Composition analysis during the fermentation of dessert wine

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Abstract. The organic acid, tannin, ethanol, methanol and other components in sweet wine are important factors that affect the taste and flavour of sweet wine, and are also indicators for exploring the winemaking process and controlling the quality of products. This study primarily used ion chromatography to study the changes of acids in the winemaking process. Besides, this work also measures the proportion of other compositions including Soluble Solids, Ethanol and pH value by designing orthogonal test. The experimental result shows that the physicochemical indexes of Passito wine are 20.5° Brix, with a total acid content of 6.83 g / L. The alcohol content of the original wine is 12.0% vol, and the pH value is 3.42. It provides a reference for the control of various components such as organic acids and the supervision of wine during the winemaking process. To open up new channels for the development of other fresh fruit dessert wine brewing technology, it is of scientific and practical significance to optimize the fermentation conditions of dessert wine and improve the processing technology.

1. Introduction
Dessert wine, also known as sweet wine, pudding, and liqueur, is a wine that is generally used to drink after dessert. For dessert wines, European countries have different definitions. In the United Kingdom, dessert wine can refer to any sweet wine that can be used with meals, as opposed to white enhanced wine (such as sherry) before dinner and red enhanced wine (such as Port) \cite{1-2}. The manufacturing process of dessert wine is usually in the wine fermentation process, if alcohol is added, the fermentation will not continue, and the sugar will remain in the wine to maintain its sweetness, and the alcohol content will be increased to 19% or more \cite{3-5}.

Studying the changes in the content of various ingredients in the fermentation process of dessert wine can open new channels for the development of other fresh fruit dessert wine brewing technologies, and has scientific and practical significance for the optimization of dessert wine fermentation conditions and the improvement of processing technology \cite{6}.

The wine is made from fresh grapes or grape juice as raw materials, and is fully or partially fermented. The alcohol content is not less than 7.0%. During the brewing process, the initial organic sugar content is too high, which will prolong the fermentation cycle and increase the osmotic pressure of the solution. Large, leading to abnormal yeast metabolism, increased production of acetic acid, seriously affect the wine acid types and content changes will affect the wine's acid-base balance, which will affect the wine's flavor. Malic acid is the main organic acid in wine, with astringent and green flavor. In the fermentation process, the sour and astringent malic acid can be converted into mellow and soft lactic acid. The acidity of tartaric acid is weaker than that of malic acid, and slightly stronger than other acids. The acidity is tough and sharp, and it is generally not metabolized during the brewing process. Lactic, acetic, and succinic acids are produced during the fermentation of wine. Succinic acid is both sour and bitter. The acidity of lactic acid is weak. The acetic acid has a vinegar taste. Relevant work
tasks, the acidity of wine grapes should be 6-10 g / L, otherwise it is prone to dull, dull sensory characteristics.

During the wine making process, the content and types of organic acids will change and affect the formation of wine flavor. During the fermentation process, malic acid is partly degraded by alcohol fermentation, partly reduced by the malic acid-lactic acid fermentation route; partly tartaric acid is precipitated by potassium tartrate, partly degraded by lactic acid bacteria into lactic acid and acetic acid, the content is reduced; lactic acid, succinic acid and acetic acid. Both showed an upward trend, and the total amount of organic acids decreased. Citric acid is metabolized to produce diacetyl, which can enrich the flavor of wine. Researches by Yang et al. [6] have found that citric acid has a higher production rate than the degradation rate due to the early fermentation, and the content increases, and then it is gradually decomposed during malic acid-lactic acid fermentation. Similar to Yang’s work [6], Ren Xiaoning's [7-8] research shows that during the fermentation process, reducing the ethanol content and increasing the glucose concentration can increase the citric acid metabolism, which provides a theoretical basis for the citric acid metabolism control in the actual process [9].

