

THE OPTIMAL FERMENTATION PROCESS FOR *Pouteria lucuma* WINE USING *Saccharomyces cerevisiae* ST9

Nguyen Phuc Huy*, Huynh Thi Ngoc Mi, Vi Nha Tran, Pham Thi Hong Khanh

Can Tho University of Technology

ARTICLE INFO	ABSTRACT
Received: 27/07/2025 Revised: 06/01/2026 Published: 09/01/2026 KEYWORDS Fermentation <i>Lucuma</i> <i>Pouteria lucuma</i> Fruit wine <i>Saccharomyces cerevisiae</i> ST9	<i>Pouteria lucuma</i>, known as lêkima in Vietnamese, originating from South America. Lucuma is widely cultivated in Vietnam due to its high nutritional value. Thank to its natural sweet taste, lucuma pulp has been investigated for its potential in various food products such as coffee, cookies, and ice cream. This study aims to identify the optimal fermentation conditions for producing lucuma wine using <i>Sac</i> ST9, which was isolated from lucuma pulp. The investigated parameters included the initial total soluble solids (15, 20, and 25 °Brix), pH values (3.5, 4.5, and 5.5) and yeast inoculation densities (10^6, 10^7, and 10^8 CFU/mL). Additionally, a 5 L fermentation trial was conducted, and the microbiological and sensory characteristics of the final product were evaluated. The results indicate that the optimal fermentation conditions for <i>Pouteria lucuma</i> wine are 25 °Brix, pH 4.5, and 10^7 CFU/mL yeast concentration. The 5 L <i>Pouteria lucuma</i> wine trial was fermented for 10 days under these optimal conditions, yielded a product with an ethanol content of 12.50% (v/v) and received very favorable sensory quality for clarity and color, aroma, and taste. Furthermore, the microbiological parameters of the product met QCVN 6-3:2010/BYT, issued by the Ministry of Health.

QUY TRÌNH LÊN MEN RƯỢU VANG LÊKIMA (*Pouteria lucuma*) TỐI ƯU SỬ DỤNG CHỦNG NẤM MEN *Saccharomyces cerevisiae* ST9

Nguyễn Phúc Huy*, Huỳnh Thị Ngọc Mi, Vi Nhã Trần, Phạm Thị Hồng Khanh

Trường Đại học Kỹ thuật – Công nghệ Cần Thơ

THÔNG TIN BÀI BÁO	TÓM TẮT
Ngày nhận bài: 27/07/2025 Ngày hoàn thiện: 06/01/2026 Ngày đăng: 09/01/2026 TỪ KHÓA Lên men Lêkima <i>Pouteria lucuma</i> Rượu vang trái cây <i>Saccharomyces cerevisiae</i> ST9	<i>Pouteria lucuma</i> thường được biết đến với tên tiếng Việt là lêkima là loại cây trồng có nguồn gốc từ Nam Mỹ. Lêkima được trồng khá phổ biến ở Việt Nam với giá trị dinh dưỡng cao. Nhờ vào vị ngọt tự nhiên, thịt quả lêkima được nghiên cứu để bổ sung tạo ra các sản phẩm như cafe, bánh quy, kem. Nghiên cứu này nhằm khảo sát các điều kiện tối ưu để sản xuất rượu vang lêkima sử dụng chủng nấm men <i>Saccharomyces cerevisiae</i> ST9 được phân lập từ thịt quả lêkima. Các điều kiện khảo sát bao gồm hàm lượng chất tan ban đầu (15, 20, và 25 °Brix), giá trị pH (3,5, 4,5, và 5,5), và tỷ lệ nấm men bổ sung (10^6, 10^7, và 10^8 CFU/mL). Bên cạnh đó, thử nghiệm lên men 5 L và các chỉ tiêu vi sinh vật và cảm quan của sản phẩm cũng được thực hiện. Kết quả cho thấy các điều kiện tối ưu lên men rượu vang lêkima là 25 °Brix, pH 4,5 và mật số nấm men bổ sung 10^7 CFU/mL. Thử nghiệm lên men 5 L trong thời gian 10 ngày cho ra sản phẩm có hàm lượng ethanol là 12,50% v/v và được đánh giá cảm quan rất tốt về độ trong và màu sắc, mùi, và vị. Ngoài ra, các chỉ tiêu vi sinh vật của sản phẩm cũng đạt yêu cầu theo quy định QCVN 6-3:2010/BYT của Bộ Y tế.

