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Heterogenous Market Preferences on Cryogenic Frozen Jackfruit in Malaysia

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ABSTRACT:
The recent national policy continues to strategize for higher value and more competitive value-added commodities, including jackfruit, particularly for the export markets. The most crucial challenge of the jackfruit industry is to maintain the fruit's quality due to its limited shelf-life and the consequences of being fragile and perishable, exposing the fruits to higher losses. Fresh jackfruit can be stored no longer than 14 days to maintain its physical and nutritional qualities, limiting not only market activities along the supply chains but also market access, particularly for export purposes that often take 30-60 days depending on the logistics and destination. In line with the market need for frozen fresh products, the Malaysian Agricultural Research and Development Institute (MARDI) has developed the frozen jackfruit technology using cryogenic freezing techniques as an alternative marketing solution for fresh tropical fruits. Different from other freezing techniques, cryogenic applies liquid nitrogen as a freezing agent and could extend the shelf-life up to six months, while maintaining the quality of freshness, taste, colour and most importantly, nutritional values. Previous studies revealed that rapid freezing of fruits provides better quality and improves the internal microstructure. Recent market trends showed that frozen fruit is experiencing rapid growth, becoming more aggressive and one of the most promising market segments of the agribusiness sector, as consumers are increasingly shifting toward healthier food products. Additionally, the demand for frozen fruits has shown substantial growth due to their high nutritional values, progressively being used in industry applications, and thus gaining momentum in research activities along with the growing food markets.

KEYWORDS: Frozen jackfruit, cryogenic, variety J33, export, Malaysia

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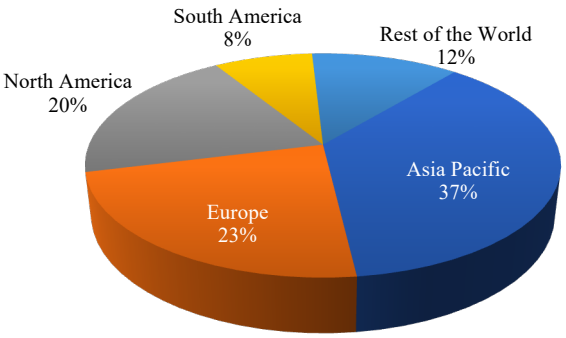
INTRODUCTION

Despite a long-standing goal to boost national income through export spillover effects, the Malaysian fruit trade performance has remained in deficit for several years. The recent national agricultural policy development and plans continue to strategize the new aim for a higher value and more competitive value-added fruit commodities, while durian and jackfruit are leading the list. Jackfruit, specifically the J33 variety, is identified as one of the most potential tropical fruits due to its physical attributes and premium quality, satisfying the national self-sufficiency rate, and thus providing auxiliary strength in competitive fruit markets. Globally, the jackfruit market size reached a value of USD 311.71 million in 2022 and is expected to grow at a Compound Annual Growth Rate (CAGR) of 3.4% between 2023 and 2028. Furthermore, it is projected to reach a value of USD380.96 million by 2028 (Expert Market Research, 2023). In 2020, the Asia Pacific was recorded as the largest jackfruit market, globally (37%), and is anticipated to remain dominant in the near future followed by North and Central America (28%) and European countries (23%) (Figure 1). Nevertheless, the most crucial challenge of the jackfruit industry is to maintain the quality of fresh jackfruits due to their limited shelf-life and the consequences of being fragile and perishable. This could provoke and expose the fruits to highly destructive diseases stemming from fungal and bacterial infections and

