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ORIGINAL ARTICLE

Impact of Drying on Physicochemical Properties and Nutritional Composition of Crystal Longan (*Pometia pinnata*)

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ABSTRACT - Crystal longan is a seasonal fruit rich in sugar, water and nutrients that support microbial growth, resulting in a short post-harvest lifespan and limited year-round availability. This study investigated the effect of different drying treatments as preservation methods on the proximate content and physicochemical properties of crystal longan flesh. The proximate composition was evaluated based on ash, moisture, protein, fat, and carbohydrate. Physicochemical properties were evaluated based on pH, titratable acidity, total soluble solids, and water activity. Results showed oven-dried crystal longan flesh has the lowest moisture and protein contents, whereas the sun-dried flesh had the lowest ash and carbohydrate contents. The highest pH (7.0), titratable acidity (0.05 g/100 ml) and water activity (0.50) were observed in the oven-dried flesh. Among the methods, vacuum drying produced the most favorable proximate composition and physicochemical properties, followed by oven drying and sun drying. Overall, all drying treatments significantly influenced the nutritional and physicochemical characteristics of dried crystal longan flesh. These findings provide valuable information on the nutritional quality and physicochemical attributes of dried crystal longan, supporting the potential development and market visibility of crystal longan-based product, particularly in Sarawak.

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INTRODUCTION

A nutritious diet is crucial for preserving general health, especially for boosting immunity and averting illness. Many people view dried fruits as easy, nutrient-dense snacks that are high in vitamins, minerals, and dietary fibre without the added sweets. Dried fruits are a great substitute for sweet snacks because, for instance, consuming less added sugar has been linked to a decreased risk of obesity, type II diabetes, and cardiovascular diseases [1-2]. *Pometia pinnata*, also called crystal longan or dragon's eyes, stands out among the others because of its distinct nutritional qualities, sweet, delicious flavour, and translucent, juicy flesh. *P. pinnata*, a member of the Sapindaceae family and native to tropical countries like Malaysia and Southeast Asia, is valued for its extensive cultural, economic, and health significance [3-4].

From July to October, crystal longan is a seasonal fruit that is prized for its traditional medical use as well as for fresh eating. The fruit is used to cure conditions including fever, gastrointestinal issues, and hypertension since it is high in dietary fibre, vitamin C, and vitamin E [5]. The fruit's translucent, juicy flesh, which adds to its visual and sensory appeal, is reflected in the name "crystal". In Sarawak, Malaysia, the longan holds significant cultural importance, rooted in its long history of traditional consumption and reputed medicinal properties. Nevertheless, *P. pinnata* has problems common to tropical fruits, such as a short shelf life brought on by microbiological spoiling by bacteria, yeast, and mould, despite its popularity

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and extensive use in Sarawak, Malaysia [6-7]. These problems emphasize how important it is to use efficient preservation methods to preserve its quality and availability.

One of the most popular and successful food preservation techniques is drying, which aims to lower moisture content and water activity to prevent microbial growth. Although traditional sun drying is economical and environmentally favourable, exposure to heat and impurities frequently leads to variable quality and nutritional loss. Although it may change the texture and flavour, oven drying offers more control over temperature and duration, resulting in more consistent quality and less nutrient degradation [8]. Modern low-pressure vacuum drying is excellent at conserving heat-sensitive substances like vitamins while retaining the fruit's colour and texture. But it costs more and calls for specific equipment [4]. Given these variations, comparative studies are essential to determine the optimal drying method that preserves the desired physicochemical, proximate, and sensory characteristics of the dried fruit.

Specifically, despite the nutritional and economic potential of crystal longan, no published studies have examined the effects of different drying techniques on its flesh. This critical gap in knowledge restricts efforts to extend its shelf life, improve marketability, and promote product diversification in both local and international food sectors. Therefore, this study investigates the impact of sun drying, oven drying, and vacuum drying on the physicochemical characteristics and proximate composition of crystal longan flesh. These findings are expected to extend the fruit's shelf life, enhance its market value, and strengthen its availability as a nutritious and culturally significant food. Furthermore, this work will contribute valuable data on the composition of dried crystal longan, supporting product development and market expansion in both local and international food industries, while preserving its unique sensory characteristics.

