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Physicochemical properties of dragon fruit palmyra neera wine

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Abstract

Dragon fruit-palmyra neera wine is a functional beverage processed from dragon fruit (*Hylocereus polyrhizus*) juice blended with palmyra (*Borassus flabellifer*) neera. Wine processing was done by spontaneous fermentation where the source of fermentative bacteria was obtained naturally from the neera. Fermentation was carried out for 21 days then wine aging was continued for 3 months. The physicochemical properties (pH, tartaric acid, alcoholic content, total soluble solid, reducing sugar content, color and antioxidant activity) were determined using standard scientific procedures of food characteristics. The resulting parameters after 3 months of wine aging showed a pH value of 2.85, a tartaric acid of 25.71%, an alcoholic content of 35%, a total soluble solid of 10°Bx, a total reducing sugar content of 3.78 g/100 mL, a DPPH activity of 56.94%, and a chroma test score of 10.05. The data reported in this study provide base information to produce a functional wine processed from a combination of dragon fruit juice-palmyra neera, which is acceptable for the winery industry.

1. Introduction

Dragon fruit (*Hylocereus polyrhizus*), genera of *Selenicereus* and *Hylocereus* is introduced as a non-climacteric cactus fruit which is popular in Southeast Asian countries such as Vietnam, Thailand, Philippines, Malaysia, including Indonesia (Jalgaonkar *et al*., 2022). Arivalagan *et al*. (2021) reported dragon fruit is cultivated in several varieties, but the varieties that are common and can be consumed are dragon fruit with very red flesh (*Hylocereus costaricensis*), red dragon fruit with white flesh (*Hylocereus undatus*), fruit with yellow skin and white flesh (*Selenicereus megalanthus*), and pink fruit with red flesh (*Hylocereus polyhyzus*). The flesh has a soft texture, sweet and slightly sour. Its flesh is scattered with small black seeds which are edible and crunchy (Jalgaonkar, 2020). Several studies reported that dragon fruits are rich in nutrients such as vitamins, minerals (potassium, magnesium and calcium), dietary fibre and carbohydrates, especially reducing sugars such as fructose (0.4-2.0 g/100 g) and glucose (3.0-5.5 g/100 g) (Tran *et al*., 2015; Hossain *et al*., 2021). Sekar *et al*. (2016) reported red dragon fruits are higher in antioxidants than white dragon fruits. Flesh and peel of red dragon fruit contain betacyanin which is beneficial as colorants and antioxidants to free radicals (Manihuruk *et al*., 2017; Hossain *et al*., 2021). Extracts (flesh and peel) of dragon fruits also contain anti-cancer, anti-lipidemic, anti-inflammatory, anti-spasmodic, and antimicrobial effects (Joshi and Prabhakar 2020). Consuming dragon fruit can reduce the total amount of cholesterol, triglycerides, and LDL-cholesterol while increasing HDL -cholesterol levels (Harahap *et al*., 2020; Fadlilah *et al*., 2021).

In general, dragon fruit cannot be stored and it is consumed fresh or processed into juice or puree with a limited shelf life (Rodeo *et al*., 2018; Muhialdin *et al*., 2020), therefore, further processing is needed (e.g. making into syrup, jam or candies) to maintain nutritional content, extend shelf life and reduce losses (Dartsch *et al*., 2009; Jalgaonkar *et al*., 2022). In addition, red dragon fruit (*Hylocereus polyrhizus*) has great potential to be utilized for the processing of an alcoholic beverage such as wine due to the attractive red pigment of the juice makes it similar to grape juice (Jalgaonkar *et al*., 2022).

In the wine-making process, the addition of sugar and the concentration of the starter are important factors that affect the characteristics of the resulting wine. Huan *et al*. (2020) reported red dragon fruit has a sugar content of between 16-20°Bx. This value is dissimilar to the sugar content in grapes (*Vitis vinifera* L.), which is above

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20°Bx. Sugar added to fruit juice provides nutrients that support microbes carry out their activities. In addition, the composition of added sugar also aims to obtain the desired alcohol content (Velic *et al*., 2018).

