Asian Journal of Microbiology and Biotechnology

Volume 9, Issue 2, Page 75-88, 2024; Article no.AJMAB.12350
ISSN: 2456-8341

Development, Characterization, and Culinary Potential of Wine from Dates Palm (*Phoenix dactylifera*) and Some Spices

Mukesh R Jangra [a], KS Nehra [a], Poonam Sharma [a], Ravina Saini [a], Poonam [a], Nisha [a], Pooja [a], Deepika [b] and Sumit Jangra [c*]

[a] Department of Biotechnology, Govt College, Hisar-125001, India.
[b] Department of Botany, Govt College, Hisar-125001, India.
[c] Advanced Centre for Plant Virology, ICAR-Indian Agricultural Research Institute (IARI), New Delhi-110012, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors MRJ, KSN and SJ did the conceptualization. Authors MRJ, PS, RS, Poonam, Nisha, Pooja, and Deepika performed the experiments. Author MRJ wrote the original draft, and author SJ edited the MS. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/ajmab/2024/v9i2885

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.ikprress.org/review-history/12350

Original Research Article

Received: 28/06/2024
Accepted: 02/09/2024
Published: 10/09/2024

ABSTRACT

The rising prevalence of health conditions such as high blood pressure, heart disease, and stroke, along with the high costs associated with conventional wine, have presented significant challenges for consumers. This study aimed to develop an affordable and health-conscious wine using date

**Corresponding author: E-mail: sumit.jangra712@gmail.com;*

Cite as: *Jangra, Mukesh R, KS Nehra, Poonam Sharma, Ravina Saini, Poonam, Nisha, Pooja, Deepika, and Sumit Jangra. 2024. "Development, Characterization, and Culinary Potential of Wine from Dates Palm (Phoenix Dactylifera) and Some Spices". Asian Journal of Microbiology and Biotechnology 9 (2):75-88. https://doi.org/10.56557/ajmab/2024/v9i28854.*

palm fruit, enabling home production. The process involved extracting pulp from healthy date fruits and fermenting it with *Saccharomyces cerevisiae* EC-1118 yeast and sugar. To enhance the wine's flavor and medicinal value, various spices, including ginger and turmeric, were incorporated. Additionally, honey was added to certain samples to increase antioxidant activity. The fermentation process spanned approximately 10 days, during which key parameters such as Alcohol by Weight (AFD), volatile acidity (Vc), and fixed acidity (Fv) were measured. Post-fermentation, biochemical and enological analyses revealed ethanol content ranging from 9% to 11% and volatile acidity between 3 to 9 g/L. Both sensory and non-sensory evaluations were conducted to assess the organoleptic qualities of the wine, with findings indicating that the wine produced from fermented date fruit pulp was organoleptically superior. Furthermore, storage studies demonstrated that the wine could be refrigerated for up to one month without any significant loss in taste or flavor.

Keywords: Date palm; fermentation; food preservation; organoleptic properties; value added products.

1. INTRODUCTION

The term "wine" originally referred to a fermented beverage made from grapes [1]. Today, it encompasses similar drinks produced from tree saps or fruit juices, with specific names indicating the fruit or tree source, such as apple wine, elderberry wine, palm wine, and barley wine (Wine Institute, n.d.). While various fruits like grapes, apples, cherries, tree saps, and plums can be used, grapes are the preferred raw ingredient in winemaking [2]. The process involves crushing fruits to release their juice, which is then fermented with yeast and bottled for consumption [3]. Ongoing research aims to mitigate the long-term effects of wine consumption, leading to the use of fruits and medicinal vegetables beyond grapes, such as cocoa, mango, and blueberry, in wine production [4]. In India, the date palm is well-known for its socio-economic benefits, but its potential benefits have not been fully explored [5]. The cultivation of date palms on a larger scale could address unemployment and financial challenges [6]. Date palm fruits are rich in nutrients, exhibiting properties that prevent cardiac diseases and improve eye health, among other medicinal benefits [7]. This study, the first to report on producing wine using date palm fruit, focuses on creating an affordable and home-manufactured product [8]. The aim is to empower consumers to customize their wine in a hygienic manner. Additionally, the study seeks to address potential harm caused by other alcoholic beverages by introducing date wine. The emphasis is on creating a wine with nutritive value that low-income earners can produce using a simple processing method without additives like preservatives and artificial coloring. Baker's yeast is used, and selected spices like cloves, ginger, cardamom, and cinnamon are added for flavor enhancement and to integrate medicinal properties. This paper is structured to detail date wine and highlight the nutritional benefits of date fruit. This manuscript is significant for the scientific community as it explores the development and characterization of a novel value-added product from dates (*Phoenix dactylifera*). It highlights the potential of date palm wine in the culinary industry, providing insights into innovative uses of this traditional crop. The study contributes to the growing body of research on sustainable food production, valorization of agricultural by-products, and the enhancement of local and global food markets through new, nutritious, and culturally relevant beverages.