DOI: <https://doi.org/10.34238/tnu-jst.13309>

* Corresponding author. Email: nphuy@ctu.edu.vn

1. Introduction

Pouteria lucuma commonly known as lucuma, sapotille mamey, or sapote Mamey, is a prominent fruit tree species within the genus *Pouteria*, belonging to the family Sapotaceae and order Ericales. This species is indigenous to the Andean region of South America, with native populations found in Peru, Ecuador, and Chile [1] – [3]. The first documented European encounter with *P. lucuma* occurred in Ecuador in 1531 [1]. Its historical significance is further underscored by archaeological evidence, including its depiction on pottery unearthed from burial sites of indigenous coastal Peruvian communities [1].

The internal composition of lucuma is mainly characterized by its high content of carbohydrates, protein, carotenoids, and other bioactive compounds [4] – [7]. Compared to fruits like avocado, passion fruit, coconut, and banana, lucuma has less water but more protein [1], [8], [9]. Notably, it is reported that lucuma contains various sugars, such as glucose, fructose, sucrose, and inositol, as well as organic acids including tartaric, ascorbic, succinic, malic, gallic, and citric acid [2], [3]. According to Belščak-Cvitanović [10], the highest polyphenol content is found in chocolates supplemented with lucuma and carrot.

Lucuma can be eaten fresh, though some people find the raw fruit less appealing because of its unusual aftertaste and lack of crispness compared to other fruits. Once peeled and deseeded, it can be enjoyed directly as a sweet. Despite its sweet flavor, lucuma pulp might not appeal to some people due to its odd aftertaste. The fruit pulp can also be dried into powder, which is then used as a food additive in various processed foods [11], [12]. It is a good ingredient for making ice cream, yogurt, coffee, cookies, brownies, and bakery products [13] – [16]. To diversify lucuma-based products, therefore, this study explores the fermentation of lucuma wine using *Saccharomyces cerevisiae* ST9 isolated from lucuma pulp [17].

2. Materials and methods

2.1. Materials

The fully ripened lucuma fruits with vibrant yellow skin were collected at a local farm in Ke Sach, Soc Trang. The fruits were peeled and deseeded to obtain the flesh. Thereafter, the flesh was pureed by a juicer (Philips HR1811, Netherlands) to facilitate the release of cell sap and increase the surface area for yeast-substrate interaction, optimizing the fermentation process. During pureeing, an equal volume of water was added to the fruit flesh to aid the pureeing process. Subsequently, the remaining water was added to achieve a final fruit-to-water dilution ratio of 1:2. To enhance the yield of lucuma juice, 0.3% (v/v) pectinase enzyme and 0.3% (v/v) amylase enzyme were added, and the mixture was then incubated for 2 hours at 50 °C before the fermentation process. The lucuma juice was then filtered for further experiments.

Saccharomyces cerevisiae ST9 (*Sac* ST9), a strain isolated from lucuma and known for its high fermentation ability [17], was prepared for microbiological media. A single colony was added to 100 mL YPD broth which was sterilized at 121 °C for 15 min. The culture was then shaken at 150 rpm on a shaker at room temperature (28 ± 2 °C) until it reached an appropriate rate of cell density, and *Sac* ST9 was added to the prepared lucuma juice for the fermentation process.

2.2. Methods

2.2.1. General procedure

The pretreated lucuma juice was adjusted to the appropriate pH and total soluble solids (TSS). The sample mixtures were supplemented with 120 mg/L NaHSO₃ and stabilized for 2 h. Thereafter, *Sac* ST9 was inoculated, and the fermentation was conducted at room temperature (28 ± 2 °C) for 10 days. After fermentation, the product was filtered, sterilized, and bottled in 250 mL glass bottles for further analysis.