MATERIALS AND METHODOLOGY

Sample Collection and Preparation

The crystal longans were purchased in bulk from the local seller in Sibu, Sarawak. The fruits were placed in a polystyrene box and kept in frozen condition at -20℃ to preserve the quality before use. Before drying treatments were conducted, each fruit was washed under running tap water to remove any visible dirt. The shell was peeled, and the fresh flesh was extracted by removing the seed. The fresh and clean crystal longan flesh was washed and dried at room temperature (20℃ to 25℃) and less than 40% relative humidity (RH) for 10 minutes. The flesh were then subjected to three drying treatments, and one portion served as the control group which is the fresh sample.

Drying Treatments

Three drying treatments were used for this study which are sun drying, oven drying, and vacuum drying. Each group of drying treatments used 300 g of crystal longan flesh, which was sliced into thin pieces approximately 0.5 cm thick and 4 cm long. The fresh slices were placed on a stainless-steel tray lined with baking paper. For sun-drying, the trays containing the crystal longan flesh slices were placed inside the drying nets and placed under direct sunlight between 30 ± 5℃ for 3 days of a total exposure of 15 hours. The sliced flesh was turned periodically to ensure uniform exposure to heat. Meanwhile, vacuum drying requires the trays containing the crystal longan flesh slices to be placed in a vacuum dryer (Memmert, Germany) at 60℃ and 69 mbar for 24 hours [9]. Samples that were subjected to oven drying were placed in an oven dryer (Memmert, Germany) at 60℃ for 24 hours [10]. The choice of 60℃ for vacuum and oven drying balances moisture removal and quality preservation, as it improves drying efficiency without compromising product quality [11]. The weight of partially dehydrated pulps was recorded every 10 minutes until constant weight were obtained for all drying treatments. Upon completion of the drying treatments, the dried samples were immediately cooled to room temperature, ground into fine powder using a blender, and then stored in airtight, high-density polyethylene bags at -20℃ until further analysis of proximate content and physicochemical properties.

Determination of pH, Titratable Acidity and Total Soluble Solids

The pH of fresh, oven-dried, sun-dried, and vacuum-dried crystal longan pulp was measured using a pH meter where the electrode was immersed in 1 g of each grounded sample that was dissolved in 10 ml distilled water to observe the pH reading [12]. The titratable acidity was determined according to the AOAC method [13] by employing titration of the dried sample with 0.1 N NaOH to a distinct endpoint. The dried sample was prepared into juice beforehand by dissolving it in 30 ml of distilled water and centrifugated for 10 minutes at 4℃ and 4000 rpm. The titratable acidity was calculated and expressed as g per 100 ml. Total soluble solids (TSS) was measured using a digital refractometer. The measurement was performed on a homogenised extract prepared by reconstituting 5 g of the grounded dried sample in 45 ml of distilled water (1:9 w/v ratio) [13]. The result was reported in °Brix. Water activity was measured using a water activity analyzer (Meter Aqualab 4TE, United States).

Proximate Analysis

Proximate analysis for moisture, ash, protein, and fat content was conducted according to AOAC methods where 2 g of grounded dried sample was used for every analysis of each dried sample group as well as the control sample [13]. The sample was incinerated in a muffle furnace (Nabertherm, Germany) at 550℃ for 12 hours for ash content determination. The moisture content was determined by drying the grounded sample in the oven at 100℃ for 24 hours. The crude protein was determined by using the Kjeldahl method with the sample being digested, distillated, and titrated. A conversion factor of 6.25 was then used for the calculation of protein percentage. Fat content was determined by using the Soxhlet method based on the FOSS Soxtec extraction system of ST 255. Meanwhile, the total carbohydrate content was determined by calculation using the difference method, as described in James' analytical methods, by subtracting the sum of the percentages of moisture, protein, fat, and ash from 100% and expressed in terms of percentage [14].

