Physicochemical characterization of pineapple peel wine

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Abstract. Pineapple peel was used for the elaboration of wine as an alternative to traditional fruit wine. The evolution of quality parameters of the wine through the whole winemaking process was monitored. Significant changes occurred over the winemaking process were noted. Results pointed out that the utilization of pineapple peel in the fermentation of fruit wines was a viable alternative, which not only made full use of fruit waste resources, but also developed a new product into the market.

1. Introduction

The increasing demand of wine, as popular alcoholic beverages, has stimulated value-added product development. Currently, the wine market is turning to diversification by means of the development of different products through innovative craftsmanship and alternative raw materials. On the meaning time, nowadays the phenomenon of food waste has attracted considerable interest from the whole society. Food waste involves a sustainability issue related to food security and an economic problem reducing the profitability of manufacturers as well. Given the issue, it is time to effectively manage food waste.

Pineapple peel, produced by processing industry, represent 29-40\% (w/w) of the whole pineapple weight[1]. Abundant evidence indicates the presence of crucial bioactive substance and aroma compounds in pineapple peels[2-3]. The development of pineapple peel wine not only can help minimize the waste burden, but also meet the intensive demand from the public for novel quality products. In spite of the fact that some study on pineapple wine has already been conducted, there is litter report on pineapple peel wine, covering the whole fermentation process[4-5]. Consequently, the purpose of this study was to produce and investigate the promising prospects of pineapple peel wines as novel alcoholic beverage.

2. Materials and Methods

2.1. Chemicals and reagents

Yellow mauritius pineapple were purchased from Nanpai Farms (Zhanjiang, Guangdong Province).
Pectinase, cellulase, and tutin (98%) were obtained from Shanghai Yuanye Biological Technology Co., Ltd. Folin-Phenol was obtained from Sigma–Aldrich (St. Louis, MO, USA). In addition, sodium nitrite, aluminum chloride, sodium hydroxide, anhydrous sodium carbonate, and phenolphthalein were all analytically pure and purchased from Sinopharm Group.

2.2. Wine making
The pineapple peel was added to distilled water at a ratio of 1.5:1 and then subjected to maceration treatment at 70°C for 30 min. Whereafter, the samples were cooled to 45 ± 5°C and subjected to enzymatic hydrolysis, using cellulase and pectinase as catalysis. Then, the must was pumped into the fermentor for the fermentation using yeast QA23 (200mg/L) at 18°C, and diluted with a sucrose solution to adjust the sugar content to 20°Brix. Sulfur dioxide, in the form of sodium metabisulfite, was added up to a concentration of 60 mg/L to inhibit the growth of bacteria. When the sugar content had no significant change, fermentation termination could be determined.

2.3. Quality parameters of and wines
The titratable acidity (TA), pH value, soluble solids, alcohol, total flavonoids and phenolic content were determined at regular intervals throughout the fermentation according to the methods in GB/T 15038-2006[6]. The determination of total flavonoid content was adopted aluminum chloride color method, and total phenols content was determined by the Folin–Ciocalteau method[7].

2.4. Statistical analysis
Samples were analyzed in triplicate for each wine replicate and results expressed as the mean value and standard error.

3. Results and discussion
3.1. Changes in pH and TA during fermentation
The pH and TA, reflecting the change of free acid during fermentation, have a critical contribution on the color, aroma and flavor of fermented products and their levels can be used as an index of shelf-life. The pH and TA were illustrated in Figure 1. In the first 3 days of fermentation, the pH value dropped significantly, and the pH value was 3.14 at the 3rd day. Then, the pH value remained constant until the end of the fermentation. Nonetheless, some fluctuations in its concentrations were detected. Simultaneously, initial total acid value for pineapple peel must was 3.06 ± 0.04 g citric acid/L and increased until the 4th day of fermentation. Subsequently, the trend was nearly flat, with little change. Similar trends have been demonstrated in other fruit wines as well[8].