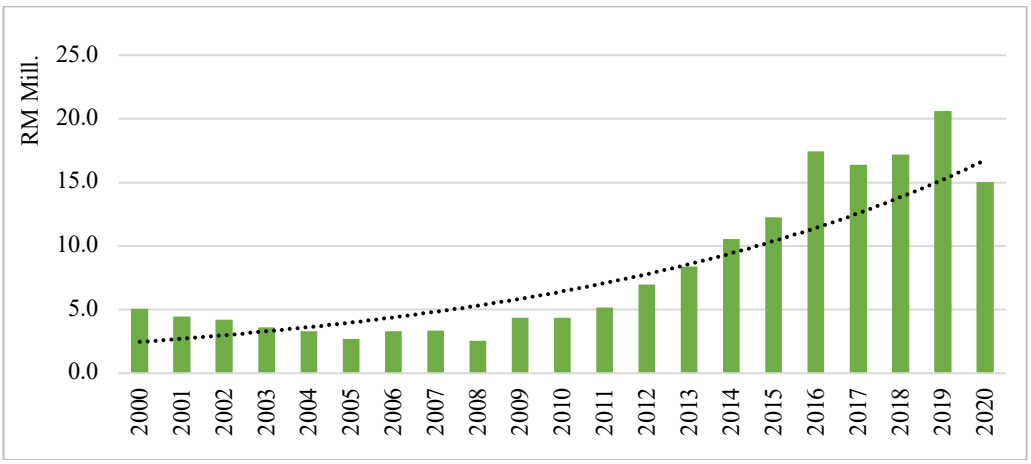
ultimately contributing to higher losses. Therefore, these situations could limit not only market activities along the supply chains but also market access, particularly for export purposes.



Source: Industry Arc (2023)

Figure 1. World Jackfruit Market Share (2020)

Previous innovation established by the Malaysian Agricultural Research and Development Institute (MARDI) on frozen durians using a cryogenic method received positive impacts when the commodity successfully gained market access to explore a new market segment in China. Currently, research on jackfruit was conducted due to its increasing market size and is expected to have the potential for the frozen segment. Additionally, Malaysia has gained market access and export protocol of fresh jackfruit to several countries, including Australia, Japan, Singapore, the Middle East, Hong Kong and Europe (DOA, 2023). Fresh jackfruit that can be normally stored no longer than 14 days to maintain its physical and nutritional qualities under ambient temperature and conditions has limited the marketing of fresh jackfruit, particularly in the export market. This is because the exporting process takes about 30-60 days depending on the logistics and destination country of the importer. In line with the market needs for frozen fresh products, MARDI has developed a frozen jackfruit technology using cryogenic freezing techniques, as an alternative marketing solution for fresh fruits. Different from other freezing techniques, cryogenic applies liquid nitrogen as a freezing agent and could extend the shelf-life up to six months, while maintaining the quality of freshness, taste, colour and most importantly, nutritional values (Razali et al., 2020). In fact, rapid freezing of fruits provides better quality and improves the internal microstructure (Allan-Wojtas et al., 1998). Based on the jackfruit export performance in the last ten years, it clearly showed a significant increase from RM4.3 million (2010) to RM20.6 million (2019) (Figure 2). Globally, the cryogenic frozen jackfruit is expected to be competitive for market expansion, either in existing markets or exploration of new markets.



Source: MAFS (2021)

Figure 2. Total Export of Fresh Jackfruit in Malaysia (2000 – 2020)

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Frozen fruits are not relatively new, albeit the global market share is marginal. Over the years, temperate fruits have dominated the market in the frozen segment, while strawberries, raspberries, blueberries and peaches are leading the markets, however, recent trends showed that tropical fruits are now more favourable. Recent trends showed that the frozen fruit market has witnessed rapid growth globally, as the market size is forecasted to reach USD5.59 billion at a CAGR of 6.7% from 2020 to 2027 (Grand View Research, 2023; East Fruit, 2023). Additionally, an analytical review of the global market revealed that frozen fruit and vegetables are one of the most promising market segments of the entire horticultural business (FAO, 2023). Furthermore, frozen fruits offer immense promise in food industries, as consumers are increasingly shifting toward healthier food products, while the demand for frozen fruits has shown substantial growth due to their high nutritional values. This is progressively being used in industry applications, and thus gaining momentum in research and development activities along with the development of the food science sector (Transparency Market Research, 2023).