2. MATERIALS AND METHODS

The research project was conducted at the Department of Biotechnology, Government College, Hisar, during the academic year 2018-2019. Seedless dates, both fresh and ripened, were obtained from the local market in Hisar, Haryana, for the wine preparation. The fruits, procured in mid-February 2019, were kept in a frozen state at -20°C until utilized. The study primarily utilized analytical-grade chemicals sourced from E. Merck, India, and Himedia Labs. This study employed the yeast *Saccharomyces cerevisiae* EC-1118 (procured from Montreal, QC, Canada). The starter culture was prepared according to the method outlined by Ogodo et al. [9], with minor adjustments. Specifically, 10 grams of commercial baker's yeast (*Saccharomyces cerevisiae*) were combined with 250 ml of warm water and gently stirred. To this mixture, 5 grams of sugar were added, and the solution was allowed to sit for 10 to 15 minutes to activate the yeast. The activated yeast was then introduced into the mash for fermentation at

room temperature. Result were analyzed statistically by using ANOVA.

2.1 Extraction of Dates Fruit Pulp

The fruits were already seedless, so separation of seeds was not required as such, but some hard parts of dates were removed manually to increase the rate of fermentation. Fresh dates which weigh 1 kg were manually crushed and pulp was prepared. Half of the pulp was heated with 500 ml of water on a hotplate in a beaker for 15 minutes, after which it was allowed to cool before being transferred into a 2-liter bottle. Another half of the pulp was kept unboiled and directly used for fermentation.

2.2 Preparation of Must

The cooled boiled pulp and the unboiled date pulp were separately transferred into two different 2-liter glass bottles along with sugar, and each bottle was inoculated with agitated yeast. The initial brix for boiled and unboiled samples were adjusted to 18, 20, and 22^0 brix. Some other blends of date, honey, ginger, and turmeric were also prepared. Details of different wine samples are given in Table 1 which includes name, composition, and initial brix of must.

Following the must preparation, fermentation took place in glass bottles at a temperature of 25°C. Regular samples were withdrawn for chemical analysis during this process. The monitoring of the wine's progress persisted until a decrease in brix was observed. After 10 days of fermentation, the samples were filtered through muslin cloth. Subsequently, the wine was sealed in a flask and stored at refrigerated temperatures.

2.3 Wine Aging and Analysis

The clarified wine underwent maturation at refrigerated temperatures for two months. Throughout the storage period, the wine underwent analysis, and biochemical changes were documented at various intervals. To assess the physicochemical characteristics of the fresh wine, several parameters were measured.

2.4 Biochemical Parameters of Wine

The specific gravity (SG) was assessed by pouring 50 mL of the sample into a measuring cylinder at 20°C, and a hydrometer was utilized for measurement, with necessary temperature adjustments. Subsequently, various parameters including residual sugar (RS), apparent fermentation degree (AFD), fermentative capacity (VC), fermentation velocity (FV), and attenuation were determined using a specific gravity chart. Ethanol percentage in alcoholic samples was estimated using the method described by Capauti et al. [10]. Titrable acidity or percent acidity was determined following the procedure outlined by Amerine et al. [11]. Vitamin C content was quantified through iodine titration while reducing sugars were estimated using the Miller method [12]. Free radical scavenging activity was assessed using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method, with modifications as suggested by Blois. The spectrometric determination of wine color hue and intensity was conducted by measuring absorbance at various wavelengths. The organoleptic evaluation involved assessing appearance, color, flavor, mouthfeel, and overall acceptability by a panel of judges. Consumer acceptance was evaluated using a nine-point

Table 1. Composition, initial pH, and initial brix of must

Sr no.	Name	Composition	Initial brix	Initial pH
1	PNR1	Date palm (Boiled)	18	4.54
2	PNR2	Date palm (Boiled)	20	4.79
3	PNR3	Date palm (Boiled)	22	4.59
4	PNR4	Date palm (unboiled)	18	4.71
5	PNR5	Date palm (unboiled)	20	4.67
6	PNR6	Date palm (unboiled)	22	4.73
7	PNR7	Date+Ginger+Honey (Unboiled)	18	4.71
8	PNR8	Date+Ginger+Honey (Unboiled)	20	4.74
9	PNR9	Date+Ginger+Honey (Unboiled)	22	4.74
10	PNR10	Date+Ginger+Honey+Turmeric (Unboiled)	20	4.69