2.2.2. *Determination of initial sugar for lucuma fermentation*

The pretreated lucuma juice was adjusted to pH 4.5 with the total soluble solids (TSS) of 15, 20, and 25°Brix, respectively. The fermentation process was carried out as described in the general procedure. The experiment was performed in triplicate.

2.2.3. *Determination of pH value for lucuma fermentation*

The pretreated lucuma juice was adjusted to pH levels of 3.5, 4.5, and 5.5, along with the optimal TSS determined in section 2.2.1. The fermentation process was carried out as described in the general procedure. The experiment was performed in triplicate.

2.2.4. *Determination of yeast concentration for lucuma fermentation*

The pretreated lucuma juice was adjusted to the optimal TSS determined in section 2.2.1 with the pH value selected from section 2.2.2. The sample mixtures were subsequently supplemented with *Sac* ST9 at a density of 10^6 , 10^7 , and 10^8 CFU/mL, respectively. The fermentation process was carried out as described in the general procedure. The experiment was performed in triplicate.

2.2.5. *Trial fermentation in the 5-liter batch of the lucuma wine*

The 5-liter scale of pretreated lucuma juice was adjusted to the optimal TSS as determined in section 2.2.1, with the pH value selected from section 2.2.2. The mixture was then supplemented with 120 mg/L NaHSO_3 and stabilized for 2 h. Subsequently, *Sac* ST9 at the cell density selected in section 2.2.3 was inoculated into the sample. The fermentation was carried out at room temperature ($28 \pm 2^\circ\text{C}$) for 10 days. Afterwards, the product was filtered, sterilized, and preserved at 4°C up to 3 weeks. Lucuma wine was then analyzed for the microbiological criteria and sensory evaluations. The experiment was performed in triplicate.

2.2.6. *Physicochemical analyses*

The pH value was measured using a digital pH meter (Hanna, America). The TSS, expressed in °Brix, was measured using a manual Atago refractometer (0-33 °Brix, France). Ethanol content (% v/v) at 20°C was determined using the distillation method. The total acid content (%) was determined by titration with 0.1 N NaOH, total sugar content (%) and reducing sugar (%) were determined by the dinitrosalicylic acid (DNS) assay [18], and vitamin C content (mg/%) was determined by the indophenol method [19].

2.2.7. *Microbiological and sensory analyses*

The microbiological parameters were conducted by the Center of Analytical Services and Experimentation of Ho Chi Minh City – CASE Cantho. Lucuma wine was analyzed for microbiological criteria, including total yeast and mold (CFU/mL), *Coliforms* (CFU/mL), and *E. coli* (CFU/mL), all in accordance with International Organization for Standardization guidelines [20]. Sensory evaluation of wine in terms of clarity and color, aroma, taste, and overall confidence was done according to Vietnam National Standard TCVN 3217:79 [21].

2.2.8. *Statistical analyses*

The data was analyzed using one-way ANOVA by Minitab 17 (Minitab LLC., USA) and graphed in Excel 2016 (Microsoft Inc., USA).

3. **Results and discussion**

3.1. *Physicochemical characteristics of lucuma*

In any product manufacturing process, raw materials are a crucial factor that influences production and determines the final product's quality. Therefore, analyzing the chemical

composition of raw materials is an essential first step to evaluate both the quality of the raw material itself and the quality of the finished product. In this study, lucuma shows a low sugar concentration (15.82%), total acid content (0.15%), and water content (62.55%) (Table 1). Thus, additional sugar and water are needed to promote efficient fermentation.

Table 1. Physicochemical characteristics of lucuma

Constituent	Approximate value
Moisture (%)	62.55
TSS (°Brix)	13.00
Total acid content (%)	0.15
Total sugar content (%)	15.82
Reducing sugar (%)	13.41
pH	5.20
Vitamin C (mg%)	0.20

Note: The values in this table were the mean values of triplication.

