The Development of Wine Using Mint Leaves Toward Consumer Acceptance

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Abstract

The objective of this study was to develop formulations and flavors of wine fermented with mint leaves to meet consumer preferences. The experiment was divided into two phases. In the first phase, suitable fermentation conditions for wine production were investigated. The experimental design was created using a Central Composite Design (CCD) from the Response Surface Methodology (RSM) software. Two independent variables were studied: sugar content (°Brix) and fresh mint leaves weight (g/600 ml). Two levels, low (-1) and high (+1), were defined for each factor using a two-level factorial design. A total of 14 experimental sets were conducted, and various parameters were measured every 3 days for 15 days. Sample 4, which used 75 g of fresh mint leaves and started with a sugar content of 22 °Brix, exhibited the highest alcohol content at 9.15 % and 10 °Brix. Sample 4 was therefore deemed suitable for further investigation in phase 2, which focused on studying the sensory acceptance of consumers towards wine fermented for 0 - 2 weeks and had its sugar content adjusted to 10, 12, 14, and 16 °Brix after 2 weeks of fermentation. The samples that underwent a 2-week fermentation period and had their sugar content adjusted to 12 °Brix showed the highest overall preference scores.

Keywords: Wine; Mint Leaves; Aged Wine

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Introduction

At present, the alcoholic beverage industry in Thailand is experiencing a slow growth. Alcoholic beverages with the highest consumption and market value are beer, accounting for 72.2 % of the total alcoholic beverage consumption, followed by spirits (25.9 %), and wine (1.0 %). It has been observed that although the wine consumption rate in Thailand is still relatively low, there is a continuous upward trend [1]. This has led to a significant number of wine products entering the market. While most foreign wines are produced from grapes, Thailand produces various types of wine mainly from different types of fruits. Only a small proportion of wines are made from herbs [2]. Surojanametakul, V. and Karuwanna, P. [3] produced herbal wine from herbal plants including mint, ginger, lemongrass, bael fruit and kaffir lime. Thailand imports a significant quantity of wine. Wine production, therefore, offers an alternative for processing and adding value to local products. The overall quality of herbal wine is determined by its clarity, color, aroma, and accepted taste. When physically examined using testing methods, each characteristic must score an average of at least 60 % from all testers, with no individual characteristic scoring less than 30 % of the maximum points. Adulteration with non-original ingredients and visible bubbles due to repeated fermentation are not allowed.

The Community Product Standard for Herbal Wine (MoPCh.31/2546) [4] defines herbal wine as a type of distilled alcoholic beverage that is produced by processing herbal ingredients. Herbal wine should have an alcohol content not exceeding 15 degrees per 100 milliliters by volume.

Mint, scientifically known as *Mentha cordifolia* Opiz, is a local herb commonly found in Thailand. It belongs to the Lamiales order of the Lamiaceae family. It is a low-growing plant with soft, short hairs covering all parts of the stem. The stem is square-shaped, with green-purple-brown coloration. The leaves are wide, oval-shaped, and have an opposite arrangement on the stem. They are smooth on the surface, have short stalks, rounded tips, and serrated edges and measure 1.5 - 2.5 cm in width and 2 - 3 cm in length. The flowers are arranged in clusters that arise from leaf axils. One of its distinctive features is its refreshing and cool aroma, attributed to the presence of menthol oil [5]. It has a taste similar to lemongrass, lime, and alcohol [6]. As a result, mint is used as an ingredient in various food products, such as ice cream and herbal hot and cold teas. It is also mixed with other herbs in dishes, fresh fruits, desserts, and wine [7]. Picard, M., Franc, C., Revel, G., and Marchand, S. [8] stated that mint contains important compounds, such as monoterpenes, which can influence the aroma of wine. The addition of mint to wine ingredients results in a minty aroma that enhances consumer preference. Martín-Garcia, A., Abarca-Rivas, C. Riu-Aumatell, M., and López-Tamames, E. [9] emphasized that aroma is a crucial qualitative parameter for wine. They identified more than 60 compounds from various chemical classes, including esters, alcohols, terpenes, furans, norisoprenoids, and fatty acids. Volatile evaluations over time revealed a significant relationship between furans and aging.