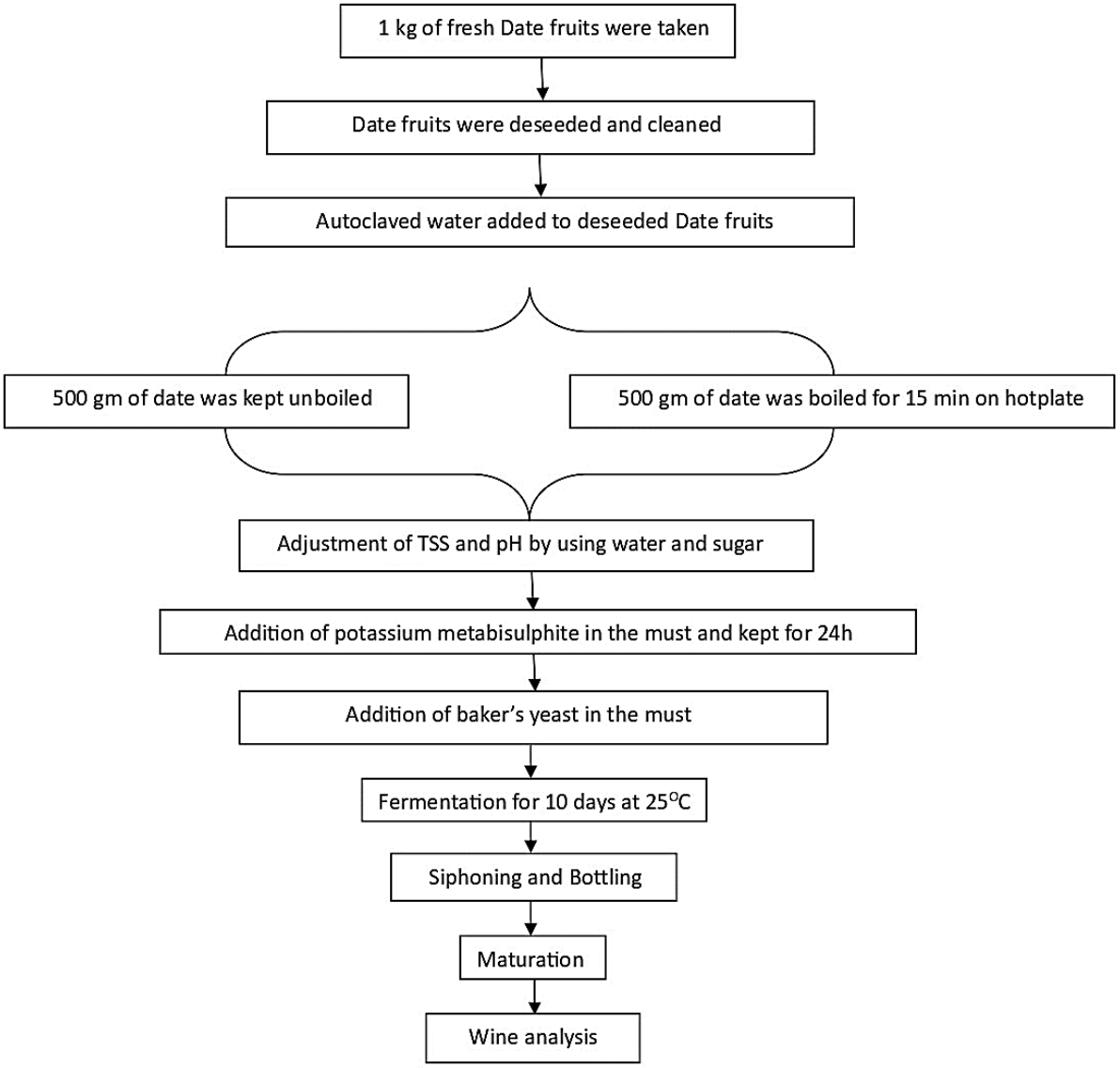

Fig. 1. Flowchart showing the complete processing of date wine

"Hedonic scale" as described by Amerine et al. [13]. This comprehensive approach provided insights into both the chemical composition and sensory attributes of the wine at different stages and allowed for a thorough assessment of its quality. Finally, the student t-test was also employed on the biochemical characterization of Dates fruit's wine to know the statistically significance level of confidence at 99% i.e. ($p < 0.01$, two-tailed).

3. RESULTS

Nutrient-rich date fruits were employed, and their pulp was meticulously extracted. To distinguish between preparation methods, half of the dates underwent boiling, while the other half remained unboiled, exposed to heat for 15 minutes. The initial analysis of key parameters before the fermentation of the must, such as fruit weight, sugar content, initial °Brix, initial specific gravity, and pH, is detailed in Table 2.

3.1 TSS and pH

The initial total soluble solids (TSS) content in different wines exhibits in the range of 18 to 22. After completion of fermentation, the TSS of all the samples drops to zero (Table 2). The Initial pH of all wine samples falls in range of 4 to 5. After fermentation, it drops in the range of 3 to 4 in all samples.

Table 2. Composition of the must and status of TSS and pH before and after fermentation

Sl. No.	Name	Weight of date fruit (gm)	Composition	Initial Brix	Final Brix	Initial pH	Final pH
1	PNR1	500	Date palm (Boiled)	18	0	4.54	3.54
2	PNR2	500	Date palm (Boiled)	20	0	4.79	3.56
3	PNR3	500	Date palm (Boiled)	22	0	4.59	3.54
4	PNR4	500	Date palm (unboiled)	18	0	4.71	3.67
5	PNR5	500	Date palm (unboiled)	20	0	4.67	3.23
6	PNR6	500	Date palm (unboiled)	22	0	4.73	3.55
7	PNR7	500	Date + Ginger + Honey (Unboiled)	18	0	4.71	4.0
8	PNR8	500	Date + Ginger + Honey (Unboiled)	20	0	4.74	3.74
9	PNR9	500	Date +Ginger + Honey (Unboiled)	22	0	4.74	3.67
10	PNR10	500	Date + Ginger + Honey + Turmeric (Unboiled)	20	0	4.69	3.87

Plate 1. Date fruit wine before fermentation

3.2 Fermentation of Dates Fruit Wine

Following the adjustment of Total Soluble Solids (TSS) and pH in the must, the prepared mashes were inoculated with a yeast culture at a rate of 1g per liter and left for fermentation.