Durian has been given more attention in the frozen tropical fruit line due to its premium value as the commodity could guarantee the market, while recording successful business activities in the export penetration, particularly to China. Jackfruit will be the next target while focusing on penetrating frozen export markets. The main target industry players are cryogenic frozen durian producers, as the facilities and operations can be optimized that reflect more effective costs, viability and returns. Prior to the cryogenic technology being spread to industries, comprehensive evaluations of the economic viability, consumers' acceptance and industry reviews are required to ensure the technology is applicable and the final products are economically practical and acceptable to the stakeholders, industries and consumers. Consequently, this study evaluates the market acceptance, economic viability and industry reviews on the cryogenic frozen jackfruit (var. J33), relative to the fresh jackfruit. Previous studies discovered that colour and texture parameters played a fundamental role and were highly associated with quality influencing the consumers' choice, and further determining the acceptance of food products (Chen et al., 2019). The specific objectives of this study are to identify the acceptance magnitude among household consumers and industries, to measure the willingness to pay (WTP) for frozen jackfruit according to the attributes of texture (crunchiness), taste, and colour of the physical pulp, and to analyze the economic returns and viability at the production level. Therefore, those parameters are expected to determine the market potential of frozen jackfruit.

This study utilized primary data and applied both quantitative and qualitative methods. Primary data was obtained from the consumers' acceptance, industry reviews and sensory evaluations from both groups. Considering that frozen jackfruit has a higher potential for export purposes rather than the local market, the target respondents were not only Malaysians but also foreigners who were selected purposively from an international event held in Kuala Lumpur where the location consumer study was conducted. Major data analysis focused on the quantitative methods, including the analysis of variance (ANOVA) to provide statistical evidence on the different acceptance and preferences between jackfruit samples, the contingent valuation model (CVM) to determine the WTP for frozen jackfruit in a hypothetical market, and the economic viability analysis to measure the cost and returns of producing frozen jackfruit using cryogenic technique relative to other existing freezing methods. The thematic method was applied to analyze industry reviews, complementing the methodology from an industry perspective. The detailed methodology is provided in the next section. Overall, the results indicated that cryogenic frozen jackfruit is acceptable to both locals and foreigners. In fact, the results showed no statistically significant difference between frozen and fresh jackfruit pulps (controlled sample). Industry players confirmed the market acceptance and suggested market opportunities, especially in the global markets. The economic viability analysis validated that frozen jackfruit with both the blast freezing and cryogenic techniques was viable, but the latter required lower production costs, and thus was more economical and cost-effective, particularly the minimal processing (MP) form to penetrate the export markets.

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METHODS

Using a purposive and random sampling approach with voluntary participation, this study managed to collect primary data from 200 household consumer respondents, not only local but also foreign consumers who could represent the international markets. The sensory test was conducted during a consumer survey in conjunction with an international exhibition in Malaysia. Before the sensory test, each respondent was supplied a survey kit containing three blind samples representing: i) frozen jackfruit pulp from cryogenic whole fruit; ii) frozen jackfruit pulp from cryogenic minimally processed; iii) fresh jackfruit pulp (as a controlled sample in this study) and a set of structured questionnaires. A brief step was also provided before the sensory evaluation began. All samples were prepared using the same jackfruit variety, J33, and each sample was pasted with a code that was randomly arranged (i.e., numbers and digits) to ensure that the code order was not consecutive. This step is important to prevent respondents from being influenced by the code and sample order, which might affect the test responses. After tasting, every respondent was required to evaluate their acceptance of each pulp sample's attribute, comprising of pulp colour, aromatic, juiciness, sweetness, crunchy texture and overall acceptance using the 7-hedonic scale (from 1 = Mostly dislike to 7 = like the most). The respondents were required to perceive the WTP according to a given bidding price in the final part of the evaluation. From the industry reviews, information was collected using a focus group discussion (FGD), engaging 20 industry players who were purposively selected from the Malaysian Fruit Association group, including producers, wholesalers and exporters of tropical fruits in Malaysia. To measure the economic viability, both data from the producer and innovator were validated. Currently, none of the producers has any engagement or specialization in frozen jackfruit production using the cryogenic technique in Malaysia. However, some producers applied different freezing methods, such as blast-freezing, thus providing baseline data to estimate the cryogenic freezing production costs and returns, and the economic viability assessment.