Statistical Analysis

All experiments were conducted in triplicates. All results were expressed as mean ± standard deviation. Statistical analysis was performed using Minitab Statistic software. Experimental results were subjected to a one-way analysis of variance (ANOVA) and the significant differences among means at 95% confidence limits ($p<0.05$) were determined by the Tukey test.

RESULTS AND DISCUSSION

pH, Titratable Acidity, and Total Soluble Solids

Table 1 illustrates the impact of different drying methods on the physicochemical properties of *P. pinnata* flesh, providing a comparative analysis with its fresh counterpart. The pH of crystal longan flesh is a crucial indicator of acidity and its capacity to suppress microbial proliferation. The fresh flesh of crystal longan displayed a neutral to slightly alkaline pH of 7.69 ± 0.01, which significantly reduced ($p<0.05$) across all drying processes. Sun-dried fruits generally exhibit the lowest pH compared to vacuum and oven-dried counterparts, primarily due to higher retention of organic acids such as citric and malic acids, and environmental factors [15-16]. The slower drying process in sun drying helps preserve volatile compounds and phenolic acids, thereby enhancing acidity [17]. As moisture evaporates, the remaining organic acids become more concentrated, which can lead to a lower pH level in the final product, even if the overall moisture content is relatively high. In contrast, vacuum and oven drying employ higher temperatures and faster drying rates, which degrade organic acids and phenolic compounds, resulting in comparatively higher pH values [18-19]. Although vacuum drying is gentler than oven drying, it still leads to some loss of volatile acids [20]. However, titratable acidity (TA) showed no statistically significant difference ($p>0.05$) across all samples. The non-significant change in TA, which is counter-intuitive to the expected concentration effect of drying, suggests that the gain from concentration was counterbalanced by a substantial loss of volatile organic acids through thermal degradation and volatilization [15].

Table 1. Physicochemical Properties of Fresh and Fried Crystal Longan Flesh Prepared by Different Drying Methods

Samples	pH	Titratable Acidity (g/100 ml)	Total Soluble Solids (°Brix)
Fresh	7.69 ± 0.01[a]	0.07 ± 0.01[a]	18.50 ± 0.00[a]
Oven-dried	7.05 ± 0.01[b]	0.05 ± 0.03[a]	8.00 ± 0.00[b]
Vacuum-dried	6.92 ± 0.01[c]	0.05 ± 0.01[a]	11.00 ± 0.00[c]
Sun-dried	6.57 ± 0.01[d]	0.04 ± 0.01[a]	7.50 ± 0.00[d]

All results are expressed as mean ± standard deviation of triplicate. Results of the same column followed by different superscript letters are significantly different at $p<0.05$.

Total soluble solids (TSS), an essential measure of fruit sweetness and ripeness, exhibited significant differences ($p<0.05$) between fresh and dried crystal longan samples. Fresh samples yielded the highest total soluble solids (18.50 °Brix), which unexpectedly reduced after drying. While theoretically the loss of moisture should generally increase solute concentration due to the concentration effect, this study suggests that the combined effects of thermal degradation and reduced sugar solubility overshadowed this expected increase [23]. Sun drying caused the most substantial decrease (7.50 °Brix), primarily because the prolonged thermal exposure enhanced non-enzymatic browning reactions, such as the Maillard reaction, leading to greater sugar destruction [24-25]. In contrast, vacuum drying best preserved the soluble solids (11.00 °Brix) by minimizing thermal and oxidative degradation due to the lower temperature and oxygen-free environment [26]. These results reinforce the critical role of controlled drying techniques in mitigating sugar loss and maintaining overall fruit quality [22]. Previous research also reported comparable decreases in total suspended solids for sun-dried mangoes [25].

