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Comparison of Jackfruit Quality at Two Malaysian Locations

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Abstract: Global warming caused by anthropogenic activities has caused climate change that affect the world weather pattern including rising in temperature and uncertain rainfall pattern, which can impact the yield of plants. Jackfruit (*Artocarpus heterophyllus*) is one of the main fruits in Malaysia and claimed as "miracle crop" by climate experts due to its resilience to climate change. The objective of this research is to compare jackfruit quality in two different agro-climatic regions as a preliminary assessment of potential climate effects. The Tekam Yellow (J33) jackfruit variety was harvested from commercial plot located in Kota Tinggi, Johor and Pengkalan Hulu, Perak. Monthly temperature and rainfall data during its fruiting season, encompassing the period from June 2023 until January 2024 were obtained from NASA Power. During those periods, Kota Tinggi, Johor exhibited higher maximum and minimum temperature and higher accumulated rainfall and rainfall frequency compared to Pangkalan Hulu, Perak. The Total Soluble Solids (TSS) and moisture content of jackfruits from both locations showed no significant differences ($p>0.05$) in this preliminary comparison. While these results suggest jackfruit quality parameters may not be strongly affected by the range of climatic conditions observed in this study, the small sample size, single season data, and presence of confounding factors limit definitive conclusions. Further research with larger samples and controlled conditions is needed to fully assess jackfruit's climate resilience.

Keywords: Jackfruit, temperature, rainfall, climate change, Malaysia

1. Introduction

Climate change caused by global warming has become a critical issue worldwide as it will have an impact on food security with the increasing population in the future. In recent years, the impact of climate change has become more apparent with the irregular and altered rainfall patterns, increase in temperature and frequency of extreme weather events, such as heatwave, floods and droughts (Sundarrajan et al., 2025). According to the IPCC's Sixth Assessment Report (IPCC-AR6), Nationally determined contributions (NDCs) announced by October 2021 stated that global GHG emissions in 2030 are projected to make it likely that global warming will exceed 1.5°C during the 21st century, thereby increasing the difficulty of limiting temperature rise to below 2°C. Peninsular Malaysia is projected to experience prolonged dry periods in the future, accompanied by a decrease in the frequency of days with very heavy rainfall (Chung et al., 2023). This can have a direct influence on the growth and maturation of fruit crops. Heat stress during flowering and fruit set can significantly decrease fruit yield, whereas irregular rainfall patterns may interfere with pollination and increase the susceptibility to pest and disease outbreaks (Sundarrajan et al., 2025). Besides, climate change will accelerate the risk of food shortages by reducing the yields of major cash crops such as wheat, soybeans and corn, which are vital food sources for both livestock and humans **(**Weintraub et al., 2022**).** Therefore, it is crucial to find a reliable and alternative food source with abundant of nutrients for future food security.

Jackfruit (*Artocarpus heterophyllus*) belongs to the family of Moracea and is one of the main fruits in Malaysia. In 2023, jackfruit cultivation in Malaysia covered a planted area of 9,582 hectares, producing an annual yield of 40,813 metric tonnes (DOA, 2024). Jackfruit is a versatile fruit and has so many potentials for food security. Besides the fruits that are rich in nutrients, each part of the jackfruit trees has medicinal values properties, the jackfruit peel can be used as an adsorbent for toxic dyes and jackfruit latex is useful in cement industry (Kalse et al., 2022). Jackfruit can be consumed raw or cooked, either in its ripe or unripe form, and is widely used in a variety of sweet and savory dishes (Sreeni, 2020).

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In Malaysia, several jackfruit varieties are cultivated, including Tekam Yellow (J33), Mantin, and Mastura. However, the most popular and preferred variety is Tekam Yellow (J33) due to its sweeter taste and less juicy texture compared to other varieties (Ismail et al., 2013). Jackfruit has been referred as a "miracle crop" by leading food security experts due to its higher resilience to the impacts of climate change compared to major staple crops like corn and wheat (Weintraub et al., 2022). However, for optimal growth, jackfruit requires favorable environmental conditions, particularly a lowland tropical climate with optimum temperatures between 27°C and 31°C and an annual rainfall of about 2,540 mm (DOA, 2000). Despite the challenges in distinguishing the impacts of nutrients, pest and disease control from temperature and rainfall effects on jackfruit quality, this study aimed to compare the quality of the jackfruit variety Tekam Yellow grown in two different agro-climatic planting areas.

