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Quality Changes of Merlot Grape in Different Plots in Shihezi Region during Ripening Period

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Abstract. In order to analyze the fruit ripening quality of Merlot grapes in the blocks of 5-1, 5-2 and 5-3 in Shihezi region, various physicochemical indexes of Merlot grapes in different blocks were measured from August 23 to September 7, 2017 and 2018, respectively. The results showed that as the grapes maturation, the sugar accumulation showed an upward trend. The total sugar content of the three plots during the ripening period was 194.2-259.1 g/L (measured by glucose), and the total sugar of 5-1 was the highest, 259.1 g/L. The total acid content showed a downward trend, ranging from 9.3 to 4.6 g/L (measured by tartaric acid), the highest value in 5-1 was 5.3 g/L when was harvested, and the fastest decline of total acid belonged to 5-3 plots. PH was generally on the rise from 3.39 to 3.83, meanwhile increase of 5-3 grapes was the fastest compared with other two, with a small difference between 5-1 and 5-2.Tannin continued to decrease with the change range between 6.24 and 1.04 mg/g, and tannin in block 5-2 decreased the fastest with both 2.08 mg/g of 5-1 and 5-3. The content of total phenol decreased after increase. 5-3 grape increased the fastest and also decreased the fastest block from 46.25 mg/L to 104.779 mg/L to 44.118 mg/L. 5-1 total phenol rose in the second place, but decreased in the slowest, and finally remained at 60.662 mg/L. The content of anthocyan in 5-1 had been on an upward trend, rising to the highest level of 111 mg/L eventually, 5-2 and 5-3 rapidly rising and then slightly decreasing. The chroma was also decreased after increase, and the fastest rising belonged to 5-1 from the lowest point of 9.563 to the highest point of 16.186, and fell slowly to 14.363. 5-3 rose to 12.75 with the slowest speed and fall to 11.05 with the fastest rate. Through comprehensive analysis of the indicators of the three plots combined with the growth environment, the fruit quality of the plot 5-1 was relatively good, which was the most suitable growth and ripening of Merlot grapes.

INTRODUCTION

Shihezi region is one of the best wine grape producing areas in China, which has many years history of grape planting and wine production. Unique geographical location and climate conditions make Shihezi a “golden zone” for grape cultivation. The temperature difference between day and night in this area is big, which endows grape with rich pigment and sugar. The winter is very cold, and the bad climate environment reduces the occurrence of diseases and pests. The main grape varieties planted in the area include Cabernet Sauvignon, Merlot, Carmenere, Chardonnay.

Merlot is originally from Bordeaux in France, which was introduced to China in 1980s.Due to its strong adaptability, good disease resistance and high productivity, Merlot has become the main red wine varieties in various producing areas in China. From July to September in Shihezi is its coloring to maturity stage, it is usually characterized by low tannins and low acidity. Therefore, Merlot wines tend to be round and smooth.

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The quality of grape can be expressed by the parameters of total sugar, total acid, tannin, total phenol, anthocyanin content. Due to the influence of external factors during the ripening of Merlot grape, the grape quality of different geographical location will be different in the same period, and the grape quality will also change in the same geographical position and different period. Grape quality changes continuously during the ripening process, which directly affects wine quality. Therefore, the determination of these indicators is a necessary condition to regulate the grape maturation process and to produce wine of different styles and qualities.

Grape quality varies with plot because of soil, topography, management and management. Color conversion to maturity is an important period of grape growth. During this period, both the external quality and internal quality of the grape will change significantly. Through the study on the quality change of Merlot grape in Shihezi production area during the period of color conversion to maturity, and the analysis of soil, climate, topography and other conditions of different plots, some reasonable suggestions for the production and management of Merlot grape in this area can be put forward.

The quality of grape is constantly changing, and each quality index shows different trends in the process of grape maturation.