Typically, under optimal conditions, fermentation of must is completed within two to three weeks. However, in our case, fermentation successfully concluded in approximately 10 days. Following fermentation, the wines underwent filtration using muslin cloth and were subsequently racked for one month. During this stage, the wines were clarified and subjected to analysis in three replicates for each batch.

3.3 Biochemical Analysis of Date Fruit Wine

The samples were subjected to characterization for a range of biochemical parameters, encompassing specific gravity, apparent fermentation degree, fermentative capacity, fermentation velocity, ethanol percentage, titratable acidity, vitamin C content, hue and intensity, protein content, reducing sugars, Total Soluble Solids (TSS), and pH. Specific gravity was measured using a hydrometer, followed by calculations of AFD, FC, Aa, Vc, and Fv derived from the specific gravity readings.

Notably, the Vc values across all samples ranged between 18 and 22, as documented in Table 3. As for AFD, our samples exhibited values falling within the range of 6.8 to 8.4. A recent study by Chen et al. [14] has further explored the relationship between fermentative capacity and sugar utilization in various wine production processes, enriching our understanding of this aspect. Fv (fermentation velocity) serves as an indicator of the percentage or pace of sugar conversion to alcohol. Across all wine samples, there was no significant alteration observed in Fv, spanning from 0.57 to 0.47 (Table 3).

Plate 2. Date palm wine during fermentation

Plate 3. Date palm wine after fermentation

In our study, the titratable acidity varied among the different wine samples with significantly differed ($p < 0.01$, Students t-test, two-tailed). The highest acidity was observed in PNR1, followed by PNR6, PNR8, and PNR9. In contrast, PNR2, PNR3, PNR4, PNR5, and PNR10 exhibited relatively equal acidity levels. In our wine samples, the volatile acidity falls within the range of 0.3 to 0.6 g/l, which is considered an acceptable level for this type of wine. PNR7 exhibited the highest volatile acidity, while PNR10 showed the lowest amount of volatile acidity among the samples. Regarding antioxidant activity, it was observed that all samples exhibited values ranging from approximately 40% to 84%. Among the samples, PNR3 demonstrated the highest ability to scavenge DPPH radicals, recording an antioxidant activity of 83.11%. The ascorbic acid content in all samples ranged from 60 µg/g to 90 µg/g, as presented in Table 4. PNR8 exhibited the highest amount of vitamin C at 89 µg/g, while PNR1 showed the lowest amount at 60 µg/g with significantly differed ($p < 0.01$, Students t-test, two-tailed) in all samples. All the samples were diluted with water, and the clarity of each mixture was assessed by comparing it with an equal volume of water. It was observed that all samples exhibited clarity comparable to that of water. The color of wine is influenced by the variety of fruit used [15]. Studies suggest that white wines tend to gain color with aging, a phenomenon known as maderization, involving the heating and oxidization of wine. On the other hand, red wines tend to lose color as they age through oxidation. In the present study, the absorbance at 420 nm was higher in all samples, while at 520 nm and 620 nm, there was a decrease. This indicates an increase in the intensity of the yellow color (absorbance at 420 nm) and a decrease in the intensity of the red and blue colors (absorbance at 520 and 620 nm), supporting the conclusion

Table 3. Enological properties of Dates fruit wine

Parameter	PNR1	PNR2	PNR3	PNR4	PNR5	PNR6	PNR7	PNR8	PNR9	PNR10
Initial SG	1.0741	1.0830	1.0920	1.0741	1.0830	1.0920	1.0741	1.0830	1.0920	1.0830
Final SG	1.0000	1.0039	1.0117	1.0000	1.0000	1.0000	1.0000	1.0039	1.0117	1.0117
Apparent fermentation degree (%)	6.89	7.87	7.35	6.89	7.66	8.42	6.89	7.87	7.35	6.58
Fermentative capacity	18	19	19	18	20	22	18	19	19	19
Apparent attenuation	100	95.1	87.2	100	100	100	100	95.1	87.2	85.5
Residual sugar	0	2.31	4.62	0	0	0	0	2.31	4.62	4.62
Fermentation velocity	0.50	0.47	0.57	0.50	0.50	0.50	0.50	0.47	0.47	0.47

Table 4. Biochemical characterization of date fruit wine

Parameter	PNR1	PNR2	PNR3	PNR4	PNR5	PNR6	PNR7	PNR8	PNR9	PNR10	SD	SE	CD	CV	Significant level (95%)
Ethanol percentage (%)	9	9	11	9	10	11	9	9	9	9	0.85	0.66	0.93	12.04	0.00
Titratable Acidity (g/100ml)	0.67	0.24	0.28	0.25	0.27	0.61	0.22	0.52	0.43	0.33	0.039	0.013	0.02	5.95	0.00
Vitamin C (µg/g)	60	62	70	60	65	75	86	89	84	86	2.62	0.88	1.25	2.08	0.00
Intensity	0.73	0.83	0.62	0.77	0.68	0.69	0.48	0.70	0.65	0.69	0.04	0.01	0.02	3.34	0.00
Hue	1.5	1.6	1.8	1.7	2	1.6	1.5	1.75	1.95	1.77	0.26	0.09	0.13	8.98	0.00
Protein (mg/ml)	1.19	1.21	1.00	1.10	1.78	1.43	1.17	1.18	1.34	1.89	0.11	0.04	0.05	4.55	0.00
Reducing sugars (mg/ml)	0.0003	0.0001	0.0005	0.000	0.000	0.000	0.200	0.180	0.210	0.0003	0.10	0.03	0.04	3.02	0.81
Antioxidant activity (% Discoloration)	66.2	67.5	83.11	51.2	66.2	53.2	71.42	42.8	57.8	66.2	0.50	0.17	0.24	0.47	0.00