Analysis of Variance (ANOVA)

The ANOVA compares whether the average values of one variable (means of the dependent variable) differ significantly across the categories of other variables (independent variable). How ANOVA calculates this is to see how the values that go into making up the means in each category are dispersed (Miller, 1997). This study applied ANOVA to estimate the mean score differences on the jackfruit attributes acceptance, specifically pulp color, aromatic, juiciness, the taste of sweetness, the texture of crunchiness and the overall acceptance between the three samples below:

i) Frozen jackfruit using cryogenic freezing for minimally processed
ii) Frozen jackfruit using cryogenic freezing of whole fruit
iii) Fresh jackfruit (controlled sample)

A one-way ANOVA was utilized to compare the two means from two independent (unrelated) groups using the F-distribution. The null hypothesis for the test showed that the two means were equal. However, a significant result should indicate that the two means are unequal (Glen, 2023; Blokdyk, 2018; Miller, 1997). Comparing the three samples, the null hypothesis (H_0) denoted that the population means of the three samples were similar, while the alternative hypothesis (H_1) was different. This could be due to at least one of the population means of the three samples being different. In other words, the null hypothesis (H_0) and the alternative hypothesis (H_1) could be addressed as follows:

$$H_0: \mu_1 = \mu_2 = \mu_3$$

$$H_1 = \mu_1 \neq \mu_2 \; or \; \mu_1 \neq \mu_3 \; or \; \mu_2 \neq \mu_3$$

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Therefore, among the three samples, if the means of any two samples are different from each other, the null hypothesis (H_0) could be rejected.

Contingent Valuation Model

The contingent valuation model (CVM) has been widely applied to evaluate nonmarket goods in multidisciplinary research areas, including environment, health care, culture, safety and economics (Whitehead & Haab, 2013; Markandya & Ortiz, 2011; Hanemann, 1994), which is extended to estimate the value for market goods (Tao et al., 2023). The CVM is a survey-based method of estimating how much an individual would be willing to pay and is a highly flexible method for the estimation of values for goods, using a hypothetical market (Sajisee et al., 2021; Ekstrand & Draper, 2000; Hanemann, 1984). Survey respondents are randomly assigned a value from a vector of prices (or bids) and subsequently asked if they are willing to pay the price to gain or avoid the proposed change (Jorgensen, 2023; Hahsler & Reutterer, 2015). A binary logistic regression model was developed to estimate the probability of answering 'Yes' to the independent variable bidding price (Hanemann, 1984). In estimating the willingness-to-pay (WTP), several assumptions are made according to the maximum and minimum values of the integral of each bidding price; the probability of saying 'Yes' is set at a value of one (1), while the probability of saying 'No' is at a value of zero (0). Therefore, a negative WTP can be rejected because zero is used as the minimum value. A multiple linear regression model was utilized to identify the variables that influence the actual rate or the maximum price that consumers were willing to pay. The generic regression model to determine the value of WTP is as follows:

$$WTP = [\beta_0 + (\beta_2 X_2) + (\beta_3 X_3) + .. (\beta_k X_k)]/\beta_1$$

Where β_0 is constant, β_1 is coefficient bid, β_k is coefficient and *Xk* are mean values of endogenous variables

RESULTS AND DISCUSSIONS

Descriptive Analysis

Consumers' acceptance and sensory evaluation were conducted in conjunction with an international trade food exhibition held in Malaysia, which included locals and foreign consumers as the targeted respondents. A simple and purposive (i.e., foreign respondents) random sampling was applied, whereby participation was voluntary. A total of 200 respondents participated, comprising 77.5% (n = 155) of Malaysians and 22.5% (n = 45) of foreigners from various regions, including the Middle East (8.5%), Asia (5.5%), Africa (5.5%), Europe (2%), South America (0.5%) and Australia (0.5%). The composition between male and female groups was approximately 45% and 55%, respectively, with 90% of the respondents below 50 years of age. The majority of the respondents were in the low-to-middle income group, earning RM4,850 per month and lower for Malaysians, while more than 70% of the foreigners earned up to RM10,970 per month. Considering that most of the respondents were residing in urban areas, the composition was considered satisfactory with the sample requirements for the targeted new product (Table 1).

