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The Standard Operating Procedure (SOP) for Exporting Frozen Whole Durian Fruit to The Republic of China

Nur Azlin Razali[a*], Siti Aisyah Abdullah[a], Wan Mahfuzah Wan Ibrahim[a], Wan Mohd Reza Ikwan Wan Hussin[a] and Suhana Safari[b]

[a]Horticulture Research Centre, Malaysian Agricultural Research and Development Institute (MARDI), MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia.
[b] Socio Economic, Market Intelligence and Agribusiness Research Centre, Malaysian Agricultural Research & Development Institute (MARDI), MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia.

*Corresponding author: nurazlin@mardi.gov.my

ABSTRACT:
Malaysia received permission to export frozen whole durian to China in August 2018. The cryogenic freezing method is proposed for use as it is one of the best techniques to supply and preserve the quality of durians all year round. Since this method is newly established and still needs to be validated during simulation and export trials, a standard operating procedure (SOP) needs to be developed to ensure the quality of whole fruit durian is preserved. A procedure comprised of sanitation treatment, cryogenic freezing, low-temperature handling, and methods for thawing frozen whole durian had been developed. The proposed disinfection treatment using sodium hypochlorite is recommended in the protocol to ensure it is free from any quarantine pests of concern to China. Furthermore, cryogenic freezing between -80 °C to -110 °C was introduced in the protocol as a treatment to prolong the storage life of Malaysian durian for exporting whole fruit form to China. An export trial was performed to validate the handling of the frozen durian in a cold chain (-18 °C) maintained until it reached the retail end. The thawing technique for frozen durian was studied in the lab and during the export trial to confirm the best eating quality. All these become a standard operating procedure to ensure Malaysian durian is safe to eat, handled in a controlled condition, and served at the best eating quality as a premium product of Malaysia.

KEYWORDS: Export trial, freezing injury, fruit quality, nitrogen freezing, quarantine

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INTRODUCTION

Durian fruit (*Durio zibethinus* Murray) is an important tropical crop in Southeast Asia. The imports are rising significantly across Asia, especially in China, Hong Kong, Taiwan and Singapore. China is the world's largest export destination for durian, importing over 29 billion Mt or up to 80% of global trade. China's importation has increased by 30% annually from 2016 to 2019, with a value of US 4,000 to US 6,000 million per year, and is estimated to spike significantly to US 14 billion by 2030. Thailand, Malaysia, and Vietnam are exporting countries of durian to China's mainland. Over 20 decades, Thailand has been a major exporter, dominating durian's global export market share with 95% of the world's supply and 99% of China's import (Narong et al., 2008). Other countries, for

example, Vietnam and Malaysia, have a small share, less than 1%. Durian from Malaysia, known as Mao Shan Wang or Musang King (D197), became famous after various promotions and advertisements from the industry attracted China's consumers and created more demand (Yuhuan, 2015). Additionally, changing lifestyles, rising discretionary expenses and consumer behaviour lead to greater consumption among the Chinese (Suhana et al., 2018). With an increase in China's demand, the price of durians also increased in China's market by about ten times, which benefits growers to gain more profits by growing durians (Poqmars, 2017). The price could go up to 120 USD/kg, three times higher than the domestic price; this variety was reported to have high demand (Durian Global Market Report, 2018). Malaysia exports to other countries as well as to Singapore (56%), Hong Kong (29.3%), Brunei (4.4%), Indonesia (3.1%) and other countries, including European and Middle East countries (less than 2%). Export to China is around 0.5%, although small, the value has increased by 6% from US 0.2 million (2019) to US 0.34 million (2020).

Musang King durian can be recognised by having green or brownish-grey skin with a spiky, broad torn and a star-shaped mark at its stylar end. Durian enthusiasts also prefer Malaysian varieties as they have a stronger aroma and are deliciously creamier than Thai varieties. Besides, Malaysia is now being approved by China to export the whole frozen durian fruit starting in 2018. The growing popularity of the Musang King has caused traders to flock to the Malaysian market and purchase in large volumes where they can genuinely gain a high profit as the price increases due to high demand in the Chinese market.

Seasonal fruits like durian will likely have an oversupply challenge, leading to a lower selling price (Udomsri et al., 2011). Technology that can maintain and prolong the postharvest storage life of seasonal crops is necessary to address this issue. Freezing is the best technique to retain fruit's quality for an extended storage duration, and fruit is accessible all year round. Durian surplus during the main season can be managed through freezing and supplied during the off-season. Furthermore, durian's pungent aroma can be concealed along the supply chain (Safari et al., 2021). Moreover, cold temperature storage reduces microorganisms' growth, extending the fruit's shelf life (Fellows, 2009). Freezing by application of liquid nitrogen offers the best quality, maintains storage life and enhances the internal micro-structure of fruits (Cheng et al., 2020). Frozen fruit is safer in terms of food safety because lowered air activity can restrain the development of microorganisms under frozen conditions (De Ancos et al., 2012).