2. Material and Methods

Jackfruit (*Artocarpus heterophyllus*) variety Tekam Yellow was harvested from commercial farms in Pengkalan Hulu, Perak and Kota Tinggi, Johor, which are located in agro-climatic zone 1 and zone 3, respectively. Zone 1 indicates the clear and consistent dry season, while zone 3 indicates no fixed dry season. The maximum temperature, minimum temperature and daily rainfall data was collected from NASA Power throughout the fruiting season of June 2023 to January 2024. NASA POWER–based data can accurately estimate most climatic variables, including maximum, minimum, and mean temperatures. However, wind speed and precipitation estimations from NASA POWER simulations still require improvement (Halimi et al., 2023). A study by Rodrigues et al. (2021) reported that NASA POWER can serve as a valuable source for generating weather datasets, particularly in locations where ground weather station data are missing or unavailable.

Ten fruit samples were harvested from ten different trees with fruits that were ready to be harvested in the fully ripened stage from both farms and tested for their qualities. Each fruit was tapped prior to harvest, and the tapping sound was evaluated for the presence of a dull hollow tapping sound since this is widely regarded as the most reliable indicator of physiological maturity in jackfruit (Kaur et al., 2024). In this particular study, the accounted fruit quality tests are Total Soluble Solids (TSS) and moisture content (MC). The TSS test was run to identify the sweetness level of the fruits by using refractometer (PAL^{TM} Series Pocket Refractometer, ATAGO Co. Ltd., Japan). Juice extracted from the jackfruit bulb was applied to the refractometer prism, and TSS values were recorded.The instrument is equipped with Automatic Temperature Compensation (ATC), thereby eliminating the need for manual temperature correction during measurement. Moisture content was measured by weighing and drying the fruit samples. Ten pulps of each jackfruit samples were dried in the oven at 70°C and the weight was measured every day until the reading was constant. The formula to calculate the moisture content (%) is as follow:

$$\text{Moisture content (\%)} = ((\text{Initial weight} - \text{Final weight}) / \text{Initial weight}) \times 100 \quad (1)$$

The data obtained was subjected to statistical analysis using SAS 9.4 software and the mean between the jackfruits variety Tekam Yellow (J33) from two different agro-climatic areas were compared using Duncan's multiple range test.

2.1 Study Limitations

This study involved a comparison of two commercial jackfruit farms registered under Department of Agriculture (DOA) Malaysia that may differ not only in climate but also in soil conditions, management practices, and many other factors. We cannot definitively attribute the observed similarities or differences to climate factors alone. The findings represent preliminary observations that warrant further investigation with controlled experimental designs.

3. Results

Figure 1 shows the total rainfall monthly in jackfruit commercial farms in Pengkalan Hulu, Perak and Kota Tinggi, Johor, which are located in agro-climatic zone 1 and zone 3, respectively. It can be observed that from June 2023 to January 2024, Kota Tinggi, Johor recorded a higher total rainfall than Pengkalan Hulu, Perak, except in November 2023, where Pengkalan Hulu, Perak experienced the highest total rainfall of 671.58 mm, which was a month before harvesting. The total rainfall recorded from June 2023 until January 2024 for Kota Tinggi, Johor and Pengkalan Hulu, Perak were 3620.74 mm and 2450.80 mm, respectively. This is consistent with the location of Kota Tinggi, Johor, which falls within Zone 3, a region characterized by the absence of a fixed dry season due to relatively consistent rainfall distribution throughout the year rather than the occurrence of prolonged dry periods.

Figure 2A and 2Bshow the mean monthly maximum and minimum temperature throughout June 2023 until January 2024 of the two agro-climatic zones, respectively. It can be observed that Kota Tinggi, Johor recorded a higher mean monthly maximum temperature compared to Pengkalan Hulu, Perak, with the highest temperature recorded of 31.13°C in October 2023. In contrast, Pengkalan Hulu, Perak exhibited a lower mean monthly temperature than Kota Tinggi, Johor, with the lowest value of 20.68°C in January 2024.