3.2. The initial sugar for lucuma fermentation using Sac ST9

Sugars are the primary substrate for producing ethanol, lactic acid, and carbon dioxide during fermentation. It can be seen that the initial TSS is a vital factor that affects both the fermentation process and the quality of the resulting wine. In the fruit winemaking, the low TSS levels won't adequately support the yeast's nutritional needs, leading to slow fermentation and failure to reach desired product specifications. Conversely, if the initial sugar is too high, yeast growth will be suppressed, resulting in the fermentation process deviating from expectations. The optimal initial sugar level for wine fermentation depends on the starting fruit juice. Typically, the initial sugar content used in *Saccharomyces cerevisiae* fermentation ranges from 20% to 24% [22]-[24]. Following the previous study on lucuma wine [17], the total soluble solids (TSS) for lucuma fermentation in this study are 15, 20, and 25 °Brix, respectively.

Table 2. The effects of °Brix on lucuma wine

The initial TSS (°Brix)	Results after fermentation				Sensory quality		
	TSS (°Brix)	Ethanol content (% v/v)	The total acid (g/L)	Residual sugar (%)	Clarity and color	Taste	Aroma
15	6.33 ^b	10.73 ^b	4.04 ^b	0.85 ^b	4.50 ^a	3.10 ^b	2.60 ^b
20	5.00 ^b	12.60 ^a	3.86 ^c	0.65 ^b	4.30 ^a	3.10 ^b	2.80 ^b
25	14.30 ^a	12.53 ^a	4.36 ^a	10.89 ^a	4.80 ^a	4.90 ^a	4.30 ^a

Note: The values in this table were the mean values of triplication observed after 10-day fermentation. The values in a group with the same superscripted letters were not significantly different at the 95% confidence level ($p < 0.05$).

In this study, the experimental results demonstrate a clear relationship between TSS and fermentation outcomes. The result shows that significant differences are observed across all three TSS treatments ($p < 0.05$). After 7 days of fermentation, the alcohol content in the 15 °Brix and 20 °Brix treatments is 8.53% v/v (Figure 1A), with no significant difference at the 95% confidence level. However, both are significantly higher than the 25 °Brix treatment with 7.80% v/v in the 7-day fermentation (Figure 1A). Remarkably, by the 10-day fermentation, the 25 °Brix treatment produces a maximum alcohol concentration of 12.53% v/v, which is not statistically different from the 12.60% obtained with the 20 °Brix treatment (Table 2 and Figure 1A). The TSS of 25 °Brix has the highest total acid content (4.36 g/L) and residual sugar content (10.89%) compared to 15 and 20 °Brix (Table 2). Besides, a noticeable improvement in aroma and taste is observed when increasing the TSS from 20 to 25 °Brix (Table 2). Particularly, at the TSS of 25 °Brix treatment, lucuma wine yields the best sensory scores across all attributes, including clarity and color (4.80), aroma (4.90), and taste (4.30).

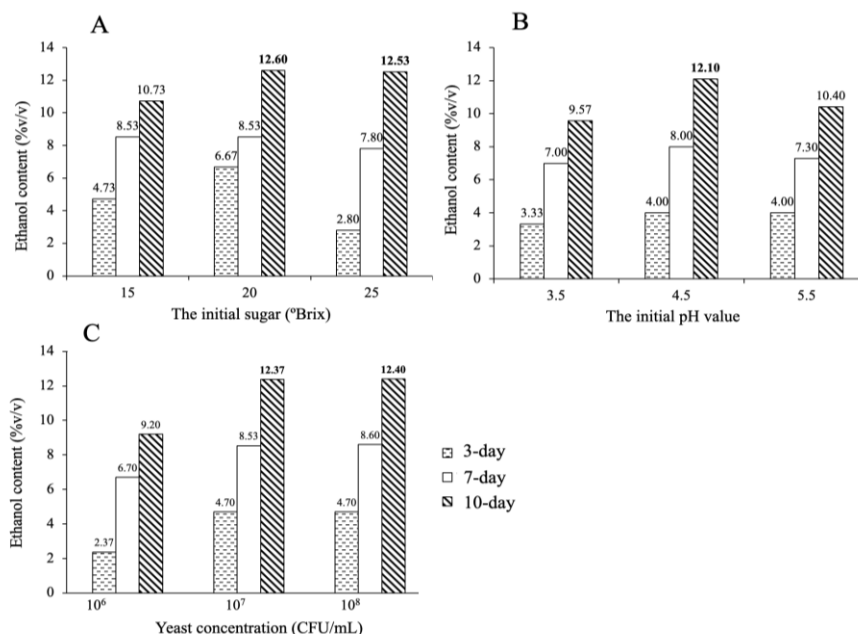


Figure 1. The effects of the initial sugar (A), pH value (B), and yeast concentration (C) on the ethanol content of lucuma fermentation