This study used neera as a natural starter extracted from the palmyra tree. Mantut *et al*. (2019) reported that palmyra neera is easily fermented by the activity of several microbes such as the *Acetobacter* sp., *Lactobacillus* sp. and several yeast genera (*Saccharomyces* sp., *Hansenula* sp., and *Candida* sp.). In addition, palmyra neera has a fairly high sugar content (>10%) so the yeast *Saccharomyces* converts sugar into ethanol and the bacteria *Acetobacter* and *Lactobacillus* oxidize alcohol to acetic acid (Mardiyah, 2017; Mantut *et al*., 2019).

This study was aimed at determining the potential of dragon fruits and palmyra neera in wine fermentation, based on the analyses of physicochemical properties (pH, colour, % TDS, % alcohol), and antioxidant (DPPH) activity during fermentation at ambient temperature. Therefore, this study has the potential to produce wine from dragon fruit juice by utilizing the activity of microbes from palmyra neera.

2. Materials and methods

2.1 Measurement of fruit weights and diameters

Fresh and fully ripe red dragon (*Hylocereus polyrhizus*) fruits were used in this study. The weight (Figure 1) of the fruits were measured on an electronic weighing machine (Valor 1000W-V12P, Ohaus) with the 0.001 kg least count, while the diameter (Figure 1) of the fruits were measured using a stainless-flexible ruler. The average values of these parameters were recorded and standard deviation of the mean values was tabulated.

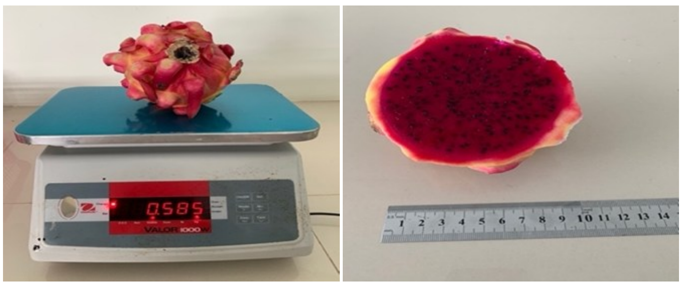

Figure 1. Weight and diameter measurement.

2.2 Preparation and processing of wine

Preparation and processing of wine (Figure 2) were done as follows: the peels of the selected fruits were removed, then the flesh was sliced into small pieces and pulped. The pulp was mixed with water (1:1, w/v ratio) to get extracted juice. Then the juice was blended with palmyra neera 1:2 (v/v ratio). Crystal cane sugar (20%), lemon juice (3%), and grape essence (2%) were also added to the blended extracts. Fermentation was done at room temperature for 7 days then solid matters were removed using a sterilized cloth and the fermentation process was continued for 3 weeks. Aging was done for a month, 2 months and 3 months after fermentation.

Figure 2. Preparation of dragon fruit puree and palmyra neera for wine processing.

2.3 Measurements of pH and titratable acidity

The pH value of samples (50 mL) was measured using a pH meter (Lab Bench pH AMT20). While, from the same sample, a known volume after weighing was mixed with distilled water and made up to a 100 mL volume. An aliquot of solution was then titrated against 0.01 N sodium hydroxide using phenolphthalein (1%) until the colour changed to light pink. The acidity was calculated using the formula reported by (Arivalagan *et al*. 2021) and titratable acidity (TA) was expressed as percentage of tartaric acid (MW = 150.087 g/mol).

$$\%\,TA = \frac{V_{NaOH} \times N_{NaOH} \times \text{MW tartaric acid}}{\text{Sample weight (g) x Aliqout sample (mL) x 1000}} \times 100$$

2.4 Soluble solid (sugar) analysis

The residual sugar concentration was estimated using Refractometer (ATC, range: 0-32°, China). Briefly, one drop of samples was placed on the prism and left for 1 min to allow for temperature adjustment before the reading was taken. The values were recorded as total soluble sugars (TSS) of dragon fruit-palmyra neera wine.

2.5 Measurement of alcoholic content

Measurements of alcoholic by volume (% ABV) were carried out using an ethyl alcohol refractometer (ATC, range: 0-80%, v/v, China) by placing a drop of liquid samples on the prism and a light blue boundary was shown as a result value of %ABV.