Kennedy *et al.*, and Muñoz-Robredo *et al.*[1-2] tested the organic acid, anthocyanin and other indicators of wine grapes from the color transition period, and found that the organic acid content was decreasing and the pigment content was increasing in the mature process of grapes. Dafny-Yalin *et al.*, Morlat and Bodin and Filippetti *et al.* [3-5] found that after the color transformation of wine grapes, reducing sugars were continuously accumulated, titration acids were continuously decreased, tannin content was decreasing, and anthocyanin content was gradually increasing. Zhang *et al.* [6] found that the soluble sugar, anthocyanin, pH and glycolic acid ratio of the fruits of different grape varieties showed an upward trend during the ripening process, while titratable acid content showed an upward trend and then a downward trend. According to the research of Su *et al.* [7], in the process of grape ripening, reducing sugar content and ratio of glycolic acid increased constantly, and the total acid content decreased constantly. The content of polyphenol in the pericarp and seed decreased first and then increased gradually. As the harvest period went on, the sensory quality of the wine improved gradually. Total flavonoids of seeds, total flavonoids of skins and total anthocyanins of skins had the greatest influence on the quality of grapes and wines. The polyphenol maturity of grapes was relatively good, and the quality of wines produced was relatively good. Li *et al.* and Laureano *et al.* [8-9] studied the indicators of sugar and titratable acid in grapes from the initial ripening stage to the harvest stage, and found that the total sugar, reducing sugar and sucrose content of fruits were continuously accumulated with the time of harvesting, while the hardness change was not obvious, and the titratable acid content gradually decreased.

Different topography, soil, water, light, temperature, and human treatments affect the quality of the grapes. The research results of des Gachons *et al.* [10] indicated that the producing area had significant influence on the main quality indexes such as berry size, sugar, acid and phenol content of wine grape fruits. Ju and Howard, Esteban *et al.*, and Doshi *et al.* [11-13] found that the producing area had significant effect on reducing sugars, total acids, pH, total phenols, tannins and total anthocyanins content of grape fruits. Wang *et al.* [14]evaluated effect of three soil types, aeolian, sierozem and irrigation silting soil, on the composition of Cabernet Sauvignon grapes in the Helan Mountainse. The grapes growing on the aeolian and sierozem soils matured sooner than those grown on the irrigation silting soil. The highest sugar, sugar to acid ratio and anthocyanin in grape were accumulated on aeolian soil. The grapes grown on the sierozem soil had the highest total phenol and tannin contents. The irrigation silting soil formed higher acidities, The berries quality from the irrigation silting soil was lower.

Tesic *et al.* [15] researched effect of air temperature in October and January, rooting depth, seasonal rainfall, clay-to-silt ratio in topsoil, and gravel percentage on grape during the maturation, and found that Site Index was related to volumetric soil moisture and soil temperature, especially with air temperature, clay-to-silt ratio and rainfall, which affected significantly canopy trait, vegetative growth, precocity of veraison, as well as malic acid, total anthocyanins, and TSS in grape fruit. Over the same period, influence of Site Index to viticultural variables was superior to climatic indices, which proved potential for vineyard zoning and site selection to grape quality.

Investigation of Koundouras *et al.*, [16] on influence of site on *Vitis vinifera* L. cv. Agiorgitiko grape in the Nemea appellation area in southern Greece demonstrated that water status between sites was in connection with the earliness of shoot growth cessation and veraison. Water deficit promoted increase of sugar and breakdown of malic acid in grape. Early water deficit could enhance the concentration of anthocyanins, total phenolics as well as glycoconjugates of the main aromatic component in grape with accumulation of bound volatile compound, which provided a basis for producing optimum wines under stressed vineyards. Navarro *et al.* [17] evaluated changes of leaf macronutrient for four Spanish grape cultivars, Bobal and Crujidera Tempranillo and Cabernet Sauvignon at different growth stages, and testified that polyphenols, tannins and anthocyanins increased with grape maturation, and meanwhile the biosynthetic potential producing resveratrol relied completely on the grape variety.