These findings align with observations from studies on other fruit wines, such as sapodilla [25], Burmese grape [26], and soursop [27]. The basic principle is that yeast uses sugar in the fermentation medium for growth and ethanol production, indicating a direct relationship between sugar consumed and ethanol produced, up to a certain point. However, very high sugar levels can cause incomplete fermentation by yeast and create osmotic pressure, which negatively impacts yeast's growth. This osmotic stress can prevent further increases in ethanol production, even when sugar is abundant. Therefore, based on both alcohol yield and sensory qualities, an initial soluble solids level of 25 °Brix is identified as the most suitable for further research.

3.3. The initial pH value for canistel fermentation using *Sac ST9*

The results indicate that *Sac ST9* exhibited robust growth across all three juice pH treatments, including 3.5, 4.5, and 5.5. At the beginning of the process, the alcohol is produced slowly over 3 days of fermentation (Figure 1B). Subsequently, yeast adaptation to the fermentation environment led to a gradual increase in alcohol production. Notably, the highest alcohol content is found in lucuma wine produced from the pH 4.5 treatment, reaching 12.10% v/v after 10 days of fermentation, statistically significant compared to the other treatments (Table 3, Figure 1B).

Table 3. The effects of pH value on the lucuma fermentation ability of *Sac ST9*

The initial pH value	Results after fermentation				Sensory quality		
	TSS (°Brix)	Ethanol content (% v/v)	The total acid (g/L)	Residual sugar (%)	Clarity and color	Taste	Aroma
3.5	13.00 ^a	9.57 ^c	5.56 ^a	9.34 ^a	3.90 ^b	3.60 ^b	3.70 ^b
4.5	13.00 ^a	12.10 ^a	3.68 ^c	9.71 ^a	4.60 ^a	4.60 ^a	4.60 ^a
5.5	12.83 ^a	10.40 ^b	3.80 ^b	8.37 ^b	3.70 ^b	2.40 ^c	2.70 ^c

Note: The values in this table were the mean values of triplication observed after 10-day fermentation. The values in a group with the same superscripted letters were not significantly different at the 95% confidence level ($p < 0.05$).

On the other hand, sensory evaluations consistently show improvements as the initial pH of the canistel juice increased from 3.5 to 4.5 (Table 3). However, these scores began to decline when the pH increased further from 4.5 to 5.5. For clarity and color, specifically, the 3.5 and 5.5 pH treatments

have similar sensory scores of 3.90 and 3.70, respectively. Meanwhile, the pH 4.5 treatment results in a significantly higher score of 4.60, as shown in Table 3. Even though the results show no statistically significant differences in residual total soluble solids or residual sugar content across the various pH treatments, the pH 4.5 treatment consistently yields the highest alcohol content after 10 days of fermentation (Table 3). A similar trend is observed in the studies of cashew apple wine [28], soursop wine [27]. Therefore, pH 4.5 was selected for further experimentation.

