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Research Article

Effects of low temperature storage of *Mastura* (J37) jackfruit bulbs on the physical quality of jackfruit frozen confection

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Abstract

Mastura (J37) jackfruit variety planted in Pahang (Malaysia) is less preferred by the consumers due to its low sweetness and high-water content properties. This has caused major backlog in the plantation as reported by Pahang State Farmers Association (PASFA). In this study, among the proposed solutions given was to build a frozen confection processing line to further process the flesh. The jackfruit used were vacuum-packed and stored under refrigerated and frozen conditions. The overrun, melting resistance, and hardness of jackfruit frozen confection produced from jackfruit stored in both low temperature conditions showed comparable results. The overrun of 50 to 55 % were obtained for frozen samples at different weeks. Jackfruit frozen confections had lower overrun compared to the controlled sample as air incorporation was prevented by the elements contained in jackfruit. The control frozen confection sample without addition of jackfruit puree resulted in an average melting mass of 24.6 g and melting resistance of 59 % which was the strongest melting resistance in comparison to other jackfruit frozen confections. The inconsistent hardness of jackfruit frozen confections suggests that the content of total soluble solid increased throughout week 1 to week 3 for refrigeration storage and week 1 to week 6 for deep-freeze storage had no trending effect on the hardness of frozen confection. The output obtained from this work provides data for the downstream processing of *Mastura* (J37) jackfruit. These data are helpful as they contribute towards the understanding of further processing of this particular jackfruit variety into end products, in order to solve the issue faced by PASFA. The solution helps decrease waste generated from the surplus and value add the variety.

1. Introduction

There are various varieties of jackfruit available in Malaysia i.e. *Mantin* (J32), *Tekam Yellow* (J33) and *Mastura* (J37). *Mastura* (J37) jackfruit variety planted by Pahang State Farmers Association (PASFA) was known to have low sweetness and contained higher water content than other varieties (Ismail & Kaur, 2013). Crane et al. (2005) reported that 100 g of fresh jackfruit has 73 % moisture, 24 g carbohydrates, 1.5 g protein, 0.3 g fat, 1.6 g fibre and 94 kcal energy. The average total soluble solid content of 40 genotypes of jackfruit was 22.56 with observed °Brix ranging from 13.72 to 32.40 (Aseef et al., 2017).

PASFA reported a surplus of *Mastura* jackfruit when the demand of *Tekam Yellow* jackfruit peaked during its season. The low demand of *Mastura* jackfruit caused backlog in the plantation which eventually lead to waste. A plan to turn the low demand *Mastura* jackfruit into useful products to enable further processing of the flesh was proposed to PASFA to solve the issue.

A preliminary study done by Johari et al. (2020) on this issue was on the use of vacuum packaging to further extend the shelf life of *Mastura* jackfruit flesh. Further processing of *Mastura* into ice cream/frozen confection was also proposed to PASFA to solve the issue and as this was foreseen to increase the value of the variety. *Mastura* jackfruit must be properly processed and packed in order to increase its storage life while retaining the qualities of its bulbs and the processed ice cream/confection. This is important to ensure the overall quality of jackfruit during ice cream/frozen confection production.

Nowadays, new ice cream/frozen confection formulations are highly enjoyed by consumers. This is one of the driving forces of the manufacturers in developing innovative and delicious formulations. Different kinds of ice cream/frozen confection exist in the market but the new ones still expands as it is required to enlarge the market proportion (Karaman & Kacacier, 2012). Fruits are good sources of sweetness, aroma and desired taste. Few examples of fruit puree used as ingredient are persimmon (Karaman et al., 2014), strawberry (Bajwa et al., 2003) and banana (Jr. & Arenillo, 2016). According to Karaman et al. (2014) the puree concentration of persimmon in ice cream preferred by consumers was 24 % and the ice cream showed better melting properties and textural characteristics. As for the strawberry ice cream, 15 % strawberry pulp in ice cream obtained the highest score in the organoleptic evaluation (Bajwa et al., 2003). Banana ice cream made from cooked banana puree was rated better than banana ice cream using uncooked banana puree in terms of taste and texture (Jr. & Arenillo, 2016).

Ice cream refers to frozen creamy dessert with fat content of more than 10 % while frozen confection contains fat of less than 10 %. Overrun is an important process that increases the volume of ice cream and it is associated with the ice cream manufacturing process (Cruz, et. al., 2009). Air is induced into the ice cream mix during the dynamic freezing process thus trapping air within the liquid matrix. A higher overrun expresses a larger amount of air bubbles inside an ice cream. Air bubbles is a part of the complex colloid system in this particular frozen dessert. Furthermore, overrun results in the partial coalescence

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and fat destabilization in the mixture. This could be seen by the creaminess and light texture given by higher overrun.