Cryogenic freezing is a method that uses mediums such as carbon dioxide or liquid nitrogen that can cause rapid freezing in contact with fruits (Allan-Wojtas et al., 1999). Pressured liquid nitrogen is applied at high speed onto the product to freeze it immediately. It permeates beyond the product's thermal resistance, producing ice cover around it and preserving its natural flavours, moisture, and nutrients (Linde, 2020). Compared to conventional freezing methods, cryogenic freezing avoids moisture loss more efficiently. With limited water loss, this method can increase the product's weight.

Cryogenic freezing is a promising method for preserving the quality of durian fruit (Razali et al., 2022). This new method had been acknowledged in the protocol for exporting frozen durian from Malaysia to China. Since this method is newly established and yet to be validated during simulation or export trials, a standard operating procedure (SOP) needs to be developed to guide exporters to ensure the quality of whole fruit durian is preserved. This study aimed to compare the quality of frozen durian during the simulation study and the export trial by sea shipment. The samples' quality was evaluated initially and at certain periods following the export trial sampling date to ensure the SOP was effective and could be applied along the supply chain until the retailers.

MATERIALS AND METHOD

Sample Preparation of Frozen Whole Durian Fruit

Durian (D197) cv. Musang King was collected from a farm in south Malaysia. This durian fruit was brought to a packing house and sorted out from any pests and diseases, and sound fruit was selected for the export grade. Then, the fruits were sanitized with 500 ppm chlorinated water to ensure it is free from quarantine pests listed in the protocol. The sanitised fruit was air-dried and subjected to the cryogenic chamber. Cryogenic freezing was applied to the durian fruits following the method by Razali et al. (2022); the temperature setting was between -80 °C and -110 °C for a minimum of one hour. Frozen durian was kept in a corrugated fibreboard (CFB) box, sealed and placed in a frozen warehouse (the temperature was at -18 °C) before shipment was conducted.

The Export Trial Procedure by Sea Shipment

All samples departed from Port Klang, Malaysia, using a 40-foot sea container. Four temperature and relative humidity (RH) loggers (HOBO CX603, Adelaide, Australia) were randomly located in the frozen whole durian fruit boxes for monitoring purposes. It took 12 days to arrive at the Port of Beijiao, Guangdong, China. All boxes were transferred to a warehouse before retail distribution. A random pick of 10 boxes, five fruits in every box, had been delivered to one retail shop in Shenzhen, China. The durian fruit was displayed on a frozen shelf to simulate retail conditions. Samples were evaluated initially after arriving in the retail shop and after five days.

The Simulation Study

For the simulation study in a static condition, 50 fruits from 10 boxes of durian samples (5 fruits per box) were transported to Kompleks Lepas Tuai, MARDI Serdang. Samples were evaluated initially and after five days following the export trial sampling date. Samples were kept at -18°C, between 80 - 85% relative humidity for four weeks. Same with the export trial, four temperature and relative humidity (RH) loggers (HOBO CX603, Adelaide, Australia) were randomly positioned in the boxes of durian inside the cold room for recording purposes.

Visual Appearance, Colour Measurement, and Total Soluble Solids (TSS)

On each evaluation day, the visual appearance of individual fruit was subjectively scored for cracking incidence, percentage of disease at the stem end, and overall acceptability ratings (Table 1). Then, the durian fruits were evaluated for internal quality. The durian pulp's surface colour was determined by a colorimeter (Minolta Chroma Meter, Model CR200, Osaka, Japan). L* (lightness), a* (red-green), and b* (yellow-blue) values were recorded from the side surface of five pieces per replication and converted to hue and chroma values. The total soluble solids (TSS) were determined using a digital refractometer (ATAGO RX-5000, ATAGO, Japan).

Table 1: Visual appearance of individual fruit

Disease at stem end (% surface area)	Overall acceptability ratings
0% = No trace	5. Excellent
<25% = Slightly affected	4. Good
16-25% = Moderately affected	3. Acceptable
25-50% = Badly affected	2. Poor
>50% = Severely affected	1. Very poor

Statistical Analysis

The experimental setup was a completely randomised design (CRD). Statistical analyses of the treatment responses were conducted using analysis of variance (ANOVA) and the means were separated by Duncan Multiple Range Test (DMRT) at the 5% level of significance. Statistical analysis was done with the SAS 9.4 software package. Experimental data are displayed as means, with discussions of significant differences.

RESULTS AND DISCUSSION

The standard operating procedure (SOP) for exporting whole durian fruit by cryogenic freezing is shown in Figure 1. This SOP involved several steps of postharvest handling, for example, sorting, cleaning, and sanitation of the fruits. Sanitation treatment with 500ppm chlorine was applied to ensure the fruits were safe and free from pests. Then, cryogenic freezing (the temperature between -80 °C to -110 °C) was applied for a minimum of one hour to make sure the core of the fruit was frozen. After freezing, the frozen durian was packed, labelled, and stored at the exporter's warehouse before shipment. The sea shipment took 12 days to arrive at the port in South China, specifically in this study, Guangdong Province. The fruits were then transferred to the warehouse, delivered to the retail outlet, and ready to be marketed. The consumer could easily open the frozen durian using the thawing technique recommendation.