3.4. Yeast concentration for lucuma fermentation using Sac ST9

A larger yeast biomass directly correlates with increased substrate consumption, which in turn leads to a proportional enhancement in the products of yeast growth and metabolism. Therefore, raising the yeast inoculation density from 10^6 CFU/mL to 10^7 CFU/mL significantly enhances the product's alcohol content at 3, 7, and 10 days of the fermentation process (Figure 1C). Nevertheless, further increasing the inoculation density from 10^7 to 10^8 CFU/mL results in a negligible change in alcohol production, increasing 0.03% v/v. Statistical analysis (Table 4) reveals a significant difference ($p < 0.05$) in alcohol content between the 10^6 CFU/mL treatment (9.20% alcohol) and the 10^7 CFU/mL treatment (12.37% alcohol). In contrast, no significant difference is observed between the 10^7 CFU/mL (12.37% alcohol) and 10^8 CFU/mL (12.40% alcohol) treatments. The sample treated with 10^7 CFU/mL exhibited total soluble solids (TSS) of 12.00, total acidity of 3.22 g/L, and residual sugar of 10.54%. These values were not significantly different from those observed in the 10^8 CFU/mL treatment ($p < 0.05$). As of the results, 10^7 CFU/mL yeast inoculation density is one of the optimal conditions for lucuma wine.

Table 4. The effects of yeast concentration on the lucuma fermentation ability of Sac ST9

Yeast concentration (CFU/mL)	Results after fermentation				Sensory quality		
	TSS (°Brix)	Ethanol content (% v/v)	The total acid (g/L)	Residual sugar (%)	Clarity and color	Taste	Aroma
10^6	14.17 ^a	9.20 ^b	2.94 ^b	12.22 ^a	3.10 ^b	3.60 ^b	3.30 ^b
10^7	12.00 ^b	12.37 ^a	3.22 ^a	10.54 ^b	4.60 ^a	4.40 ^a	4.60 ^a
10^8	12.00 ^b	12.40 ^a	3.30 ^a	10.55 ^b	4.50 ^a	4.30 ^a	4.30 ^a

Note: The values in this table were the mean values of triplication observed after 10-day fermentation. The values in a group with the same superscripted letters were not significantly different at the 95% confidence level ($p < 0.05$).

3.5. Quality of lucuma wine

Table 5. Quality evaluation of lucuma wine

Criteria	Vietnam National Standard QCVN 6-3:2010/BYT [29]	Method	Results
Colifoms (CFU/mL)	0	ISO 4832:2006	< 1.00
<i>E.coli</i> (CFU/mL)	0	ISO 16649-2:2001	< 1.00
Total yeast and mold (CFU/mL)	100	ISO 215227 2:2008	< 1.00
pH value	-	-	3.65
TSS (°Brix)	-	-	12.00
The total acid (g/L)	-	-	3.36
Ethanol content (% v/v)	-	-	12.50
The total sugar (%)	-	-	10.62

The fermentation of fruit wine was tested using a 5-liter volume. The juice was adjusted to pH 4.5 and 25 °Brix, and surveyed with a density of Sac ST9 at 10^7 CFU/mL for 10 days at room temperature. From the above experiments, Sac ST9 produced an ethanol content of 12.50% (v/v) in lucuma wine with a TSS, total acid, and pH value of 12.00 °Brix, 3.36 g/L, and 3.65, respectively (Table 5). The sensory properties were evaluated according to the criteria of TCVN 3217:79 [21]. The wine was assessed as good in clarity and color, aroma, and taste, reaching 4.42, 4.85, and 4.85 points, respectively.

Sensory evaluation results show that the wine had no strange, cloudy smell, and the color and odor were specific to the product (Figure 2). Compared to the TCVN 3217:79 [21] the sensory quality assessment of left-sided wine received a good rating.

The microbiological criteria of the final product were analyzed by the Center of Analytical Services and Experimentation of Ho Chi Minh City – CASE Cantho, and the values meet the Vietnam National Standard QCVN 6-3:2010/BYT [29] (Table 5).

4. Conclusion

This study aimed to study the optimal fermentation process of the *Sac* ST9 strain isolated from lucuma pulp. The results showed that the *Sac* ST9 strain was able to ferment lucuma pulp into wine at room temperature with an initial pH of 4.5, 25 °Brix, and yeast density of 10^7 CFU/mL. Preliminary 5 liters of fermentation for 10 days produced an ethanol content of 12.50% (v/v). The chemical and microbiological criteria of the final product were met to the Vietnam National Standard QCVN 6-3:2010/BYT [29].