Water Activity, Moisture and Ash Content

Table 2 highlights the impact of various drying techniques on water activity, moisture and ash content. Water activity (a_w) is a crucial factor influencing food safety and shelf life since it quantifies the accessibility of free water for microbial proliferation. The fresh flesh of crystal longan had an a_w of 0.55 ± 0.02, which significantly reduced ($p<0.05$) across all drying procedures. Among the dried samples, sun drying produced the lowest water activity at 0.46, followed by vacuum drying at 0.48, and oven drying at 0.50. This decline corresponds with the findings that highlighted that decreased a_w levels hinder microbial proliferation and enzymatic activity, hence extending shelf life [27]. The comparable patterns were also found in dried mango, with oven drying preserving the highest water activity due to the greater retention of bound water [9]. The reduced water activity of vacuum drying is due to its rapid moisture removal under vacuum conditions while maintaining structural integrity, making it advantageous for producing thermally sensitive fruits [28-29]. The minimal water activity recorded in sun-dried samples strengthens its efficacy in improving shelf stability; yet, extended exposure to ambient air may jeopardize other quality characteristics, including flavor and nutrient preservation [30].

Table 2. Water Activity, Moisture, and Ash Content of Fresh and Dried Crystal Longan Flesh Prepared by Different Drying Methods

Samples	Water Activity (a_w)	Moisture (%)	Ash (%)
Fresh	0.55 ± 0.02[a]	76.62 ± 1.19[a]	0.50 ± 0.00[b]
Oven-dried	0.50 ± 0.00[b]	11.79 ± 0.15[b]	2.15 ± 0.04[a]
Vacuum-dried	0.48 ± 0.01[bc]	12.16 ± 0.01[b]	2.19 ± 0.02[a]
Sun-dried	0.46 ± 0.00[c]	13.13 ± 0.03[b]	2.14 ± 0.04[a]

All results are expressed as mean ± standard deviation of triplicate. Results of the same column followed by different superscript letters are significantly different at $p<0.05$.

The moisture content, a crucial determinant of food quality, flavour, texture, visual appeal, and shelf life, was significantly reduced ($p<0.05$) in dried samples. The reduction however is essential since elevated moisture levels promote microbial proliferation and deterioration, while extremely low moisture compromises product uniformity [31; 32]. The moisture content of dried crystal longan flesh varied between 11.79% and 13.13%, with oven drying producing the minimum value (11.79 ± 0.15), while vacuum drying and sun drying preserved the maximum moisture levels (13.13 ± 0.03). Also, this substantial

reduction in moisture leads to a concentration of the remaining dry matter, resulting in higher measured values for other components. The results of dried crystal longan flesh align with research on litchis, indicating that drying techniques successfully lowered moisture content to under 15%, the optimal limit for dried fruits, hence reducing perishability and extending shelf life [33].

Ash concentration, indicative of mineral richness, was significantly higher in dried samples compared to fresh ones ($p<0.05$), with values ranging from 0.50% to 2.19%. The ash content of the dried samples showed no significant differences ($p>0.05$), with only slight variations attributed to the drying methods employed. This suggests that while the drying methods may have had a minor impact on the ash content, the overall effect was minimal and did not result in statistically significant differences. These results correspond with the previous findings which emphasize the significance of drying in improving mineral density through moisture elimination [34].

Crude Fat, Protein, and Carbohydrate

Table 3 presents the crude fat, protein, and carbohydrate content of the fresh crystal longan and those that were subjected to different drying treatments. The proximate analysis of crystal longan flesh reveals non-significant differences ($p>0.05$) in protein content among the drying methods. Since the Kjeldahl method measures total nitrogen rather than protein alone, the observed variations may stem from both protein and non-protein nitrogen compounds. Sun drying retained more nitrogen than oven and vacuum drying, likely due to lower drying temperatures minimizing nitrogen loss. In contrast, higher temperatures in oven and vacuum drying may have led to nitrogen degradation, reducing total nitrogen content [35]. The non-significant differences ($p>0.05$) between oven-dried and vacuum-dried samples suggest that both methods exert a similar effect on nitrogen retention. This aligns with the past researchers who reported that vacuum drying can result in protein losses due to denaturation and chemical reactions involving amino acids [14]. While their study focused on murta berries, the principles of nitrogen retention under different drying conditions are applicable to crystal longan flesh. Nitrogen retention in dried longan flesh varies with drying method, with sun drying preserving more nitrogen, while oven and vacuum drying result in greater nitrogen loss, likely due to thermal effects.