This research aimed to convert *Mastura* jackfruit into frozen confection and identify the physical properties of the frozen confection made with fruit bulbs stored at different conditions and times.

2. Materials and methods

2.1 Materials

Mastura (J37) jackfruit variety were purchased from Pahang State Farmers Association (PASFA) factory in Pahang, Malaysia. Further handling of the fruit to obtain the flesh and vacuum packaging process to pack the flesh were conducted as explained by Johari et al. (2020). Approximately 300 g of jackfruit bulbs in each batch were vacuum packed using a vacuum sealer (Model DZ-400, Sunwins, Malaysia) and stored in refrigerator (Model BS2DUC/Z, Berjaya, Malaysia) at 0-5 °C and deep-freezer (Model EF-5500, Elba, Italy) at -18 °C.

In this study, the experiment was conducted similar to the previous study done by Johari et al. (2020), in which the samples were evaluated for a period of 3 weeks for refrigeration storage and 6 weeks for deep-freezing storage (Table 1). The quality of frozen confection made from vacuum-packed *Mastura* jackfruit stored from 0-6 weeks in two different storage conditions i.e. refrigeration at 0-5 ^{o}C and freezing at -18 °C were investigated in this current study.

2.2 Blanching and mashing of jackfruit into puree

Raw jackfruit bulbs were converted into puree through blanching and mashing processes. The jackfruit bulb must be properly prepared and blanched to prevent either under- or over-blanching, that may affect the process flow of puree processing, energy cost of production and quality of frozen confection. The hot water-blanching process of fresh jackfruit bulb was done at 78 °C for 4 minutes (based on the trial conducted on-site). For mashing procedure, the freshly blanched jackfruit bulb was blended using a blender (Panasonic MX-GM1011H, Shah Alam, Malaysia) set to the maximum speed for 3 minutes.

2.3 Preparation of jackfruit frozen confection

The base formulation of frozen confection had the following composition: 29.0 % water, 46.6 % full cream milk, 16.5 % sugar, 3.6 % whey powder, 3.6 % creamer, 0.4 % emulsifier and 0.3 % stabilizer. This was based on the formulation used by Rahman et al. (2019) with some modifications. The wet and dry ingredients were thoroughly agitated by manual mixing at room temperature. The mix was batch pasteurized at 80 °C for 15 seconds and later homogenized using a laboratory scale homogenizer. The frozen confection mixes were then aged overnight at 0-5 °C. Jackfruit puree were incorporated into the aged mix as suggested by Goff & Hartel (2013), and the jackfruit frozen confection mix was then frozen using an ice cream machine (Model BCI600XL, Breville, USA). The produced frozen confection were stored in a deep freezer (Model EF-5500, Elba, Italy) at -18 °C. Based on Goff & Hartel (2013), the recommendation of fresh and frozen fruit required to impart the desired flavour varies from 10 to 25 % of the mass of finished product. Therefore, it was decided that jackfruit puree added was 20 % of the total mass of frozen confection mix in this experiment.

2.4 Overrun of jackfruit frozen confection

Overrun is the industrial calculation of the air added to ice cream products and is calculated as the percentage increase in volume that occurred as a result of the air addition (Marshall et al., 2012). Overrun of jackfruit frozen confection was determined according to equation 1:

$$\text{Overrun (\%)} = \frac{\text{Volume of frozen confection - Volume of liquid mix}}{\text{Volume of liquid mix}} \times 100 \quad (1)$$

2.5 Melting resistance of frozen confection

Melting behaviour of frozen confection was characterized through its melting resistance. Melting behaviour was determined through a method described by Muse & Hartel (2004), with modification. After 3 days of storage at -18 ℃, 60 g of frozen confection was placed on a 1 mm wire mesh screen. The ambient temperature was controlled at 25 ℃ ± 2 ℃. Triplicate readings were taken for each sample. Melting resistance determines the resistance of frozen confection to melting at a specific time. It was obtained by weighing the melted frozen confection after 45 minutes at ambient temperature and is expressed in equation 2:

$$\text{Melting resistance (\%)} = \frac{\text{Melted frozen confection}}{\text{Initial mass of frozen confection}} \times 100 \quad (2)$$

2.6 Penetration test: hardness of jackfruit frozen confection

Penetration test was performed to obtain the hardness of jackfruit frozen confection. A 60 g block of frozen confection was taken out of the -18 ℃ freezer and placed on the texture analyser. A TA.XT Plus Texture Analyser (Stable Micro Systems, Surrey, UK) was used in determining the hardness of the sample. Three measurements were acquired using a 45° perspex cone probe. Triplicate readings were taken from the sample. The penetration speed was set to 2.0 mm.s^{-1} and the penetration depth was 10 mm. The peak compression force obtained during penetration was the hardness (N) of the frozen confection samples.