Table 1. Demographic Composition of Respondents (n = 200)

Demographic Factors		**Freq. (%)**
Origin Country	Malaysians (n = 155)	77.5
	Middle East (8.5%)	22.5

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	Non-Malaysians (n = 45)	Asia (excl. Malaysia) (5.5%) Africa (5.5%) Europe (2%) South America (0.5%) Australia (0.5%)	
Gender		Male	45.0
		Female	55.0
Age (year-old)	18 to 29		38.5
	30 to 39		34.5
	40 to 49		17.0
	50 to 59		6.5
	≥60		3.5
Household Income/Month	**Malaysians:**		
	≤RM4,850 (B40)		69.0
	RM4,851 - RM10,970 (M40)		26.0
	≥RM10,971 (T20)		6.0
	Non-Malaysians:		
	≤RM4,850		22.2
	RM4,851 - RM10,970		51.1
	≥RM10,971		26.7
Residential Strata	Urban		77.0
	Rural		23.0

Source: Researcher

As stated above, the sensory evaluation involved two samples of frozen J33 jackfruit using two different cryogenic freezing approaches – individual pulps (MP) and whole fruit, while the fresh form was used as a controlled sample. The evaluation criteria emphasized the pulp colour, aromatic, juiciness, sweetness (taste), texture (crunchiness) and overall preferences. The mean score value on overall acceptance and preferences showed that MP was more acceptable than the whole fruit of both groups - locals and foreigners. The results for Malaysians showed that the mean score of frozen jackfruit using cryogenic MP (5.303) was higher than the whole fruit method (4.645). This means that the frozen MP was more acceptable with differences in the quality and attributes between the cryogenic MP and whole fruit freezing methods, especially the juiciness (sogginess) and texture were the important pulp attributes that showed the lowest mean scores for the frozen whole at 3.98 and 4.37, respectively, which was unacceptable. As expected, the fresh pulp (i.e., controlled sample) manifested the highest score, proving that the fresh fruits could not beat the frozen fruits, as locals were more accustomed to fresh jackfruits. In contrast, the overall preference for frozen pulp recorded a slightly higher mean score than fresh pulp among the foreign respondents, indicating that they were acceptable with no statistically significant difference. However, the mean score of specific attributes, including the pulp colour, juiciness and crunchy texture indicated a significant difference between both samples (frozen MP and fresh). A vegetable consumer study by Heinrichs (2016) found that similarities between fresh and frozen nutritional values did not have any significant effect on preferences, albeit the taste, texture, or quality factors stimulated the consumers to prefer fresh to frozen vegetables.

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Table 2. Consumer Acceptance of Frozen Jackfruit (Variety J33) Using ANOVA

Fruit Attributes	Type of Samples	Malaysians (n = 155)	**Sig.**	Foreigners (n = 45)	Sig.
Pulp Color	Sample 1	5.323a	0.051	5.644	0.017**
	Sample 2	4.897b		5.222	
	Sample 3	5.103ab		5.733	
Aromatic	Sample 1	5.174a	0.000**	5.378	0.788
	Sample 2	4.645b		5.200	
	Sample 3	5.310a		5.267	
Juiciness	Sample 1	4.271b	0.000**	4.889	0.097*
	Sample 2	3.987b		5.044	
	Sample 3	5.206a		5.467	
Taste (Sweetness)	Sample 1	5.426a	0.000**	5.689	0.44
	Sample 2	4.594b		5.467	
	Sample 3	5.529a		5.356	
Texture (Crunchiness)	Sample 1	4.510b	0.000**	4.978	0.008***
	Sample 2	4.374b		4.667	
	Sample 3	5.716a		5.667	
Overall Acceptance	Sample 1	5.303b	0.000**	5.689	0.834
	Sample 2	4.645c		5.533	
	Sample 3	5.723a		5.600	

Source: Researcher
Note: Sample 1 = frozen jackfruit (cryogenic minimally processed-MP); Sample 2 = frozen jackfruit (cryogenic whole fruit); Sample 3 = fresh jackfruits