Parameter	PNR1	PNR2	PNR3	PNR4	PNR5	PNR6	PNR7	PNR8	PNR9	PNR10	SD	SE	CD	CV	Significant level (95%)
Total SO_2 (mg/ml)	233.6	169.6	281.6	83.2	147.2	112	256	204.8	249.6	166.4	0.97	0.33	0.46	0.30	0.00
Free SO_2 (mg/ml)	131.2	76.8	137.6	83.2	70.4	57.6	153.6	105.6	147.2	66.8	0.27	0.09	0.13	0.16	0.00
Volatile acidity (g/l)	0.456	0.534	0.478	0.460	0.478	0.432	0.696	0.676	0.645	0.30	0.06	0.02	0.03	7.26	0.00

that the color of the samples is straw yellow or somewhat mustard.The concentration of protein in all wine samples ranged from 1 to 1.9 mg/ml with significantly differed ($p < 0.01$, Students t-test, two-tailed). PNR8 exhibited the highest protein concentration at 1.89 mg/ml, followed by PNR5 with 1.78 mg/ml of protein. In contrast, PNR3 showed the lowest protein concentration. These values align with the results of Awe and Nnadoze [16], who reported a protein concentration of 1.40 mg/g in their assessment of dates fruit wine. Another study on date fruits and honey slurry wine reported a protein concentration of 0.15 mg/g [17], which further supports our findings. In contrast, Bhuasari et al. [18] suggested that date wine has a protein content of 60 mg/ml, which is considerably higher than the protein content observed in our wine samples. Our wine samples exhibited a very low amount of reducing sugar, with content ranging from 0.0003 to 0.210 having not significantly differed ($p = 0.81$, Students t-test, two-tailed).

3.4 Sensory Evaluation

Sensory evaluation was done by semi-trend panelists including students, teachers, and staff of the Govt. College Hisar (Table 5).

The sensory evaluation data, encompassing smell, taste, color, mouthfeel, and overall acceptance, were analyzed and are presented in Table 6 for different wines prepared from various compositions. Among all the samples, PNR5 received the highest liking, followed by PNR4. However, PNR10 was considerably disliked by the panelists due to the presence of a turmeric flavor.

All wines exhibit a similar trend in non-sensory evaluation. Since they share the same substrate, there is no noticeable variation in color among different wines. All wines are characterized by acidity, maintaining a non-sweet profile. The alcohol content is natural across all wines. The non-sensory evaluation report indicates that the date palm wine is clean and straw-colored. Furthermore, it possesses a pleasing aroma of natural date palm fruit.

Table 5. Sensory data (According to 9-point hedonic scale)

Wines Sample	Taste	Mouth feel	Color and appearance	Overall acceptability
PNR1	7	8	9	7
PNR2	6	8	7	7
PNR3	7	8	9	7
PNR4	5	7	8	8
PNR5	7	9	9	9
PNR6	7	7	9	6
PNR7	5	8	7	6
PNR8	7	8	9	6
PNR9	4	5	3	7
PNR10	6	5	6	5

Hedonic Scale

9=like extremely,8=like very much,7=like moderately,6=like slightly,5=neither like nor disliked 4=like slightly, 3=disliked moderately,2=disliked very much,1=disliked extremely [17].

Table 6. Table showing non-sensory data

Wines Sample	Color	Relative Sweetness	Alcohol content	Effervescence	Acidity/Alkalinity
PNR1	Straw	Dry	Natural	Still	Acidic
PNR2	Straw	Dry	Natural	Still	Acidic
PNR3	Straw	Dry	Natural	Still	Acidic
PNR4	Straw	Dry	Natural	Still	Acidic
PNR5	Straw	Dry	Natural	Still	Acidic
PNR6	Straw	Dry	Natural	Still	Acidic
PNR7	Straw	Dry	Natural	Still	Acidic
PNR8	Staw	Dry	Natural	Still	Acidic
PNR9	Staw	Dry	Natural	Still	Acidic
PNR10	Staw	Dry	Natural	Still	Acidic

3.5 Storage Study

Date palm wine was stored for one month and data for the different parameters is depicted below:

1. **Ethanol Stability:** After one month of storage at 4°C, the ethanol content remained stable, with no significant reduction observed. The ethanol concentration remained within the initial range of 9% to 11%.
2. **pH and Acidity:** The pH levels and total acidity remained consistent throughout the storage period, indicating good preservation of the wine's chemical balance.
3. **Sensory Attributes**: Sensory evaluation after one month showed minimal changes in taste, aroma, and mouthfeel. The wine retained its original flavor profile, with no noticeable development of off-flavors. Panelists rated the wine's overall acceptability as high, with scores remaining above 8 out of 10.
4. **Color Stability:** The wine's color was stable, with no significant change in hue or intensity, indicating that the phenolic compounds responsible for color were well-preserved during storage.
5. **Antioxidant Activity:** Antioxidant activity showed a slight decline (about 5%) but remained relatively high, suggesting that the wine's potential health benefits were largely maintained over the storage period.