2.7 Statistical analysis

The analysis of variance (ANOVA) was carried out to analyse the results. The comparisons of different storage weeks were performed with Tukey's test (P≤0.05). Data analysis was performed using the software SPSS statistics version 25.0 (SPSS In., Chicago, IL).

3. Results and Discussion

3.1 Overrun of jackfruit frozen confection

Overrun is the calculation of the air added to ice cream products and is associated with the ice cream manufacturing process. The overrun of jackfruit frozen confection made from jackfruit bulbs stored for 0 to 3 weeks under refrigeration and deep-freeze storage are shown in Figure 1. Jackfruit frozen

Table 1. Low temperature storage of vacuum-packed jackfruit bulbs (Johari et al., 2020)

No.	Storage type	Storage temperature (^{o}C)	Storage period (weeks)	Packaging plastic
1.	Refrigerator	0-5	3	Polyethylene/Polypropylene
2.	Deep-freezer	-18	6	Polyethylene/Polypropylene

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confection made from jackfruit bulbs stored for 0 and 1 weeks had the same overruns of 53 %. Frozen confection made with jackfruit bulbs stored for 2 and 3 weeks had overruns of 48 and 54 %, respectively. Significant differences of jackfruit frozen confection overrun were observed for the refrigerated jackfruit bulbs stored from 1 to 3 weeks. The inconsistent overrun of jackfruit frozen confections suggests that the viscosity of the mix used to make frozen confection for each different week was different and caused the inconsistent incorporation of air inside the frozen confection. Generally, high liquid viscosity traps air bubbles better than the one with lower viscosity during dynamic freezing process which results in higher overrun.

Overrun of 50 to 55 % indicated significant differences between frozen samples at different weeks. The jackfruit frozen confections had lower overrun compared to the controlled sample as air incorporation was prevented by the elements contained in jackfruit. The higher water content of jackfruit liquid mixture causes the mixture to be icier and hence, reduced the whipping capacity. Therefore, air incorporation was reduced during the dynamic freezing of frozen confection.

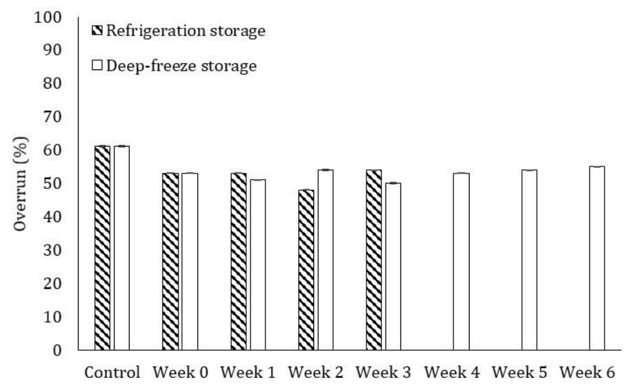

Figure 1. Overrun of frozen confection made with refrigerated and frozen jackfruit stored at different weeks

3.2 Melting resistance of jackfruit frozen confection

Melting resistance evaluates the resistance of frozen confection to melting at a specific time. The melting resistance of jackfruit frozen confection made from vacuum-packed jackfruit bulbs under refrigeration storage at 0 to 3 weeks and deep-freeze storage at 0-6 weeks are presented in Figure 2. High value of melting resistance indicates strong resistance while low value shows weak resistance of frozen confection to melting. A good melting resistance was observed in frozen confection of week 0 (49.3 %) as well as frozen confection of week 1 (44.1 %), week 2 (37.2 %) and week 3 (46.2 %).

The inconsistent melting resistance data for different weeks corresponded well with the trend shown for overrun discussed previously. No correlation can be reported between vacuum-packed jackfruit bulbs stored for 0 to 3 weeks to the melting rates and melting resistances of frozen confections. However, the control frozen confection sample without addition of jackfruit puree resulted in an average melting mass of 24.6 g and melting resistance of 59 % which was the strongest melting resistance in comparison to other jackfruit frozen confections.

There are numerous factors affecting meltdown such as the amount of air incorporated, nature of ice crystals, and network of fat globules formed during freezing. Shape retention during melting may also be caused by high solids, low overrun, associated with destabilized protein and substantial fat agglomeration as stated by Wang (2015). Jackfruit frozen confection has higher water content that comes from the fruit. It causes the frozen confection to have more ice crystals and hence, caused the frozen confection to melt faster than the controlled sample which does not contain jackfruit puree.