Average temperature and relative humidity profiles during actual sea shipment are shown in Figure 2. The temperature was managed to be less than -18 °C during storage and transportation. The importance of temperature management has also been reported by Nur Azlin et al. (2016) to export the minimally processed durian. The temperature was initially recorded at -16°C during warehouse storage. Upon departure to Guangdong, China, the temperature dropped to -28 °C and fluctuated between -28 °C to -25 °C along the sea shipment. When arrived at the Port of Beijiou, Guangdong, the temperature increased to -22 °C, then returned to -28 °C during storage at a warehouse in China. The data logger recorded the temperature increase up to -12 °C when the samples were delivered to the retail shop. Compared with static samples (simulation study), the temperature recorded was maintained at -19 °C during 16 days of storage at MARDI's cold room. The controlled environment in the simulation study was used to compare the temperature management throughout the export trial.

Figure 1. Standard operating procedure (SOP) for exporting frozen whole durian fruit to China

Relative humidity was recorded at 80% during storage at the exporter's warehouse and reduced to 65% during transportation by sea shipment (Figure 2). The sea container in this study might be set with low relative humidity to prevent weakening the box's structure due to excessive humidity. However, it adversely affected the durian quality in this study by increasing skin dehiscence incidents during shipment. On the other hand, relative humidity was maintained between 80-85% for samples stored in static storage in MARDI. A high percentage of relative humidity could prevent the husk dehiscent of durian by controlling the water loss from the fruit.

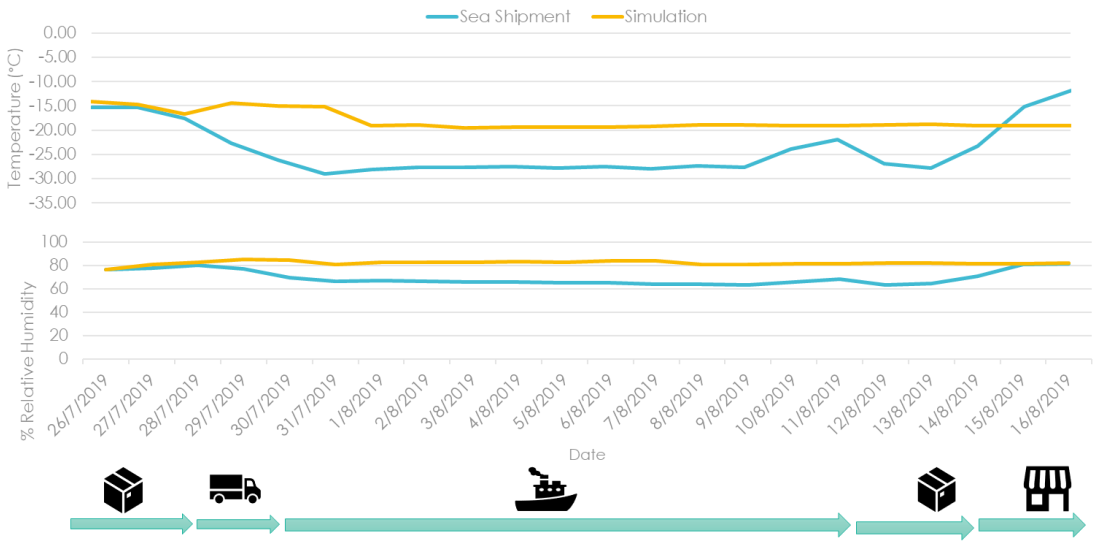

Figure 2. Comparison of temperature and relative humidity between actual sea shipment and simulation.

The frozen durian in both the export trial and simulation preserved its quality during storage of 22 days, as indicated by small changes in visual appearance, physical and chemical results. Export trial samples were found to have a 50% incidence of skin dehiscence regardless of the degree of the crack (Table 2). Skin dehiscence could result from water loss caused by low RH during transportation. Therefore, increasing the RH inside the sea container is advisable to control the water loss. No disease or fungal infection was observed for both samples. Export trial samples were rated 4.3, while simulation samples were rated 4.9 for overall acceptability. Quality assessment data showed that the TSS remained at 36-40%. The colour of the durian was preserved; the L value, chroma value, and hue degree were 69, 51 and 67°, respectively, throughout the storage period.

Table 2: Visual appearance, colour, and total soluble solids (TSS) for export trial compared to simulation samples

Parameters	Export trial (China)	Simulation (Malaysia)
Cracking	50%	0%
Diseases at the stem end	0%	0%
Overall acceptability ratings	4.3	4.9
L (Lightness) value	68.75	76.71
Chroma value	50.65	58.62
°Hue	86.73°	87.27°
Total soluble solids (TSS)	36.02%	40.48%

CONCLUSION

Demand for durian fruits, especially in China's market, has increased extremely and become more popular. This study has proved that the standard operating procedure for exporting frozen whole durian fruit using cryogenic freezing to China developed by MARDI has successfully maintained the good quality of the premium Malaysian Musang King durian. The durian quality was still preserved even after being transferred from frozen to room temperature. This new package technology will expand market opportunities for frozen whole durian fruit to be marketed widely in the Chinese market and other prospective countries.

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