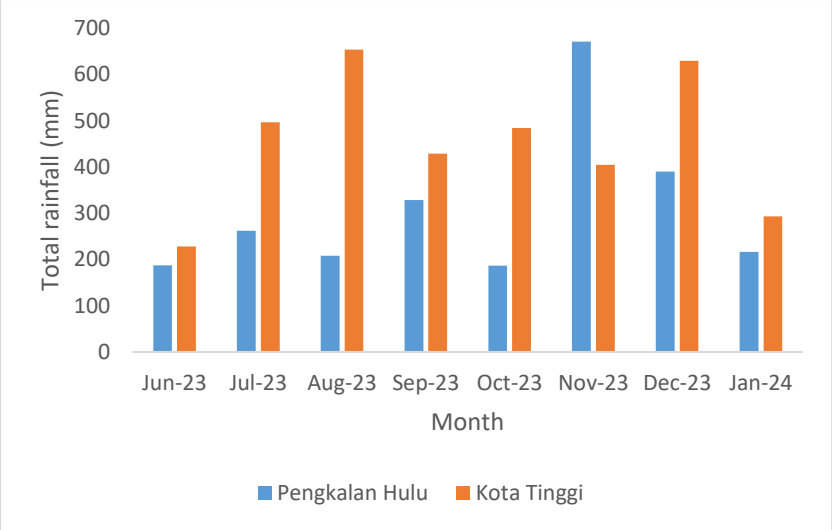

Fig. 1: Total rainfall monthly in Pengkalan Hulu, Perak and Kota Tinggi, Johor from June 2023 until January 2024 during fruiting season.

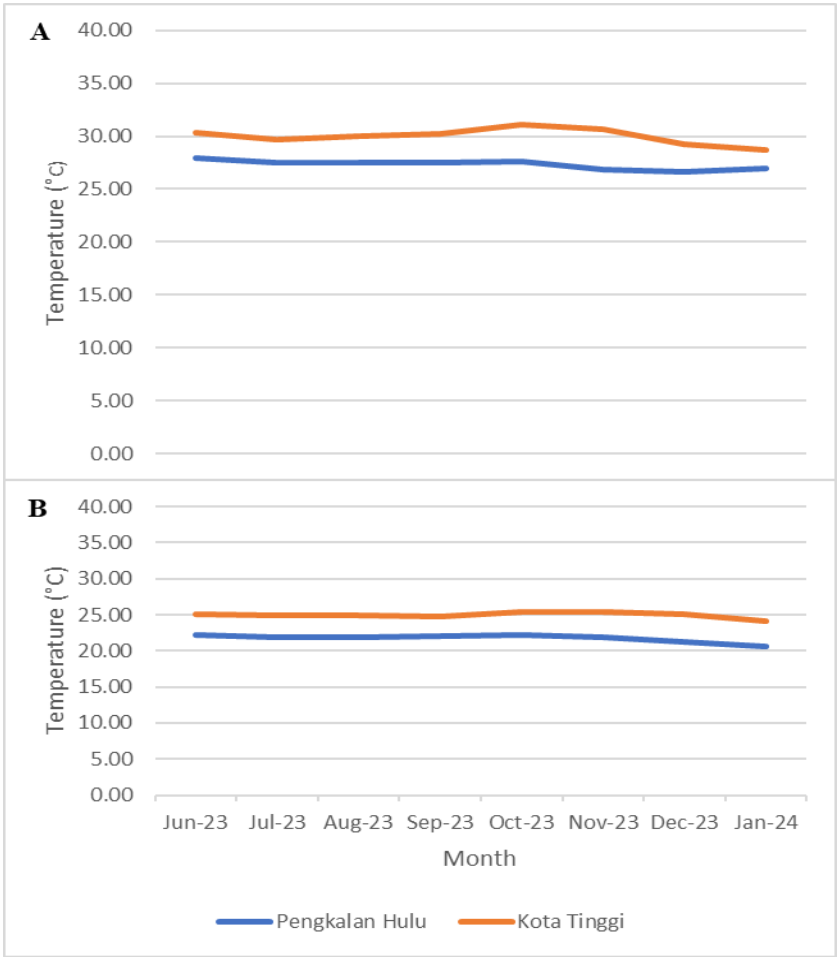

Fig. 2: Mean monthly temperatures in Pengkalan Hulu, Perak and Kota Tinggi, Johor from June 2023 to January 2024 during the fruiting season. (A) Mean monthly maximum temperature. (B) Mean monthly minimum temperature.