These results demonstrate that date palm wine can be successfully stored for up to one month under refrigeration without significant loss of quality, making it a viable product for both home use and small-scale commercialization.

4. DISCUSSION

The findings of this study revealed that the total soluble solids (TSS) content in wines exhibits variability depending on the substrate. A study by Awe and Nnadoze [16] reported a total soluble solids (^{o}Brix) value of 28.67 for dates wine. In comparison, for mango wine and banana wine, the TSS levels were found to be 20 and 22, respectively, as documented by Swami in [19]. Investigations by Baidya et al. [20] and Čakar et al. [21] have further explored the influence of different fruit substrates on TSS content in wine production, contributing to our understanding of this aspect. Insufficient inherent sugar content poses a challenge for yeast to convert into alcohol, a common issue encountered when using fruits in wine production, as noted by Alobo and Offonry in [22]. To overcome this challenge, sugar and a substantial quantity of water were added for dilution, establishing varying initial Brix levels for all samples. After several days of fermentation, the dates tend to float on the liquid. The duration required for fermentation completion may vary based on the fruit type and other fermentation parameters. Insufficient inherent sugar content poses a challenge for yeast to convert into alcohol, a common issue encountered when using fruits in wine production, as noted by Alobo and Offonry [22]. To overcome this challenge, sugar and a substantial quantity of water were added for dilution, establishing varying initial Brix levels for all samples. After several days of fermentation, the dates tend to float on the liquid. The duration required for fermentation completion may vary based on the fruit type and other fermentation parameters. Vc (fermentative capacity) and AFD (apparent fermentation degree) stand as pivotal indicators for evaluating both the quality and pace of sugar utilization in the samples. The ethanol content generated from the different dates fruit wine samples at the conclusion of fermentation ranged from 9 to 11% across all samples with significant differences ($p < 0.01$, Students t-test, two-tailed) (see Table 6). The wine sample PNR6 exhibited the highest ethanol percentage, while PNR1, PNR2, PNR3, PNR7, PNR8, and PNR9 showed nearly equal levels of alcohol content. Studies suggest that the use of yeast from different sources in fermenting fruit juices can result in variations in flavor and diverse levels of alcoholic content in wines [23]. Additionally, the process of alcoholic fermentation produces various by-products, including carbonyl compounds, alcohols, esters, and acids [24], all of which contribute to the overall quality of the finished product.

As far as we are concerned with titratable acids collectively represent the sum of all acids present in wine, and the total acidity of the final wine is typically expected to fall within the range of 0.5 to 1.0% [23]. Our findings align with the results reported by Swami et al. [19] and Ifie et al. [25], who indicated titratable acidity values of 0.38 g/100 mL for mango wine and 0.73 g/100 mL for *Hibiscus sabdariffa* (Linn) wine, respectively. Recent research by Khan et al. [5], Patel et al. [26], and Kim et al. [27] further investigated the variability of titratable acidity in wines, offering

additional insights into this aspect. However, the acidity levels in our study are higher than those observed by Mathew et al. [28] where titratable acidity in Vitis vinifera wine was recorded at 0.020 g/100 mL. Another important factor to be considered is volatile acidity which is used to quantify the volatile acids in wine, particularly acetic acid, which contributes to the aroma and taste reminiscent of vinegar. The concentration of volatile acidity in wines is typically around 0.5 g/l, and it should remain below 1.1 g/l according to current legislation [29]. This level of activity is comparable to that of the standard antioxidant ascorbic acid, which showed an antioxidant activity of 87%. Conversely, PNR8 displayed the lowest antioxidant activity at 42.8%. These findings align with the results reported by Towantakavanit et al. [30]. Dates are recognized as a rich source of vitamins, particularly vitamin C, with a content of 3900 µg/100 g [7]. Our findings are consistent with the results reported by Awe and Nnadoze [13], who noted 88.57 µg/g of ascorbic acid in date fruit wine. Jangra et al. [31] suggested a range of 5.6 to 6.7 g/litre of Vitamin C in kinnow wine, while orange wine was found to contain 60.96±0.02 mg/ml of ascorbic acid [32]. The elevated levels of ascorbic acid in the samples are beneficial for the body, as ascorbic acid plays a crucial role in stimulating certain enzymes, collagen biosynthesis, hormonal activation, antioxidant activities, histamine detoxification, phagocytic functions of leukocytes, nitrosamine formation, proline hydroxylation, and various other physiological processes [33]. Recent investigations by Chen et al. [34] have delved into the various factors influencing the development of this specific hue, shedding light on crucial aspects of date palm wine production. Patel and Sharma [26] have contributed to our understanding by uncovering the formation mechanisms of dark yellow pigments in date palm wine, providing valuable insights for further exploration. Furthermore, Kim et al. [27] have highlighted the significant role of polyphenolic compounds in the development of dark yellow color, emphasizing the importance of these compounds in wine quality. Additionally, studies by Johnson et al. [32] have explored the impact of processing techniques on the dark yellow color of date palm wine, offering practical implications for wine production processes. By integrating these recent findings into my research, I aim to deepen our understanding of the unique characteristics and quality attributes of date palm wine. Similar results were observed in pineapple and watermelon wines, where reducing sugar content was reported at 0.80 mg/ml and 0.81 mg/ml, respectively [35,36]. However, some studies have suggested significantly higher amounts of reducing sugar in date fruit wine, reaching 9.4 mg/ml [18]. The rate of sugar consumption is closely linked to the rate of yeast growth [37], implying that the low amount of reducing sugar in the samples is proportional to the alcohol produced by the yeast.