2.6 Determination of total reducing sugars

The total reducing sugar content was determined using Nelson-Somogy procedure (Shao and Lin, 2018). Briefly, 1 mL of the dilute wine is transferred to a clean tube and 1 mL of the Nelson reagent was added. Measured standard solution tubes were placed together on a single rack and immersed in a boiling water bath for

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20 minutes. After heating, the tubes are quickly cooled in running water and the mixtures are added with 1 mL of the arsenomolybdate reagent. The mixtures of the tubes are vortexed and diluted with 7 mL of deionised water. The mixture samples and standard solution then were placed in the cuvettes for reading via a spectrophotometer. The spectrophotometer was adjusted to a wavelength of 540 nm and the absorbance of the solutions obtained from the spectrophotometer was recorded. The zero setting on the spectrophotometer is made through a reagent blank tube run like the samples.

2.7 Colour evaluation

Colour measurement was done using a colorimeter reader (CHNSpec CS-10, China). The colorimetric values (L*, a*, and b*) representing lightness, redness/ greenness, and yellowness/blueness, respectively were recorded. The instrument was calibrated using a standard black tile and a white board supplied by the manufacturer. The wine samples were poured into plastic cups and three readings were taken. The average values were recorded. Chroma $[C^*=(a^*2+b^*2)^{1/2}]$ was then calculated from CIE a* and b* (Bunga *et al*., 2021).

2.8 Antioxidant activity

DPPH (2,2-Diphenyl-1-Picrylhydrazyl) scavenging activity was determined according to the method reported by Mitrevska *et al*. (2020) with slight modifications. Briefly, 4 mg of DPPH in 100 mL of 96% EtOH (w/v) was prepared and the absorbance (used as control) was measured using spectrophotometer (SP-UV1000-DLAB), read at 517 nm. Then, wine samples were diluted 1:10 (v/v) with dH_2O and 2 mL of diluted wines were added to 2 mL of DPPH solution in 96% ethanol (w/v) and vortexed for 5 sec. The absorbance was measured at 517 nm after samples were incubated in the dark for 30 min at ambient temperature. The inhibition percentage of DPPH at the steady state was determined using the following equation:

$$\%\,\text{inhibition} = 1 - \frac{\text{Abs}_{\text{sample}}}{\text{Abs}_{\text{control}}} \times 100$$

2.9 Statistical analysis

All experiments were carried out from three replicates. Data were performed using MiniTabâ Software version 17.0 (MiniTab Inc., Pennsylvania, USA). Assessments were analyzed using a one-way ANOVA, expressed as the mean ± standard deviation (SD).

3. Results and discussion

3.1 Fruit weight and diameter

Table 1 shows the average values of weight and diameter of the dragon fruits. The fruits had an average weight of 535.0±39.9 g (ranged from 500.0 to 600.0 g) and diameter of 8.9±0.4 cm (ranged from 8.0 to 10.0 cm). In this study, only whole (fresh, undamaged and ripe) fruits were used, as the quality of fruits can be very important consideration that could influence the final product (e.g. taste, colour and aroma) of wine (Boss *et al*., 2015).

Table 1. Weight and diameter of the fruits.

Parameter	Mean ± SD	Range
Weight (g)	535.0±39.9	500.0 - 600.0
Diameter (cm)	8.9±0.4	8.0 - 10.0

3.2 Titratable acidity and pH value

The pH and acidity (Table 2) are important values and contribute to the freshness and acidity of the wine. Titratable acidity of the dragon fruit-palmyra neera wines ranged between 5.03 - 19.95% and 6.28 - 25.71%, respectively. The pH value in the wine was acidic throughout the period of aging. Previous studies reported fruit wines contained a complex mixture of organic acids such as tartaric, malic, acetic, citric, and lactic acids, of which tartaric and malic acid are the main acids, accounting for over 90% (Robles *et al*. 2019; Mendes Ferreira and Mendes-Faia, 2020). In this study, the percentage of titratable acidity shows the occurrence of lactic acid fermentation. Acidity plays a vital role in determining wine quality by aiding the fermentation process and enhancing the overall characteristics and balance of the wine. The pH value decreased with increasing aging time, ranged from 4.89 (0 month) to 2.85 (3 months). This result is consistent to that reported on mango wine (Ogodo *et al*., 2018), fermentation of mixed (pawpaw - banana - watermelon) juices (Ogodo *et al*., 2015). Low pH and high acidity inhibitory the growth of spoilage microbes however create a conducive and competitive advantage environment for the growth of desirable microbes (Mathew *et al*., 2017). In addition, the pH value and acidity influence the tastes of wines by imparting sour tastes to the end product (Ogodo *et al*. 2015).

Table 2. Colour evaluation of dragon fruit-palmyra neera wine.