Table 1: Total Soluble Sugar (TSS) and moisture content of jackfruit quality in two different agro-climatic areas.

Agro-climatic areas	Total Soluble Solids, TSS (%)	Moisture content, MC (%)
Pengkalan Hulu, Perak (Zone 1)	25.65±4.39a	73.70±3.11a
Kota Tinggi, Johor (Zone 3)	21.73±5.68a	74.84±4.74a
p-value	0.101 (ns)	0.5329 (ns)

*Means followed by the same letter within column are not significantly different by DMRT at P≤0.05

The results for Total Soluble Solids (TSS) and moisture content of jackfruit quality harvested from two different agro-climatic areas, zone 1 and zone 3 are shown in Table 1. TSS represents the concentration of dissolved solids in fruits which influences their sweetness and texture (Al-Farsi et al., 2024). Although the mean monthly maximum and minimum temperature and total accumulated rainfall from June 2023 to January 2024 was higher in Kota Tinggi, Johor, which located in Zone 1 compared to Pengkalan Hulu, Perak that is located in Zone 3, the ANOVA results showed the differences of moisture content between two jackfruits variety Tekam Yellow from both areas were not significant ($p>0.05$). Likewise, although the TSS value of jackfruit in Pengkalan Hulu, Perak was 25.65 %, which was slightly higher than the TSS value of jackfruit in Kota Tinggi, Johor, which was 21.73 %, the ANOVA results showed they were not significantly different ($p>0.05$). The numerical difference in TSS (15%) was not statistically significant, possibly due to the small sample size and high variability within each location.

4. Discussion

The TSS values of jackfruits from both agro-climatic areas are consistent with the previously reported range for fully ripened jackfruit, which is 19.3% to 27.0% (Ranasinghe and Marapana, 2019). Previous study reported that the TSS values were lowest in the immature stage and highest in the fully ripen stage. The difference in TSS values may reflect the conversion of starch to sugar during ripening, accompanied by cell wall disintegration that releases water-soluble components. Additionally, the degradation of water soluble pectic substances by polygalacturonase increases the water-soluble galacturonic acids, further contributing to the rise in TSS (Ranasinghe and Marapana, 2019). The non-significant different TSS values between the jackfruits from the two agro-climatic areas may be due to both jackfruits were the same J33 variety, harvested at the same harvesting stage, fully ripened stage, agreed with the previous studies that TSS hugely influenced by types of variety, maturity stage and harvesting time (Amin et al., 2022; Ranasinghe and Marapana, 2019). Likewise, the possible reasons why TSS and moisture content may not be sensitive to climate variations is because they can withstand the climate change as some fruit security experts claimed it as “miracle crop” and has potential for future food security (Weintraub et al., 2022). However, several factors may influence these quality parameters, including fruit maturity stage, harvesting time, and management practices, all of which play critical roles in determining overall fruit quality (Amin et al., 2022; Ranasinghe and Marapana, 2019). The limitations of this study highlight the need for future research involving larger sample sizes conducted across multiple seasons and diverse agro-climatic regions to more robustly assess jackfruit climate adaptability, as well as the influence of management practices, including pest and disease management.

5. Conclusion

The difference in monthly temperature, accumulated rainfall and pattern in two different agro-climatic areas, Kota Tinggi, Johor and Pengkalan Hulu, Perak showed no significant impact on the Total Soluble Solids (TSS) and moisture content of the jackfruit variety Tekam Yellow from both areas. However, the small sample size, single season data, and confounding variables limit our ability to draw definitive conclusions about climate resilience. Moving forward, further experiments with larger samples across multiple seasons are needed to properly assess jackfruit’s climate adaptability.

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Conflict of Interest

The authors declare no conflict of interest.

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