The fat level in crystal longan flesh, which is naturally low (0.18% to 0.45%), displayed non-significant differences ($p>0.05$) across different drying methods, with dried samples demonstrating greater fat content than fresh samples, aligning with the results observed in mango and crystal longan flesh [36]. The observed slight increase in apparent fat content following oven drying, relative to milder methods like sun drying and vacuum drying is attributed to the intense, sustained heat. This thermal treatment causes greater structural breakdown of the plant cell wall matrix, facilitating the release and enhancing the solvent extraction efficiency of lipids that were previously bound or compartmentalized [37]. Oven drying yielded the greatest fat content (0.45 ± 0.16), followed by sun drying (0.32 ± 0.06) and vacuum drying (0.28 ± 0.04). Nonetheless, there was no observable difference between the flesh of crystal fresh that had undergone sun-drying and that which had been vacuum-dried, indicating that neither drying method affected the fat content. The minimal total fat content highlights the appropriateness of crystal longan flesh for low-fat dietary uses.

Table 3. Crude Protein, Fat and Carbohydrate Content of Fresh and Dried Crystal Longan Flesh Prepared from Different Drying Methods

Samples	Protein (%)	Fat (%)	Carbohydrate (%)
Fresh	1.52 ± 0.03^{b}	0.18 ± 0.04^{b}	21.18 ± 1.16^{c}
Oven-dried	2.21 ± 0.75^{ab}	0.45 ± 0.16^{a}	83.40 ± 0.74^{a}
Vacuum-dried	2.32 ± 0.19^{ab}	0.28 ± 0.04^{ab}	83.05 ± 0.31^{ab}
Sun-dried	3.00 ± 0.53^{a}	0.32 ± 0.06^{ab}	81.41 ± 0.51^{b}

All results are expressed as mean ± standard deviation of triplicate. Results of the same column followed by different superscript letters are significantly different at $p<0.05$.

The total carbohydrate content of a food or beverage refers to the combined amount of sugars, starches, and dietary fibre. As an essential source of energy and storage, total carbohydrate content showed significant differences ($p < 0.05$) across drying methods. Dried samples exhibited higher carbohydrate contents compared to fresh samples, primarily due to moisture loss and nutrient concentration [38]. Carbohydrate concentrations ranged from 21.18% to 83.40%, with oven drying yielding the highest value (83.4 ± 0.74), followed closely by vacuum drying (83.05 ± 0.31) and sun drying (81.41 ± 0.51). These findings align with the study on mango that reported oven-dried mango having the highest carbohydrate content (83.50%), while vacuum-dried samples showed slightly lower levels (80.46%) [37]. Drying significantly influences the carbohydrate composition of fruits by effectively concentrating these nutrients as moisture is lost. Research on fruits such as bananas and figs indicates that the reduction in water content during drying leads to an increased proportion of available carbohydrates by weight [39-40]. As a result, dried fruits become denser sources of sugars and starches compared to their fresh forms.

CONCLUSION

This research illustrates the effects of various drying methods on the physicochemical properties and proximate composition of crystal longan flesh. The reduction of moisture was identified as the primary aspect affecting compositional alterations, with vacuum drying demonstrating the greatest efficacy in retaining total soluble solids (TSS), decreasing water activity (aw), and sustaining pH and titratable acidity (TA). All techniques attained safe moisture levels, hence ensuring product stability and shelf life. A significant limitation of this study is the absence of dietary fibre analysis, potentially resulting in an inadequate evaluation of total carbohydrates. Excluding fibre may lead to an overestimation of digestible sugars and an under-representation of the complete nutritional profile. Further studies ought to integrate fibre analysis, evaluate storage stability, and investigate health-related applications that could enhance the quality and value of dried crystal longan products.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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