Figure 2. Lucuma wine

REFERENCES

- [1] J. F. Morton, *Fruits of Warm Climates: Lucmo*, Michigan: Julia Frances Morton, 1987, pp. 877-879.
- [2] E. M. Yahia and F. Guttierrez-Orozco, "Lucuma (*Pouteria lucuma* (Ruiz and Pav.) Kuntze)," in *Postharvest biology and technology of tropical and subtropical fruits*, vol. 3, *Cocona to mango*, E. M. Yahia, Ed., 1st ed. Woodhead Publishing, 2011, pp. 443-449.
- [3] C. Fuentealba, L. Gálvez, A. Cobos, *et al.*, "Characterization of main primary and secondary metabolites and in vitro antioxidant and antihyperglycemic properties in the mesocarp of three biotypes of *Pouteria lucuma*," *Food Chemistry*, vol. 190, pp. 403-411, 2016.
- [4] M. C. Nguyen and D. Q. Le, "Lycopene, β -carotene, vitamin C and total carbohydrates in mango, papaya, watermelon and lucuma," *Science and Technology Journal of Agriculture & Rural Development*, vol. 12, pp. 170-175, 2014.
- [5] C. Taiti, I. Colzi, E. Azzarello, and S. Mancuso, "Discovering a volatile organic compound fingerprinting of *Pouteria lucuma* fruits," *Fruits*, vol. 72, no. 3, pp. 131-138, 2017.
- [6] Q. D. Le, "Analyzing the total carbohydrate, β -carotene and lycopene contents in lucuma (*Pouteria campechiana*) which is grown in Tra Vinh province," *Industry and Trade Magazine*, vol. 10, pp. 131-137, 2021.
- [7] M. Masullo, A. Cerulli, C. Pizza, *et al.*, "Pouteria lucuma Pulp and Skin: In Depth Chemical Profile and Evaluation of Antioxidant Activity," *Molecules*, vol. 26, no. 17, 2021, Art. no. 5236.
- [8] J. W. H. Yong, L. Ge, Y. F. Ng, and S. N. Tan, "The chemical composition and biological properties of coconut (*Cocos nucifera* L.) water," *Molecules*, vol. 14, no. 12, pp. 5144-5164, 2009.
- [9] M. L. Dreher and A. J. Davenport, "Hass avocado composition and potential health effects," *Crit. Rev. Food Sci. Nutr.*, vol. 53, no. 7, pp. 738-750, 2013.
- [10] A. Belščak-Cvitanović, D. Komes, M. Dujmovic, *et al.*, "Physical, bioactive and sensory quality parameters of reduced sugar chocolates formulated with natural sweeteners as sucrose alternatives," *Food Chemistry*, vol. 15, no. 167, pp. 61-70, 2015.
- [11] S. R. R. Pertiwi, S. Nurhalimah, and A. Aminullah, "Optimization on process of ripe canistel (*Pouteria campechiana*) fruit flour based on several quality characteristics," *Braz. J. Food Technol.*, vol. 23, 2020, Art. no. e2019056.
- [12] S. R. R. Pertiwi, R. Sunarya, T. Rohmayanti, and A. Aminullah, "Optimization on formulation of foamed overripe canistel powder using response surface methodology," *Rev. Bras. Frutic.*, vol. 42, no. 3, 2020, Art. no. e-145.

