	77.14±0.76[a]	77.96±1.21[a]	79.32±2.54[a]	80.33±0.95[a]	78.86±2.44[a]
Vacuum packed	78.28±1.62[a]	77.07±1.68[a]	79.44±0.52[a]	80.46±0.24[a]	79.65±1.23[a]	81.21±2.09[a]
Unvacuum packed	78.81±1.21[a]	79.04±0.70[a]	0.03±1.36[a]	79.63±1.88[a]	80.94±0.56[a]	81.30±1.32[a]

[Data represent mean ± standard deviation, means that did not share a letter are significantly different]

Note; Control sample (jackfruit bulb that has not been dipped with $CaCl_2$ solution but being vacuum packed), Vacuum packed sample (jackfruit bulb that was dipped with 1% $CaCl_2$ solution and being vacuum packed, Unvacuum packed sample (jackfruit that was dipped with 1% $CaCl_2$ but not being vacuum packed).

3.3 Texture analysis

In terms of firmness, the jackfruit's texture was assessed. The jackfruit sample's texture on day 0 is 27.6N, 25.01N, and 23.48N for the control sample, vacuum-packed samples, and unvacuum-packed samples, respectively. For the control samples, the value dropped until day 9 and then rose from 21.91 N to 28.32 N on day 12 before dropping again on day 15. For samples that were vacuum-packed, the value continued to fall until day 12 of storage before rising once more on day 15 of storage. The value for the unvacuum packed samples declined on day 3, but increased on day 6, and then the experience changed on day 9 and day 12 in the opposite directions.

This is due to the pressure when using vacuum packaging that cause the cell structure of the bulb collapse thus making it less firm. However, as not all of the bulbs used as samples have the same firmness value, it may be caused by another factor, resulting in an inconsistent pattern in the analysis' results. According to Table 6, unvacuum packed samples have the greatest flesh firmness value of 22.67N because they did not go through vacuum processing, which prevented any pressure from building up on the bulb during storage. Since the p-value for this study was less than 0.05 ($P<0.05$), the results were significant.

Table 6: The texture of the samples during storage

Day	0	3	6	9	12	15
Sample						
Control	27.60±3.58^{a}	24.57±3.29^{a}	20.43±0.60^{a}	21.91±5.65^{a}	28.32±5.56^{a}	19.74±0.40^{a}
Vacuum packed	25.01±5.79^{a}	23.02±5.00^{ab}	20.53±10.49^{a}	17.72±9.22^{a}	17.18±6.07^{a}	19.63±5.53^{a}
Unvacuum packed	23.48±5.23^{a}	14.45±2.17^{b}	19.47±6.41^{a}	13.13±2.34^{a}	19.61±3.51^{a}	22.67±4.43^{a}

[Data represent mean ± standard deviation, means that did not share a letter are significantly different]

Note; Control sample (jackfruit bulb that has not been dipped with $CaCl_2$ solution but being vacuum packed), Vacuum packed sample (jackfruit bulb that was dipped with 1% $CaCl_2$ solution and being vacuum packed, Unvacuum packed sample (jackfruit that was dipped with 1% $CaCl_2$ but not being vacuum packed).

3.4 Sensory analysis

By referring to the Table 7, the coded sample 321 has the highest average of acceptance score value which is approximately around 7 (like moderately) which indicates that the sample was the most preferred sample by the panelists, followed by sample 345 which has the average acceptability score value around 6 (like slightly). Sample 367 has the lowest average of the acceptability score value given by the 50 untrained panelists of around 5 (neither like nor dislike).

Table 7: The average attributes score for three types of samples by 50 untrained panelists

Attribute Sample	Color	Appearance	Odor	Texture (firmness)	Flavor	Overall acceptability
345	6.86±1.86^{a}	6.66±1.67^{a}	6.48±1.95^{a}	6.48±1.87^{a}	5.78±2.22^{b}	6.20±1.88^{b}
321	6.32±2.01^{a}	6.52±1.81^{a}	6.7a0±1.68^{a}	6.94±1.68^{a}	7.20±1.73^{a}	7.14±1.57^{a}
367	6.88±2.05^{a}	6.68±1.97^{a}	6.40±1.97^{a}	6.32±2.08^{a}	5.60±2.09^{b}	5.96±1.99^{b}

[Data represent mean ± standard deviation, means that did not share a letter are significantly different]

Note; 345: Control sample (jackfruit bulb that has not been dipped with $CaCl_2$ solution but being vacuum packed), 321: Vacuum packed sample (Sample that was dipped with 1% $CaCl_2$ solution and being vacuum packed, 367: Unvacuum packed sample (Sample that was dipped with 1% $CaCl_2$ but not being vacuum packed).

Table 8: The one-way ANOVA for the overall acceptability of the samples

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	38.89333	2	19.44667	5.85863	0.003564	3.057621
Within Groups	487.94	147	3.31932			
Total	526.8333	149				

The F value (5.859) is greater than the F critical value (3.058), as shown in Table 8, indicating that there is a substantial difference between the three samples in terms of overall acceptability. The null hypothesis will be disproved as a result. The sample is significantly ($P<0.05$) different from one another, according to the data, it may be deduced. The jackfruit that has been vacuum-packed was the sample that was most preferred, whereas the jackfruit that has not been vacuum-packed was the least desired, according to the data collected from the panelists.

4. Conclusion

Cutting and separating bulbs to prepare for consumption is laborious. Consumption of the bulbs is further restricted by their short shelf life after being separated from fruit. In conclusion, by selecting the correct packaging the properties of the fresh bulb can be preserved for a longer time. The pH value of the sample dipped with calcium chloride were lower compared to the sample that was not dipped with calcium chloride solution. However, the pH value of the control sample has the lower standard deviation compared to the sample that was not being vacuum packed, indicating the data obtained from the experiment much closer to the mean of the group. Thus, it can be concluded that the pH value of the vacuum packed sample 4.89 with standard deviation of 0.01 is the best. Besides that, the vacuum packed sample experience the lease moisture loss compared to the other two sample which only 3.45%. The data obtained from the experiment for lightness, chroma and hue of the sample were not significant ($p>0.05$) while the data obtained for the firmness of the sample was significant ($p<0.05$). From the sensory analysis, vacuum packed sample has the highest value of acceptability among the other two samples. From all the data obtained it can be seen that vacuum packed sample has better pH value, moisture content, and flesh firmness compared to unvacuum packed sample after storage for 15 days. The recommendation for the future study is only use one fruit per analysis to prevent significant variations in texture, pH, and color. Next is ascertain that the sample's maturity index is known. Thirdly, include the undipped sample with $CaCl_2$ and unvacuum packed sample as the control sample.

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