Herbal wine fermentation present various challenges, such as off-tastes, undesirable colors or odors, low alcohol content, and sweetness [7]. Therefore, the objective of this study

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was to find the appropriate conditions for fermenting wine from mint leaves and stems to achieve the standard alcohol content of 7 - 15 degrees, which is the standard for industrial wine products [2]. Additionally, the study aims to enhance the value of mint and add uniqueness to Thai beverages.

Materials and Methods

1. Studying the Suitable Conditions for Wine Fermentation

The Central Composite Design (CCD) experimental design from the Response Surface Methodology (RSM) was employed to study two independent variables: sugar content (^{o}Brix) and the weight of fresh mint per 600 ml. Each parameter was defined at two levels (two-level factorial design): the lowest (high; -1) and the highest (low; +1) values, as shown in Table 1. The minimum sweetness level was set at 16 and the maximum at 22 ^{o}Brix, based on sweetness levels reported in wine fermentation [10]. This range was chosen to avoid excessive yeast growth and to consider cost-effectiveness.

The minimum weight of fresh mint was set at 25 g and the maximum at 75 g. These values were based on a 1:12 ratio (g/ml) of mint from a report published by Karuwanna, P. [7]. The total number of experimental sets to be conducted was calculated using Equation (1), resulting in a total of 14 experimental sets. The detailed experimental design is presented in Table 2.

$$\text{Number of Experimental Sets (N)} = 2^n + (2 \times n) + 6 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (1)$$

Where

N = the number of experimental sets

n = the number of independent variables

Table 1 The independent variables in the CCD for finding the suitable conditions for wine fermentation

Factor	Name	Coded Low (α-1)	Central (0)	Coded High (α+1)
A	Sugar content (^{o}Brix)	16	19	22
B	Mint content (w/v)	25	50	75

The fresh mint leaves were sorted and cleaned before being weighed according to the experimental sets and blended with 400 ml of clean water. The sugar content was measured using a hand refractometer, and adjusted to the desired level for each experimental set by adding sugar, following the Pierce-Square method [11]. The pH was then adjusted to 3.4 - 3.5 using 0.1 NaOH and 0.1 M citric acid. Subsequently, $(NH_4)_2HPO_4$ was added to achieve a concentration of 0.003 %, and the volume was adjusted with distilled water to reach 600 ml. The mixture was pasteurized at 100 ^{o}C for 5 min and poured into a fermentation tank. Dry yeast, Saccharomyces cerevisiae K1V-116 (1016-02), were prepared in a ratio of 0.3 g per 1 liter of sample and added to the fermentation tank. The fermentation tank was sealed with an airlock and incubated at room temperature (25 - 30 ^{o}C) for 15 days. The parameters were then recorded throughout the fermentation process by collecting 5 ml samples on days 0, 3, 6, 9, 12, and 15. The sugar content, alcohol, acidity, and pH levels were analyzed to determine the optimal fermentation conditions for the next steps.

Table 2 The parameters designed using the CCD method within the RSM program

Treatment	Mint content (g/600 ml) or 4.16 - 12.5 % (w/v)	Sugar content (^{o}Brix)
1	25	16
2	75	16
3	25	22
4	75	22
5	31	19
6	69	19
7	50	16.73
8	50	21.27
9	50	19
10	50	19
11	50	19
12	50	19
13	50	19
14	50	19

2. Study of Wine Maturation at Different Times

The optimal conditions determined from the previous experiments were used. A clear solution was separated from the mixture, filtered through a fine white cloth. Wine sedimentation was settled by adding an 8 % bentonite solution at a rate of 6 ml per liter. The solution was then stored at temperatures ranging from 4 to 15 ^{o}C for 2 days. Afterward, the clear solution was separated and clarified using aseptic techniques, and then fine-filtered using a WHATMAN membrane filter Nylon 0.2 um, 47 mm in diameter. The clarified wine was then bottled, sealed, labeled, and matured at 15 ^{o}C for 0, 1, and 2 weeks. The wine samples from each week of maturation were tested for sensory acceptance by 30 consumers. Additionally, sugar content, alcohol, pH, and acidity levels were analyzed in 3 replicates of each sample at 0, 1, and 2 weeks.