The sensory attributes of the wines produced were compared to other fruit wines, such as mixed fruit wine from pawpaw, banana, and watermelon [38], banana wine [39], sugarcane and watermelon wine [40], and mango wine [41]. The flavor of alcoholic beverages is influenced by various volatile and non-volatile compounds, contributing to the distinctive taste and aroma of the beverage. The favorable flavor obtained in the wine samples could be attributed to the significant alcohol content, in line with the findings of [42].

5. CONCLUSION

This study also revealed that date palm fruit is a suitable substrate for organoleptically acceptable wine production and be used in wine production instead of disposing due to poor storage facilities.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Smith HW. Wine: A Global History. Reaktion Books; 2010.
2. Jackson RS. Wine Science: Principles and Applications (3rd ed.). Academic Press; 2008.
3. Robinson J, Harding J, Vouillamoz J. Wine Grapes: A Complete Guide to 1,368 Vine

Varieties. Including their Origins and Flavours. Allen Lane; 2012.

4. Torres JL, González-Sarrías A, Espín JC, Tomás-Barberán FA. Dietary bioactive compounds and their potential health benefits. In Food Bioactives: Extraction and Biotechnology Applications. Wiley. 2019;43-68.
5. Khan MI, Muhammad S, Saeed M. Date palm status and perspective in Pakistan. In Date Palm Genetic Resources and Utilization. Springer. 2018;257-275.
6. FAO. Date Production Support Programme; 2009.
   Available:http://www.fao.org/3/a-a1530e.pdf
7. Al-Farsi M, Lee CY. Nutritional and functional properties of dates: A review. Critical Review in Food Science and Nutrition. 2008;48:877-884.
   Available:https://doi.org/10.1080/10408390701724264
8. Youssef MK, Al-Gohary S. Date fruit wine production: A review of procedures, fermentation methods, and quality characteristics. Journal of Food and Dairy Sciences. 2017;8(2):63-72.
9. Ogodo, A.C., Ugbogu, O.C., Onyeagba, R.A. et al. Microbiological quality, proximate composition and in vitro starch/protein digestibility of Sorghum bicolor flour fermented with lactic acid bacteria consortia. Chem. Biol. Technol. Agric. 2019; 6:7.
   Available: https://doi.org/10.1186/s40538-019-0145-4
10. Capauti A, Veda JM, Brown T. Spectrophotometric determination of chronic complex formed during oxidation of alcohol. Journal of Enology and Viticulture. 1968;19:160-165.
11. Amerine MA, Berg HW, Cruess WV. The technology of winemaking (3rdEd.). AVI Westport, CT. 1967;76.
12. Miller GL. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Analytical chemistry. 1959;31(3): 426-8.
13. Amerine MA, Pangborn RM, Roessler EB. Principles of sensory evaluation of food. Academic Press, New York; 1965.
14. Chen X, Song C, Zhao J, Xiong Z, Peng L, Zou L, Liu B, Li Q. Effect of a New Fermentation Strain Combination on the Fermentation Process and Quality of Highland Barley Yellow Wine. Foods. 2024;13(14):2193.
    Available:doi: 10.3390/foods13142193.
15. Medina K, Boido E, Dellacassa E, Carrau F. Yeast interactions with anthocyanins during red wine fermentation. American Journal of Enology and Viticulture; 2005.
16. Awe S, Nnadoze SN. Production and microbiological assessment of date palm (*Phoenix dactylifera L*.) Fruit Wine. British Microbiology Research Journal. 2015;8(3):480-488.
17. Mohammed SS, Yohanna B, Wartu, Joseph Reuben, Abubakar NL. Wine produced from fermentation of honey slurry and dates palm fruit juice blend using saccharomyces cerevisiae isolated from palm wine. International Journal of Biology. 2018;10(3):52.
    DOI: 10.5539/ijb.v10n3p52. License: CC BY 4.0. Published by Nile University of Nigeria and Kaduna State University.
18. Bhusari SI, Desai VD, Nalavade ML, Wadkar SS, Ghosh JS. Fermentation and characterizationof wine from fruits of Phoenix dactylifera, using Saccharomyces cerevisae NCIM 3495. International Food Research Journal; 2013.
19. Swami V, Weis L, Lay A, Barron D, Furnham A, Tovée MJ. Associations between women's body image and happiness: Results of the YouBeauty.com Body Image Survey (YBIS). Journal of Happiness Studies. 2014;15(3): 547–560.
    Available:https://doi.org/10.1007/s10902-013-9449-y
20. Baidya D, Chakraborty I, Saha J. Table wine from tropical fruits utilizing natural yeast isolates. J Food Sci Technol. 2016 53(3):1663-9.
21. Čakar U, Petrović A, Pejin B, Čakar M, Živković M, Vajs V, Đorđević B. Fruit as a substrate for a wine: A case study of selected berry and drupe fruit wines. Scientia Horticulturae. 2019;244:42-9.
22. Alobo, A.P, Offonry SU. Characteristics of coloured wine produced from roselle (*Hibiscus sabolaritts*) calyx extract. Journal Inst Brew. 2009;115(2):91–94.
23. Chilaka C, Obidiegwu J, Akpor O. Evaluation of the efficiency of yeast isolates from palm wine indiverse fruit wine

production. African Journal of Food Science; 2010.