- [13] S. R. R. Pertiwi, N. Novidahlia, F. L. Rohmanto, and A. Aminullah, "Sensory evaluation of cold coffee drink with addition of canistel (*Pouteria Campechiana*) fruit powder," *Coffee Science*, vol. 18, 2023, Art. no. e182109.
- [14] D. A. Paragados, "Acceptability of canistel (*Lucuma nervosa* A.DC) fruit flour in making cookies," *Asia Pacific Journal of Multidisciplinary Research*, vol. 2, pp. 66-73, 2014.
- [15] S. R. R. Pertiwi, A. Aminullah, R. Hutami, and A. Nirmala, "Application of non-gluten canistel (*Pouteria campechiana*) flour-maizena mocaf-tapioca composite on the processing of steamed brownies," *Jurnal Agroindustri Halal*, vol. 4, no. 2, pp. 153-161, 2018.
- [16] A. Meegepala, U. A. Majeed, A. M. M. Asmath, and A. M. Rikasa, "Development of cookie composited with canistel (*Pouteria campechiana*) and rice flour," *J. Bangladesh Agril. Univ.*, vol. 20, no. 4, pp. 441-448, 2022.
- [17] P. H. Nguyen, T. T. A. Tran, N. T. Vi, and N. T. T. Nguyen, "Isolation and selection of yeasts from lekima fruit (*Pouteria lucuma*) capable of fermenting wine," *Can Tho Journal of Science and Technology – Can Tho University of Technology*, vol. 2, pp. 49-57, 2024.
- [18] M. Božinović, T. Sokač, A. Šalić, A. M. Dukarić, M. Tišma, M. Planinić, and B. Zelić, "Standardization of 3,5-dinitrosalicylic acid (DNS) assay for measuring xylanase activity: detecting and solving problems," *Croat. J. Food Sci. Technol.*, vol. 15, no. 2, pp. 1-12, 2023.
- [19] S. S. Nielsen, "Chapter 15: Vitamin C Determination by Indophenol Method," in *Food Analysis Laboratory Manual*, Springer, 2017, pp. 143-146.
- [20] International Organization for Standardization, "Food Microbiology Including Microbiology of Animal Feeding Stuff," 2006. [Online]. Available: <https://www.iso.org/ics/07.100.30/x> [Accessed July 27, 2025].
- [21] Ministry of Science and Technology, *Vietnam National Standard 3217:79: Liquors, Sensory Evaluation-Methodology Test using Marking*, (in Vietnamese), Hanoi, 1979.
- [22] K. Tamrakar, A. Lama, B. Dhakal, L. Adhikari, M. Shrestha, and J. Amatya, "Qualitative analysis of wine prepared from banana and orange," *International Journal of Food Science and Nutrition*, vol. 5, no. 1, pp. 60-63, 2020.
- [23] B. O. Horváth, D. N. Sárdy, N. Kellner, and I. Magyar, "Effects of high sugar content on fermentation dynamics and some metabolites of wine-related yeast species *Saccharomyces cerevisiae*, *S. uvarum* and *Starmerella bacillaris*," *Food Technol. Biotechnol.*, vol. 58, no. 1, pp. 76-83, 2020.
- [24] T. K. T. Doan, D. Q. B. Le, T. N. M. Huynh, et al., "Investigation of wine fermentation of three-leaf cayratia (*Cayratia trifolia* L.) using *Saccharomyces cerevisiae* 2.1," *F1000Research*, vol. 12, 2023, Art. no. 312.
- [25] V. B. Nguyen, T. T. T. Nguyen, T. L. Nguyen, T. C. Pham, and N. T. Chau, "Isolation and selection of yeast high ethanol tolerance strains from fermented fruit of *Manilkara zapota* (L.) P. for sapodilla wine fermentation," *Journal of Scientific Research and Economic Development - Tay Do University*, vol. 11, pp. 218-227, 2021.
- [26] V. V. Nguyen and V. T. Nguyen, "Isolation, selection and identification of yeast strain for *Baccaurea ramiflora* wine fermentation," *Can Tho Univ. J. Sci.*, vol. 54, no. 7B, pp. 22-32, 2018.
- [27] X. P. Huynh, V. K. Huynh, T. H. Le, et al., "Optimization of fermentation conditions in wine production from soursop (*Annona muricata* L.) using *Saccharomyces cerevisiae* FBY015," *TNU Journal of Science and Technology*, vol. 226, no. 5, pp. 95-103, 2021.
- [28] T. T. G. Vo, M. H. Nguyen, T. A. H. Le, T. S. H. Nguyen, T. H. S. Phan, and V. K. Nguyen, "Optimization of three factors influencing the main fermentation process in cashew apple wine," *CTU Journal of Science*, vol. 55, no. 4, pp. 21-26, 2019.
- [29] Ministry of Health, *Vietnam National Standard QCVN 6-3:2010/BYT: National technical regulation for alcoholic beverages*, (in Vietnamese), Hanoi, 2010.