3. Parameter Analysis

The alcohol content (%) of the wine was estimated using chemical equations, and the results were expressed as a percentage (V/V). A graph illustrating the relationship between time and alcohol content was created.

Sugar content (^{o}Brix) of the wine was analyzed using a hand refractometer, and the results were recorded. A graph illustrating the relationship between time and sugar content was created.

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pH values were measured using a pH meter (Mettle brand, Five Easy model, United States), and the results were recorded. A graph illustrating the relationship between time and pH values was created.

Citric acid content in the wine was analyzed using a titration method with 0.1 N sodium hydroxide solution [12], and the results were recorded. A graph illustrating the relationship between time and acid content was created.

Sensory evaluation was performed on 30 general consumers, including university students and staff from Khon Kaen University, Nong Khai Campus. Consumer acceptance was assessed using a 9-Point Hedonic Scale, where 1 indicated 'dislike extremely' and 9 indicated 'like extremely.' The characteristics evaluated included appearance, color, odor, flavor and overall preference. The evaluations were conducted in a laboratory under white light.

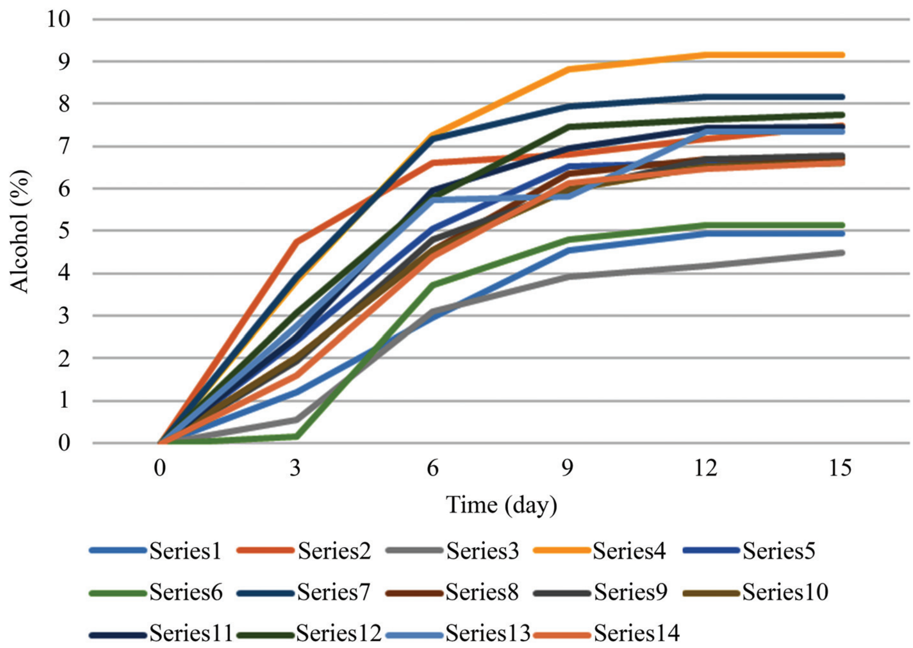
4. Statistical Analysis

The parameter values were expressed as means ± standard deviations. Variance analysis was performed using Analysis of Variance (ANOVA) at a 95 % confidence level. Differences in means were analyzed using Duncan's Multiple Range test with the SPSS Windows Version 28 statistical software.