Furthermore, WTP was measured for frozen jackfruit, typically represented in monetary figures. WTP refers to the maximum price that a consumer is willing to pay for a product, while potential customers are likely willing to pay less than this threshold. In most cases, consumers tend to pay a lower price. Additionally, WTP can vary significantly between consumers with the variance often caused by differences in the customers' population, typically classified as either extrinsic (i.e., age, gender, income and education) or intrinsic (i.e., desire, passion and risk tolerance) factors (Stobierski, 2020). Several methods have been applied to measure WTP. This study applied both a survey and focus group, which is one of the effective ways of determining consumers' WTP by asking them directly after tasting the frozen jackfruit samples. Surveys involved the respondents and quantifiable data, while focus groups were obtained from industry players with more nuanced and qualitative information. The quantifiable data on WTP was analyzed using the contingent valuation model (CVM). The CVM is a stated preference (survey) method in which respondents are asked to state their preferences in hypothetical or contingent markets when individuals state their maximum WTP for a product. The WTP of local consumers was estimated at RM13.65/500 grams, which was slightly higher than the bidding price (RM12.00/500 grams), while the foreigners' WTP was estimated at RM16.01/500 grams, much higher than the bidding price (RM14.00/500 grams). The significant variable stated that the attributes of preferred sweet taste positively influence the WTP for both consumers' categories (Table 3). Therefore, the results suggested that the WTPs for frozen jackfruits were higher than the bidding prices for both Malaysians and foreigners.

Table 3. Contingent Valuation Model of Willingness-To-Pay by Consumer Category

Variables	**Malaysian**			
	B	**S.E.**	**Wald**	**Exp (B)**
Constant	-4.885*	2.964	2.716	0.008
Bidding price	-0.164	0.201	0.665	1.178
Attribute: Taste	1.360*	0.754	3.257	3.898
Attribute: Aromatic	0.210	0.440	0.226	1.233
Repeat purchase	-0.841	0.714	1.390	0.431
Product availability	1.917**	0.805	5.666	6.798

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$WTP_M = [\beta_0 + \beta_2 + \beta_3 + \beta_4] / \beta_1$	= [-2.239] /-0.164 = **13.65**			
Variables	**Foreign**			
	B	**S.E.**	**Wald**	**Exp (B)**
Constant	-6.795	7.605	0.798	0.001
Bidding price	-0.486	0.500	0.945	1.627
Attribute: Texture	-1.072	1.722	0.388	0.342
Attribute: Aromatic	1.071	1.320	0.659	2.919
Attribute: Taste	-1.200**	1.420	0.714	0.301
Nutritional values	0.046	1.840	0.001	1.047
Gender x Income	0.167	0.313	0.284	1.181
$WTP_F = [\beta_0 + \beta_2 + \beta_3 + \beta_4 + \beta_5] / \beta_1$	= [-7.783] /-0.486 = **16.01**			

Source: Researcher
Note: *, ** sig. at 0.1 and 0.05, respectively.

The qualitative information gathered from the focus group with industry players of 13 individuals (i.e., producers, exporters and importers) was analyzed using the thematic method. Table 4 displays the summary of industry reviews on frozen jackfruit. Relative to the whole fruit freezing method, the frozen MP using the individual pulp method indicated a higher preference due to a better taste. In fact, the taste of MP was highly acceptable with not much difference from the fresh sample. The frozen MP was more practical and could target the right markets and even penetrate new markets, especially those countries with well-accepted frozen fruits that have gained market access and export protocols, and growing demand for tropical fruits, including Japan and Australia. Therefore, frozen jackfruit is strongly recommended for the export markets, instead of domestic, albeit the packaging and labeling should provide useful information on preparing before consumption (i.e., thawing process, etc.).