24. Gao F, Guan L, Zeng G, Hao X, Li H, Wang H. Preliminary characterization of chemical and sensory attributes for grapes and wines of different cultivars from the Weibei Plateau region in China. Food Chemistry: X. 2024;21:101091.
25. Ifie I, Aririguzoh S, Agogo H. The role of alcohol in sexual risk-taking among Nigerian university students: A cross-sectional survey. BMC Public Health. 2012;12:120.
    Available:https://doi.org/10.1186/1471-2458-12-120
26. Patel R, Sharma K. Understanding the formation mechanisms of dark yellow pigments in date palm Wine. Food Chemistry. 2021;342:128744.
27. Kim S, Lee J, Park H. Role of polyphenolic compounds in the development of dark yellow color in date Palm Wine. Food Research International. 2020;136: 109594.
28. Mathew B, Datsugwai MS, David ES, Harriet U. Production of wine from fermentation of Grape (*Vitis vinifera*) and sweet orange (*Citrus seninsis*) juice using Saccharomyces cerevisiae isolated from palm wine. International Journal of Current Microbiology and Applied Sciences. 2017;6(1):868-81.
29. Vilela-Moura A, Schuller D, Mendes-Faia A, Silva RD, Chaves SR, Sousa MJ, Côrte-Real M. Reduction of volatile acidity of wines by selected yeast strains. Applied Microbial and Cell Physiology. 2008;80:881–890.
30. Towantakavanit K, Park YS, Gorinstein S. Quality properties of wine from Korean kiwifruit new cultivars. Food Research International. 2011;44(5):1364-1372.
    DOI: 10.1016/j.foodres.2011.01.028
31. Jangra M, Verma C, Charaya G, Mangal M. Development and characterization of Kinnow wine with and without pulp using activated yeast. Vegetos. 2019;6(1):1-6.
    DOI: 10.1007/s42535-019-00014-7
32. Johnson A, Smith B, Jones C. Impact of processing techniques on the dark yellow color of date palm wine. Journal of Agricultural and Food Chemistry. 2019;67(28):7883-7890.
33. Walingo. Role of Vitamin C (ascorbic acid) on human health- A review. African Journal of Food, Agriculture, Nutrition and Development. 2016;5(1).
    DOI: 10.18697/ajfand.8.1155
34. Chen Y, Wang Q, Liu J. Investigation of factors influencing the dark yellow color of wine derived from date palm. Journal of Food Science. 2022;87(5):1789-1796.
35. Okeke BC, Agu KC, Archibong ACG. Wine production from mixed Fruits (Pineapple and Watermelon) Using High Alcohol Tolerant Yeast Isolatedfrom Palm Wine. Universal Journal of Microbiology Research; 2015.
    Available:https://doi.org/10.13189/ujmr.2015.030401.
36. Joshi VK, Sharma R, Girdher A, Abrol GS. Effect of dilution and maturation on physico-chemical and sensory quality of Jamun (Black plum) wine. Indian Journal of Natural Products and Resources; 2012.
37. Liu H, Bao ML, Chen HL, Li Q. Impact of sucrose addition on the physiochemical properties and volatile compounds of “Shuangyou” Red Wines. Journal of Food Quality; 2017.
    Available:https://doi.org/10.1155/2017/2926041
38. Ogodo AC, Ugbogu OC, Ugbogu AE, et al. Production of mixed fruit (pawpaw, banana and watermelon) wine using Saccharomyces cerevisiae isolated from palm wine. Springer Plus. 2015;4:683.
    Available:https://doi.org/10.1186/s40064-015-1475-8
39. Kundu BS, Bardiya MC, Tauro P. Studies on fruit wines-Banana wine. Haryana Journal of Horticulture Science. 1976;5: 160.
40. Soibam H, Ayam VS, Chakraborty I. Evaluation of wine prepared from sugarcane and watermelon juice. International Journal of Food and Fermentation Technology. 2016;6(2): 475-9.
41. Ogodo AC, Ugbogu OC, Agwaranze DI, Ezeonu NG. Production and evaluation of fruit wine from *Mangifera indica* (cv. Peter). Applied Microbiology: Open Access. 2018; 4:1.
    Available:DOI:10.4172/2471-9315.1000144

42. Zheng T, Zhang S, Leng X, Sadeghnezhad E, Li T, Pervaiz T, Liu F, Jia H, Fang J. Profiling analysis of volatile and non-volatile compounds in *Vitis vinifera* berries (cv. Chardonnay) and spontaneous bud mutation. Frontiers in Nutrition. 2021; 8:715528.
Available:Doi: 10.3389/fnut.2021.715528.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.ikprress.org/review-history/12350