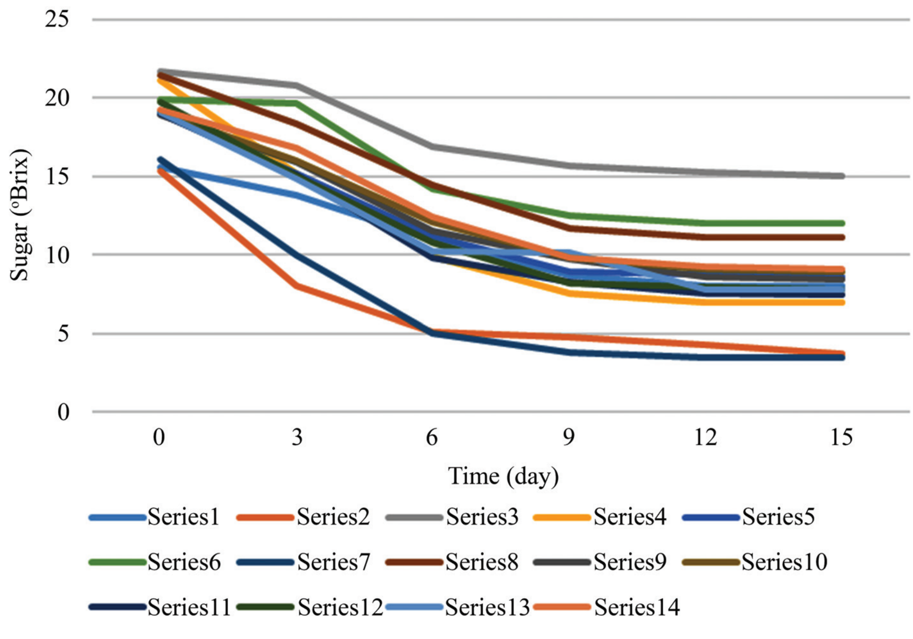
Results and Discussion

1. Suitable Conditions for Wine Fermentation

The parameter values analysis, including sugar content (^{o}Brix), alcohol content (%), acidity (g/100 ml), and pH in the 14 wine treatments during the fermentation process on days 0, 3, 6, 9, 12, and 15 are shown in Figure 1. An increase in alcohol content was observed from day 0 to day 7 in all experimental sets, after which the slope began to decrease from day 9 until day 15 (Figure 1(a)). This trend correlated with the sugar content, which continuously decreased from day 0 to day 7, after which the slope remained constant from day 9 until day 15, as depicted in Figure 1(b). The experimental set 4 had the highest alcohol content, which was 9.15 %, followed by experimental set 7, with an alcohol content of 8.15 %. Both of these sets had remaining sugar content of 7 and 3.15 ^{o}Brix, respectively. Meanwhile, the acidity in all experimental sets slightly decreased from 0.43 - 0.57 % to 0.27 - 0.37 % on day 15, as shown in Figure 1(c). This was consistent with the pH values, which remained relatively stable, ranging from 3.33 - 3.56 on day 1 and 2.96 - 3.65 on day 15, as illustrated in Figure 1(d). Both acidity and pH values were influenced by the raw materials and the fermentation process, with the latter being a significant factor in the production of herbal wines. The organic acids that may form during fermentation include succinic acid, lactic acid, citric acid, and pyruvic acid [13]. The acid content and pH values obtained were close to those reported in herbal wines, with acid levels typically ranging from 0.3 - 0.5 % and pH values in the range of 3.0 - 3.5 [7]. Based on the experimental results, experimental sets 4 and 7 were selected for sensory evaluation by 30 general consumers in order to identify the most suitable conditions for further study in phase 2.