This phenomenon might be, because a-ketoglutaric and succinic acids are produced in the glyceropyruvic fermentation pathway, especially in the early stage of fermentation. Pyruvic acid, produced in glycolysis and in glyceropyruvic fermentation, goes on to form other secondary products, like a-ketoglutaric acid, 2,3-butanediol.
3.2. Changes in soluble solids and alcohol during fermentation

The soluble solids in must mainly involve soluble sugars contained in the fruit itself and the addition of sucrose. Figure 2 shows that initial quick decrease followed by a final stability, with the increasing of time. By the 8th day, the soluble solids had dropped to 7.50 °Brix. As fermentation proceeds, yeast continues to decompose carbohydrates. At the beginning of the alcoholic fermentation, yeast reproduces and metabolizes vigorously, decomposing carbohydrates quickly, so the soluble solids content declines faster, but ethanol gradually accumulates during winemaking and the pH decreases. The reduction of sugars and other factors will inhibit the anabolic activity of yeast, which in turn slows the decline of soluble solids until balance is maintained in the late fermentation.

Alcohol is a critical parameter for evaluation of fruit wine quality. The alcohol content of pineapple peel wine increased continuously with the increase of fermentation days. The maximum content of alcohol was obtained at the 8th day in the fermentation(Figure 2). Pineapple peel wine has a negative correlation between the the content of alcohol and soluble solids. At the beginning of fermentation, alcohol accumulate fastly with sugar metabolism vigorous. As fermentation proceeds, more yeast is in aging, raw materials become more scarce, and external factors become worse. It was 7 days after fermentation that many factors such as alcohol level and bacterial aging caused the yeast to synthesize ethanol at a slower rate until it remained stable in the late fermentation period.
3.3. Changes in Flavonoids during fermentation

Flavonoids, mainly cyanidin-3, 5, 3'-triglucoside and cyanidin-3, 5-diglucoside in pineapple peel, are essential for the quality of wine through their contribution to oxidative stability and organoleptic characteristics[10-11]. Flavonoids content showed a tendency to increase during fermentation(Figure 3). The total flavonoids increased quickly in the first 3 day, Subsequently, fluctuated and rised slightly. This phenomenon can be explained that more flavonoids are gradually dissolved with the increase of alcohol produced by yeast and flavonoids are so unstable and susceptible.

Figure 3. Evolution of flavonoids in wine during the winemaking.

3.4. Changes in phenolic substances during fermentation

Pineapple peel is abundant in phenolic substances, such as N,N'-diferuloylspermidines, cyanidin hexosides, quinic and isocitric acid[9]. Phenolic compounds are essential for the organoleptic characteristics by influencing the colour, astringency and aroma[10]. Figure 4 shows the changes of the total phenols content during fermentation. Initial phenols content of the must was 406.60 mg GAE/L. Phenolics increased with increasing winemaking process and a large amount of phenolics was reached in the 5 day. After the equilibrium time, phenolic content remains basically unchanged. In the early stage of the fermentation, phenolic substances were gradually leached out, leading to a gradual increase in total phenols content in the wine. This may be due to the increasing alcohol content in the fermentation broth and the production of large amounts of carbon dioxide, which are conducive to the leaching of polyphenols into the wine. Up to now, the research conclusions on the changes of polyphenols during the fermentation of fruit wine are not consistent. Qi concluded that the polyphenol content fluctuated during the fermentation of kiwi wine[11] . However, a slight decrease in the total phenolic content in pomegranate wines has also been reported[12]. The main reasons for the above different research results are that there are many factors that affect the change of total phenolics content such as the characteristics of the fruit used and winemaking processes[13]. Therefore, further research should be focused on the rules and mechanisms of polyphenols changes throughout the fermentation stage in conjunction with specific fermentation processes.
Figure 4. Evolution of phenolic substances in wine during the winemaking.