Colour parameter	Aging time (months)			
	0	1	2	3
L*	8.34±0.40	11.76±0.31	12.46±0.68	13.20±0.29
a*	-1.57±0.44	-2.41±0.02	-2.61±0.56	-3.47±0.59
b*	3.77±0.28	4.30±0.60	4.65±0.14	9.42±0.60
C*	4.10±0.08	4.94±0.51	5.35±0.16	10.05±0.39

Values are presented as mean± SD.

3.3 Alcoholic content, total soluble solid, and reducing sugar content

The alcoholic content of the wines increased from 0% to 37%, then decreased to 35% after aging for 3 months (Table 3). The result of the total soluble solids decreased with increasing aging time from 19°Bx to 10° Bx. While the total reducing sugar content (g/100 mL) decreased from an initial value of 19.36±3.73 to 3.78±0.10. The decrease in tartaric acid content during aging time is similar to the study in cashew apple wine performed by Mohanty *et al*. (2006). Other substances such as acetic acid, glycerol, and higher alcohols, were produced during alcoholic fermentation, resulting in a lower pH and higher TA (Boondaeng *et al*., 2021). Acidity is a crucial indicator that shows the correctness of the fermentation process.

According to Cendrowski *et al*. (2021), if wine is exposed to air during the initial stage of fermentation and the alcohol content is still present in a small percentage, acetic acid formation due to the presence of *Acetobacter* spp. may occur and will affect the quality of the wines. In general, all alcoholic beverages contain less than 15% ethanol. The higher the alcohol content, the more resistant the beverages will be subjected to bacterial contamination. The wine produced in this study smelled like acetic acid. This condition (high concentration of ethanol, 35%, and a decrease of TSS content) supports strains of *Acetobacter* spp. which are better adapted (Boondaeng *et al*., 2021).

3.4 Antioxidant activity

The antioxidant activity (% inhibition) in the present study was measured in wine by the free radical scavenging with DPPH method, elimination of the reactive oxygen species (ROS) by hydrogen peroxide (H_2O_2). The wine showed antioxidant activity with % inhibition (DPPH) values of 66.70±1.23% and decreased to 56.94±0.71% after 3 month-aging time. The antioxidant activity of wine against DPPH radicals is due to the presence of hydrogen atoms, leading to the termination of the chain reaction (Boondaeng *et al*., 2022). However, this result depends on the type of fruits and acid value during process of fermentation.

3.5 Colour evaluation

Colour is one of the leading parameters that can attract consumers to a product and can support the marketing of the product (Velic *et al*., 2018). Colour parameters characterized as lightness (L*), redness (a*), yellowness (b*), and chroma (C*) for dragon fruit-palmyra neera wines are shown in Table 2. During 3 months of aging time after fermentation, the wine reduced the colour from violet-pink (month 0) to light-brown (after 3 months of aging). The a* value decreased from a -1.57±0.44 (at day 0) to a -3.47±0.59 (at month 3), however, the b* value increased from a 3.77±0.28 (at month 0) to a 9.42±0.60 (at month 3). Also, the L* value increased with the progression of aging periods up to month 3 from an average of 8.34±0.40 (at month 0) to 13.20±0.29 (at month 3). Then, followed by the rising of the C* value from 4.10±0.08 (at month 0) to 10.05±0.39 at the end of aging time.

4. Conclusion

Dragon fruits and palmyra neera are widely available in tropical countries and the presence of desired compounds such as antioxidant activity, and other physicochemical attributes suggest that they have potential as raw materials for alcoholic beverage processing. In addition, the data reported in this study provide base information to produce a functional wine which is acceptable for the winery industry.

Conflict of interest

The authors declare that the research was conducted without any potential conflict of interest.

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Table 3. Physicochemical characteristics of dragon fruit -palmyra neera wine.

Titratable acidity	Aging after fermentation (month)			
	0	1	2	3
pH	4.89	4.45	3.04	2.85
Tartaric acid (%)	6.28±0.16	16.79±0.16	24.08±1.98	25.71±2.39
% ABV	ND	37	35	35
TSS (°Bx)	19	16	12	10
Total reducing sugar (g/100 mL)	19.36±3.73	14.19±0.57	9.97±0.12	3.78±0.10
DPPH activity (% inhibition)	66.70±1.23	63.52±0.82	60.05±0.61	56.94±0.71

Values are presented as mean± SD. ND: Not detected.

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