(a) Changes in alcohol content during fermentation



(b) Changes in sugar content during fermentation

Figure 1 Sugar content, alcohol content, acidity, and pH values in the 14 wine treatments

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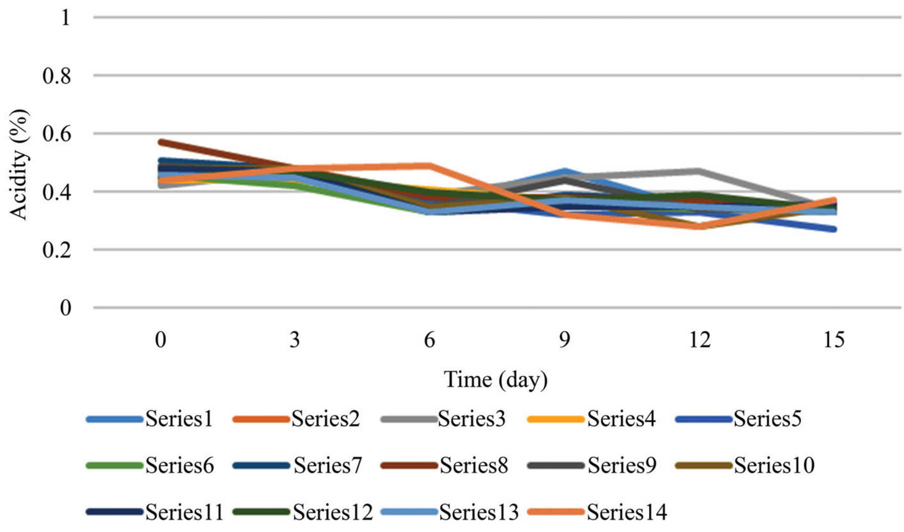
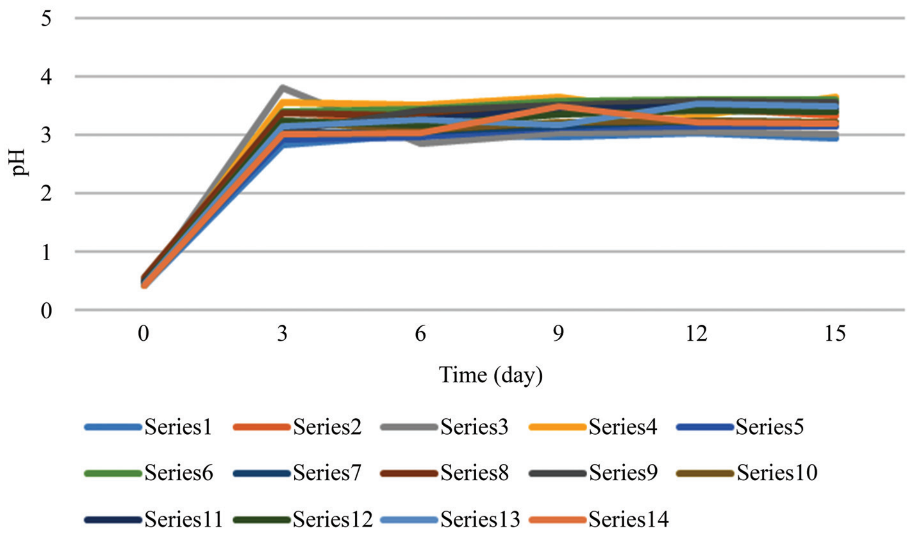


(c) Changes in acidity during fermentation



(d) Changes in pH content during fermentation

Figure 1 Sugar content, alcohol content, acidity, and pH values in the 14 wine treatments (Cont.)

The sensory evaluation of the wine products from experimental set 4 (mint leaves 75 g, 22 ^{o}Brix) and experimental set 7 (mint leaves 50 g, 16.73 ^{o}Brix) is shown in Figure 2. The analysis using One-Way ANOVA (F-Test) at a 95 % confidence level showed that the experimental set 4 received significantly higher scores in terms of odor, sweetness, residual taste, and overall preference compared to experimental set 7 ($p<0.05$). This could be attributed to the higher alcohol content in the experimental set 4 compared to set 7. These two sets were palatable to the majority of consumers owing to a stronger and more distinct aroma. Based on these test results, experimental set 4 was selected as the suitable condition for further study.