4. Conclusion
A new kind of pineapple peel wines has been developed and assessed in this study. Their main quality parameters throughout the whole winemaking process were monitored. A manifest role of the fermentation stages on the final quality of the wine was remarked on. After fermentation, the wine produced contained 14.71% vol (v/v) alcohol, in line with the requirements of low-alcohol health wine. The soluble solids only is 7.50°Brix, the content of titratable acid, total flavonoids and phenolic were 3.06 g citric acid/L, 182.76 mg GAE/L and 675.43 mg GAE/L, respectively. It is necessary to further study how to preserve and enhance as much as possible those desirable wine properties in the whole winemaking stages, so as to achieve pineapple peel wines with improved characteristics.

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References
[1] Choonut, A., Saejong, M. and Sangkharak, K. (2014). The production of ethanol and hydrogen from pineapple peel by Saccharomyces cerevisiae and Enterobacter aerogenes. Energy Procedia. 52:242–249.
[2] Riya, M. P., Antu, K. A., Vinu, T., Chandrakanth, K. C., Anilkumar, K. S. and Raghu, K. G. (2014). An in vitro study reveals nutraceutical properties of Ananas comosus (L.) Merr.var. Mauritius fruit residue beneficial to diabetes. J. Sci. Food Agric. 94:943–950.
[3] Freitas, A., Mold–ao-Martins, M., Costa, H. S., Albuquerque, T. G., Valente, A. and Sanches-Silva, A. (2015). Effect of UV-C radiation on bioactive compounds of pineapple (Ananas comosus L. Merr.) by-products. J. Sci. Food Agric. 95:44–52.
[4] Dellacassa E , Trenchs O , Laura Fariña, et al. (2016) Pineapple (Ananas comosus L. Merr.) wine production in Angola: Characterisation of volatile aroma compounds and yeast native flora[J]. International Journal of Food Microbiology, 241.
[5] Pino J A , Queris O ., (2010) Analysis of volatile compounds of pineapple wine using solid-phase microextraction techniques[J]. Food Chemistry, 122(4):1241-1246.
[6] GB/T 15038-2006, Wine, fruit wine general analysis method.
[7] Zhang G. W., He L., Hu M. M.(2011) Optimized ultrasonic-assisted extraction of flavonoids from Prunell avulgaris L. and evaluation of antioxidant activities in vitro. Innovative Food Science & Emerging Technologies, 12(1): 18-25.

[8] Hidalgo, C., Torija, M. J., Mas, A., & Mateo, E. (2013). Effect of inoculation on strawberry fermentation and aceticification processes using native strains of yeast and acetic acid bacteria. Food Microbiology, 34, 88–94.

[9] Christof Björn Steingass, Glock M P , Schweiggert R M , et al. (2015) Studies into the phenolic patterns of different tissues of pineapple (Ananas comosus [L.] Merr.) infructescence by HPLC-DAD-ESI-MSn and GC-MS analysis. Analytical & Bioanalytical Chemistry, 407(21): 6463-6479.

[10] Czyzowska, A., & Pogorzelski, E. (2002). Changes to polyphenols in the process of production of must and wines from blackcurrants and cherries. Part I. Total polyphenols and phenolic acids. European Food Research and Technology, 214(2): 148–154.

[11] Qi Y., Fan M., Cheng Z., Huang J., Miao Z. (2016) Study on Polyphenol Composition and Antioxidant Properties of Kiwi Wine in Main Fermentation Process. Food Research and Development, (24): 6-12.

[12] Mena P , Girones-Vilaplana A , Marti N , et al. (2012) Pomegranate varietal wines: Phytochemical composition and quality parameters. Food Chemistry, 133(1): 108-115.

[13] Bénédicte L, Isabelle K, Laurent P, Pierre-Louis T. (2013). Evolution of Analysis of Polyphenols from Grapes, Wines, and Extracts. Molecules, 18: 1076-1100.