Ion chromatography is a kind of high-performance liquid chromatography, and its separation principle is to use the difference of the ion exchange capacity of different ions to be measured to achieve the separation. Yang et al. [10] used ion chromatography to simultaneously determine the content of nine organic acids in wine, and used it as a detection method to study the law of organic acid change and the amount of quantitative change in the process of making Cabernet Sauvignon grapes from grape juice to raw wine. Zhang Si et al. [11] used ion chromatography to simultaneously determine the nine organic acids in Likou wine, and analyzed the influence of wine region, year and main components on the content of organic acids. Tian Peng et al. [12] conducted a systematic study on the retention behavior of organic acids in beer and white wine on anion exclusion chromatography columns, and determined that the optimal chromatographic conditions were hydrochloric acid concentration 1.10 mmol / L, flow rate 0.80 mL / min, and tetrabutylammonium hydroxide. The concentration is 5.0 mmol / L and the flow rate is 1.10 mL / min, which avoids the interference of water negative peaks on organic acids. Du Lijun et al. [13] first used ion chromatography-tandem mass spectrometry to detect tartaric, malic, citric and succinic acids in wine. Ohira et al. [14] used N, N-dimethylaminoethyl methacrylate-modified cellulose membranes to transfer organic acids from complex samples to ultrapure water by electrodialysis, and detected them by ion exclusion chromatography, and filtered samples with only 0.45 μm membranes. Compared with it, the early mixed peaks are significantly reduced. Ion chromatography has good reproducibility and accurate detection results, which can meet the requirements of simultaneous detection of organic acids in food, and has high sensitivity. It is an effective method for analyzing low-content and low relative molecular weight organic acids in wine, but the analysis period is longer. Not suitable for rapid testing of samples [15-17].

2. Materials, methods and experimental result

2.1. Organic Acids Measurement

2.1.1. Material and instrumentation Ion chromatograph, equipped with conductivity detector and automatic sampler, automatic regeneration suppressor, ultrapure water, anion standard solutions.

2.1.2. Methodology. Tartaric, malic, succinic, lactic, acetic, and citric acids are the main organic acids in wine, of which malic acid and tartaric acid account for more than 90% of the total acid. Malic, tartaric and citric acids are derived from the grape itself [4]. Acetic, lactic and succinic acids are mainly produced during the fermentation process, and citric acid can be added artificially. Citric acid can improve the flavor of wine, but too much will produce too much acetic acid, resulting in uncoordinated taste and harm to human health, so the amount of citric acid should be strictly limited [5-8].
2.1.3. Experiments and results. Through analysis of various experimental influencing factors such as chromatographic column, flow rate, solution pH, initial gradient concentration, etc., gradient elution conditions suitable for the separation of 26 components in liqueur were explored, and multi-level gradient elution-ion chromatography was established as the method for simultaneous determination of liqueur organic acid and anions as shown in figure 1.

![Figure 1](image1.png)

**Figure 1.** The Total Acidity within 10 days by using ion chromatogram. X-axis is time (half days each), Y-axis is the total acidity (mg/L).

In summary, during the liqueur brewing process, the soluble solids showed a downward trend, and the higher the fermentation temperature, the shorter the sugar consumption start time, the faster the sugar consumption rate; in the liqueur brewing process, the total of the acid content remained relatively stable, or decreased slightly. During the brewing process of sweet wine, the content of volatile acid showed an upward trend, and they all met the standard value of sweet wine's acid content \( \leq 2.1 \) L. Its soluble solids content is 20.5° Brix, with a total acid content of 1.6 g / L and a wine precision of 8.2%, has laid the foundation for further research on cost reduction and fermentation intensity.

The total acid content is 12.3 L, and the volatile acid content is 66.0 mg / L. At the same time, according to the selected pre-treatment method and ion chromatography conditions, the content of organic acids and anions in the actual wine sample was detected. We get the ion chromatogram of the liqueur sample as shown in figure 2.