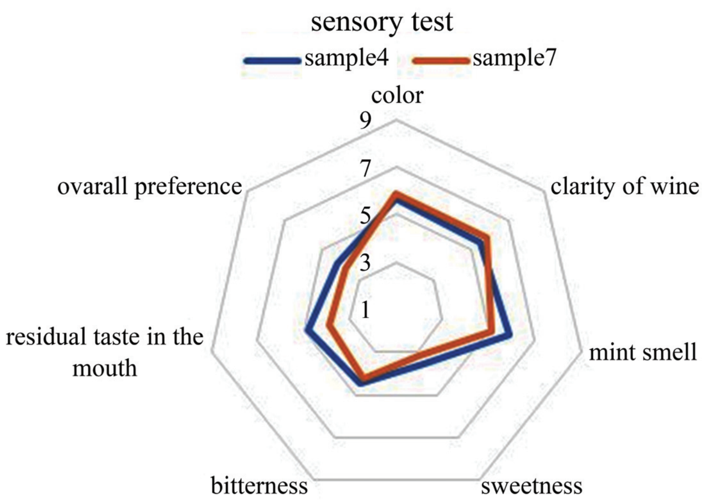


Figure 2 Sensory Evaluation of Wines from Experimental Sets 4 and 7

2. Wine Fermentation at Different Times

Fermentation of mint wine using the conditions from experimental set 4 (mint leaves 75 g and sugar content of 22 °Brix) was compared at different fermentation times and flavor refinement. The experiment was designed in three sets, including: 1) fermentation for 2 weeks followed by aging for 2 weeks, 2) fermentation for 2 weeks followed by aging for 1 week, and 3) fermentation for 2 weeks without aging. The results of various parameters, including alcohol content, acidity, and pH are shown in Table 3. No significant differences were observed in the parameters of all the experimental sets at a 95 % confidence level. Generally, sweetness decreased by approximately 1 - 3 °Brix per day as sugar was converted into alcohol [10]. However, the alcohol content obtained from all three experimental sets was relatively low compared to the initial fermentation experiment. This might have been due to the high and fluctuating temperatures during fermentation, which led to reduced yeast activity [10]. When alcohol content is low, the remaining sweetness tends to be relatively high. Nevertheless, the acidity and pH values for all three experimental sets remained within an appropriate range. In conclusion, the 2-week aging period did not significantly affect the 4 parameters. Wine aging is a process that benefits from a longer duration, as it involves chemical reactions between various substances such as acids, sugars, alcohol, esters, and phenolic compounds. It also involves the precipitation of proteins, microbial cells, and various suspended particles to clarify the wine, resulting in a clear wine with desirable taste, color, and aroma.

Table 3 Parameters of Wine fermentation at weeks 0, 1, and 2

Set	Aging time (week)	Sugar content (°Brix)	Alcohol content (%)	Acidity (g/100ml)	pH
A	2	10.00±0.10	7.81±0.08	0.34±0.03	3.72±0.01
B	1	10.33±0.23	7.85±0.15	0.32±0.02	3.71±0.04
C	0	10.13±0.12	7.90±0.13	0.34±0.02	3.70±0.02

Mean ± Standard Deviation

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The sensory evaluation of mint wine products was conducted using the experimental set A (2 weeks aging), with sugar levels adjusted to 12, 14, and 16 °Brix using spearmint syrup. This evaluation involved 6 samples with varying fermentation times and sugar adjustments, as depicted in Figure 3. It was observed that all samples differed significantly in terms of odor, sweetness, bitterness, residual taste, and overall preference, with statistical significance at a 95 % confidence level. However, there was no difference in color and clarity among the samples.

The overall preference scores showed that samples with a sugar adjustment of 12 °Brix received the highest scores for odor, sweetness, residual taste, and overall preference, compared to set C (samples with a 2-week fermentation time and no sugar adjustment) with 10 °Brix. The difference in overall preference scores was not statistically significant ($p>0.05$). In contrast, samples with no aging received the lowest overall preference scores, with statistical significance ($p<0.05$). Samples with a sugar adjustment of 16 °Brix received the highest scores for color, clarity, and odor, although there was no statistically significant difference compared to samples with a 12 °Brix sugar adjustment ($p>0.05$).