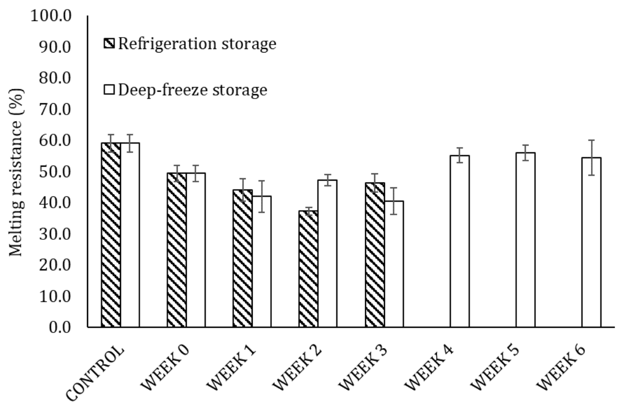

Figure 2. Melting resistance of frozen confection made with refrigerated and frozen jackfruit stored at different weeks

Similar results were observed for the melting resistance of frozen confection made from frozen jackfruit bulbs. The melting resistances range around 40 to 60 % are similar to the range of frozen confections made from refrigerated jackfruit bulbs. The controlled frozen confection sample without the addition of jackfruit puree had a lower melting mass and the highest melting resistance compared to jackfruit frozen confections.

3.3 Textural changes: hardness of jackfruit frozen confection

Hardness is defined as the resistance towards deformation by external force. Hardness of jackfruit frozen confection made from refrigerated jackfruit bulb are presented in Table 3. The hardness of frozen confection made with jackfruit bulbs stored in refrigeration storage for 0 to 3 weeks showed inconsistent hardness that ranged from 3.03 to 6.28 N. For jackfruit frozen confection made from frozen jackfruit bulbs stored for 0 to 3 weeks, the hardness increased gradually, however in week 4, the hardness was lower i.e. 2.24 N and increased to 7.15 N in week 6.

Table 3. Hardness of jackfruit ice cream made from both refrigerated and frozen jackfruit bulbs (20 % concentration)

Frozen confection hardness (N)		
Storage period (week)	Refrigeration storage (3-5 °C)	Deep-freeze storage (-18 °C)
Control	2.45±0.42[a]	2.45±0.42[a]
0	3.03±0.95[a]	3.03±0.95[a]
1	5.09±0.99[b]	2.03±0.46[a]
2	3.07±0.48[a]	3.38±0.63[ab]
3	6.28±0.69[b]	4.60±0.56[b]
4	N/A	2.24±0.23[a]
5	N/A	4.92±0.23[b]
6	N/A	7.15±0.56[c]

[a-e]Means with different letters in the same column are significantly different ($P < 0.05$)
N/A is not available due to damage of bulb due to high microbial count

The inconsistent hardness of jackfruit frozen confections suggests that the content of total soluble solid increased throughout week 1 to week 3 for refrigeration storage and week 1 to week 6 for deep-freeze storage had no trending effect on the hardness of frozen confection.

Conclusion

For the analyses on the physical properties of frozen confection (overrun, melting resistance and hardness), it was found that jackfruit frozen confection using refrigerated vacuum-packed bulbs (of different weeks) had a maintained frozen confection quality. Jackfruit frozen confection made with frozen vacuum-packed bulbs also showed similar results. All jackfruit frozen confections had lower overrun compared to the controlled frozen confection sample (without jackfruit addition). The refrigerated and frozen vacuum-packed jackfruit bulbs stored for 1 to 3 weeks and 1 to 6 weeks, respectively, showed no significant effects on the physical properties of jackfruit frozen confection. However, PASFA jackfruit processing factory preferred refrigeration, as the storage of fruit up to four weeks is the maximum holding period in the jackfruit factory. Thus, refrigeration of vacuum-packed jackfruit bulbs for 1 to 3 weeks was used in the factory to store vacuum-packed jackfruit bulbs. This work contributed in solving the surplus issue faced by the jackfruit plantation and processing factory by converting *Mastura* jackfruit into frozen confection product.

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Author contributions

Amiruddin Mat Johari: conceptualization, methodology, data curation, and writing of the original draft. Nur Aliaa Abd Rahman: supervision, project administration, reviewing, and editing of the final manuscript. Azhari Samsu Baharuddin: supervision and resources. Roseliza Kadir Basha: supervision and reviewing of manuscript. Minato Wakisaka: resources.

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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