![Figure 2](image2.png)

**Figure 2.** The Variation of Total Icon Chromatogram Within 60 mins (g/C).
2.2. Other elements measurement

2.2.1. Material and instrumentation: Passito wine, sodium hydroxide, benchmark potassium hydrogen phthalate, phenolphthalein, 95% ethanol, glucose, sodium sulfite. Facilities: MIS-3750 autoclave, SANYOElectric Co., Ltd.; GNP-9160 water-proof constant-temperature low-temperature incubator, a-type AC-DC dual-use electronic scale, Delta320 pH meter, DHG-9240 electric heating constant-temperature low-temperature incubator, a-type AC-DC dual-use electronic scale, Delta320 pH meter, DHG-9240 electric heating constant-temperature air drying oven VS-1300 ultra-clean workbench, volatile acid distillation device, alcohol distillation device, alcohol density hydrometer, SP-2000 gas chromatograph, VARIAN-100C ultraviolet spectrophotometer, juicer, fermentation tank, aging storage tank.

2.2.2. Methodology and experiment on soluble solids. The test fermentation is limited to 10 days, with room temperature (20°C) and the orthogonal test method is used to explore the determination of the soluble solids content during the fermentation of dessert wine by changing the temperature factor. A hand-held refractometer was used to quantitatively test the content of soluble solids (unit, Brix) in dessert wine.

Changes in soluble solids content during dessert wine brewing. During the fermentation process of dessert wines, the changes in soluble solids content at different temperatures are shown in the figure 3. The content of soluble solids is related to the sugar content of dessert wine (the sugar content of the finished product should be ≥125 g/L), which plays an important role in its taste. It can be seen from the figure that the inoculation amount has no significant effect on the yeast's ability to consume sugar. The higher the fermentation temperature, the shorter the start fermentation time. Determination of basic ingredients. The test determined that the content of soluble solids in the basic ingredients of grape juice was 38.5 mg/L.

2.2.3. Methodology and Experiment on Ethanol and pH. During the main fermentation of dessert wine for 10 days, the total sugar, total acid, ethanol and pH value all showed different and complicated changes, as shown in the figure 4. Due to the addition of sugar on the 2nd and 4th days of fermentation,
the alcohol content of the original wine is 12.0% vol, the total acid is 6.83 g / L, and the pH value is 3.42, which has reached the technical indicators for the production of fruit wine original wine [18].

As we can see in the figure 4 and 5, dessert wine contains methanol at the beginning of fermentation, and then declines slightly, and rises slightly at 72 h after fermentation, and has remained at a relatively stable level since then, which is consistent with the research report of wine, indicating that the methanol in dessert wine It is not a product formed by the fermentation of fruit wine, but the pectin of the raw material itself is hydrolyzed under the action of pectin methylase to produce pectic acid and methanol. Therefore, the methanol content in the fruit wine and the pectin content of the raw material. There is a certain correlation.

![Figure 4. Methyl Alcohol Percentage Within 10 Days.](image)

![Figure 5. Tannin Percentage Within 10 Days.](image)

3. Conclusion
After the sweet wine is artificially added with sugar and fermented with suitable yeast, the alcohol content is 12.0% vol, the total acid is 6.83 g / L, and the pH is 3.42. These main indicators have fully met the standard requirements of the original wine production, indicating that as long as the process design is reasonable. It is feasible to produce high-quality fermented raw wine by adding sugar.

The content of tannin is basically unchanged during the fermentation of sweet wine, indicating that the fermentation process has no effect on the content of wine tannin. During the main fermentation, post-fermentation and aging, as long as the process selection is reasonable and properly controlled, the
quality and safety index of liqueur-volatile acid can be completely controlled at 1.0 g / L (national standard ≤ 1.20 g / L).

The methanol content in the fermentation process of sweet wine is basically stable and is in the industry standard (≤400 mg / L) within the allowable range. Sweet middle and higher alcohols are by-products that accompany yeast fermentation and are produced simultaneously with ethanol. Aroma components such as acetaldehyde, ethyl acetate, ethyl caproate, ethyl valerate, and ethyl lactate and some unknown components were also detected during fermentation.

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