These results suggest that aged wine had better sensory characteristics compared to non-aged wine, even though there were no significant differences in their chemical and physical attributes. Sensory characteristics could be further improved by adjusting flavoring agents, taste, and sugar content. This aligns with research on wine consumption behavior and consumer attitudes towards homemade wine in the middle-market [14], which identified key factors in wine selection as cleanliness, sweetness, and the prominence of ingredient aromas. Longer aging processes also contribute to desired sensory attributes, as they involve various chemical reactions between substances such as oxygen increase on the surface, esters decay, and the precipitation of proteins, microbial cells, and various suspended particles, resulting in clear wine with a pleasant taste and aroma.

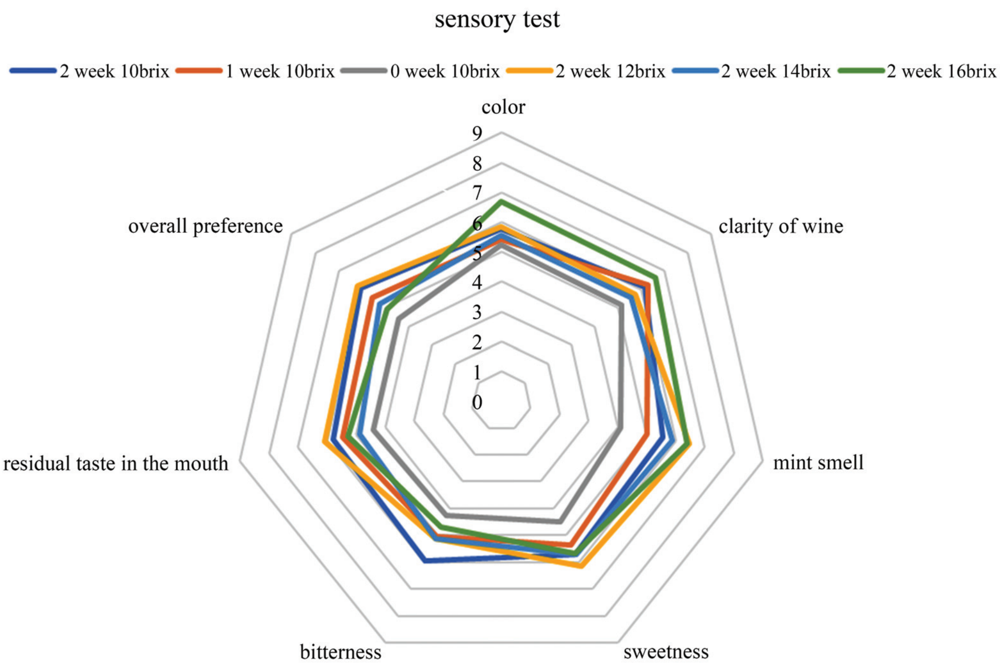

Figure 3 Sensory evaluation of wines with different aging and sugar adjustments

Conclusion

Set 4 (mint leaves 75 g, 22 ^{o}Brix) had the highest alcohol content in the first phase of the experiment, and consumers were also the most satisfied with its aroma and residual taste characteristics of set 4. Therefore, set 4 was deemed suitable for further study in phase 2, where it was observed that aging did not significantly affect alcohol content, sugar, pH, and acidity levels. However, consumers expressed greater satisfaction, particularly in the sample aged for 2 weeks with a sugar adjustment of 12 ^{o}Brix, which received the highest scores for aroma, sweetness, residual taste, and overall preference.

This study highlights the potential benefits of mint beyond its general use as a herb or food additive. It underscores the value addition potential of mint, particularly when further developed and enhanced. Such efforts can increase the value of mint leaves and promote the development of innovative products derived from mint.

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