Table 4. Summary of Thematic Analysis on Industry Reviews

Theme	Descriptions	Quotes
1. Market opportunities	Minimal processed (MP) frozen pulp has a higher potential.	*"The thawing process can cause oxidation, just like the fresh fruits. Should target the right market." (R6)* *"Can propose for the export markets, such as Japan and Australia where frozen products are well accepted." (R13)* *"Need to send to a more competitive market. Jackfruit's main competitor is Mexico in the Australian market. Therefore, it is necessary to think about the target export market." (R1)*
2. Market acceptance	No significant difference between frozen and fresh jackfruit.	*"The best jackfruit pulp is potential for the export market." (R11)* *"The best option is pulp MP." (R16)* *"After thawing, the taste is acceptable like fresh fruits." (R3)* *"No significant difference with fresh jackfruit." (R6)*

Source: Researcher

Before the technology adoption, evaluating the costs and returns to produce frozen jackfruit is pertinent. The major parameters to estimate economic viability, such as net present value (NPV), internal rate of return (IRR), benefit-cost ratio (BCR) and payback period (PP) were applied for frozen jackfruits using cryogenic (MP and whole fruit) and blast freezing techniques. The underlying assumption of these estimations is the existing cryogenic processing facility for frozen durians, a seasonal food crop, which can also be utilized for non-seasonal fruits, such as jackfruit. The financial parameters concluded that all frozen jackfruits were economically viable, either using cryogenic or blast freezing, albeit the cost of producing frozen cryogenic indicated lower than the latter. Despite requiring a higher cost, frozen MP revealed more positive returns with a larger NPV, exceeding 50% of IRR with a shorter PP, implying more returnable on investment. Therefore, the results strongly

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suggested that the frozen MP was more feasible and practical, especially for export purposes (Table 5).

Table 5. Summary of Economic Viability Analysis on Frozen Jackfruit

	Cryogenic Freezing		Blast Freezing
	Pulp (MP)	Whole fruit	(Pulp)
Cost of production (RM/500 gm)	11.44	5.59	12.45
Net Present Value (RM Mill.)	2.5	2.2	2.8
Benefit Cost Ratio (RM)	1.61	1.78	1.55
Internal Rate of Return (%)	55	46	60
Payback Period (year)	2.2	3	2.35

Source: Researcher

CONCLUSION

In line with the global uptrend frozen market for tropical fruits, MARDI has developed a technology for frozen jackfruits using a cryogenic freezing technique, focusing on the premium variety, J33. This innovation is expected to provide marketing solutions for industry players, especially those engaging in international trade, as jackfruit has an extremely limited shelf-life, which has been a long-standing critical issue in the jackfruit industry. The frozen fruits could extend their shelf-life until six months, while fresh fruits could only remain no longer than 14 days. Prior to the application, the evaluation of quality and preferences for frozen jackfruit from both the consumer's and industry perspectives, and the economic viability assessment is crucial. Primary data was obtained and gathered from consumer preference surveys and industry focus group discussions, involving sensory evaluation of three samples (frozen cryogenic pulp, frozen cryogenic whole and fresh jackfruit used as a controlled sample). The consumer survey was conducted during an international event in Kuala Lumpur to target a sample of respondents among foreigners, as the frozen form is aimed for export purposes. Major analyses were conducted, which included the ANOVA to identify the differences between the mean scores of each sample, CVM to determine the willingness to pay and thematic to draw significant points from industry reviews. The findings suggest that frozen jackfruit using cryogenic freezing and with minimal processing technique is acceptable from multiple sides, including the locals, foreigners and representative industries. In fact, the results denoted insignificant differences between frozen and fresh jackfruits among the foreign respondents. The economic viability estimates strongly suggest that the cryogenic MP form would be more feasible and returnable than the cryogenic whole fruit and blast freezing methods. The frozen jackfruit that utilizes a cryogenic freezing technique, which maintains both quality and nutritional values is expected to provide marketing solutions for the longstanding shelf-life issues in the jackfruit industry, especially for exportation. Furthermore, strong evidence has indicated that the J33 variety of frozen jackfruits can penetrate the global markets in the near future. This is due to multiple promising factors, including acceptance of the J33 variety which is attributed as a premium product, a significant growth of the global frozen fruit markets. This creates the awareness and benefits of the applications of frozen fruits and a more practical minimal process segment, especially during the off-peak season.

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