There are three soil structures in the Shihezi production area: one is a 100% sandy loam structure, with good soil ventilation, drainage, water conservation and fertilizer conservation, and strong summer radiation. The heat dissipation and heat absorption are consistent, and the light and heat from the ground to the surface of the grape is uniform. The second contains 20% sandy loam and 80% clay loam soil structure, the characteristics of the soil is poor permeability, heat preservation good, easy water, the root easily suffocate, promote the anaerobic microbial activity, poisoned root system, drought and easy to harden and which goes against the grape root, aboveground growth and fruit quality (uneven heat and cooling).The third soil structure contains 70% sandy loam and 30% clay loam.

Based on this, this study chose the above three kinds of soil structures in the Shihezi region, respectively as 5-1, 5-2 and 5-3, to research the effect of three soils change on the Merlot grapes' basic physical and chemical indexes in the mature process, which provide theoretical basis for the sustainable cultivation purpose of high quality, stable production, green and high efficiency in Merlot grape production in Shihezi region.

MATERIALS, INSTRUMENTS AND METHODS

Materials

This test site was selected at three parcels of land in Xinjiang West Region Mingzhu wine industry LTD's quality park, each of which is 13.33 hm^2 and 5-1 plot is 100% sandy loam structure. There are great differences in soil structure between plots 5-2 and 5-3. 5-3 soil structure contains 80% clay loam in addition to 20% sandy loam. 5-2 soil contains 70% sandy loam and 30% clay loam, that is, in terms of the proportion of sandy loam from high to low is 5-1> 5-2 >5-3, and the proportion of clay loam from high to low is 5-3 > 5-2 >5-1. They are from south to north of hedge cultivation with unified pruning and irrigation for 45º of single tendril inclined slightly.

Cabernet Sauvignon grapes were collected from plots 5-1, 5-2 and 5-3, respectively, from 8 a.m. to 10 a.m. on 23 and 28 August, 2, 7 and 14 September, 2017 and 2018, respectively. The collected samples were immediately stored in a refrigerator, measured in October 2017 and 2018, respectively.

Instruments

Electronic analytical balance (Quitix224-1CN), oven (DHG-9070A), pH meter (BP-10), thermostatic water bath pot (HWS-26), UV-visible spectrophotometer (UV-55), magnetic heating mixer, high-speed frozen centrifuge (KDC-140HR).

Methods

Reducing sugars (measured by glucose): Feline reagent method; Total acids (measured by tartaric acid): sodium hydroxide titration method; pH: pH meter method; Tannin: direct titration of potassium permanganate; Total phenol (measured by gallic acid): colorimetric method of Folin-Ciocalteau reagent; Anthocyanin: pH differential method; Choma: spectrophotometry. Each sample was repeated 3 times.

Data analysis

The data of basic physical and chemical indexes were processed by Excel 2010.

RESULTS AND ANALYSIS

Total Sugar

The total sugar content of the three blocks varied between 200 and 260 g/L, and the total sugar content of each block showed an increasing state (Fig. 1). Sunlight would accelerate the photosynthesis of leaves, and rapid accumulation of sugar [18], so the total sugar content showed an upward trend. the starting value of total sugar content (August 23) is very similar in three plots, but on August 28 solstice on September 2, the variation in content was relatively obvious, the total sugar content of 5-2 plot grapes was higher than that of other two block. In the later, all the sugar parallel almost to the abscissa, 5-2 grape matured earlier than the other two plots. Moreover, the rising trend of total sugar in the plots 5-1 and 5-3 after September 2 exceeded 5-2, and the final total sugar content of Merlot grapes in block 5-1 was still relatively high, which was related to the influence of different soil types, water and other factors on the sugar accumulation of grape fruits [19]. Through observation, it was found that plot 5-1 had the largest sediment concentration and sugar accumulation, while plot 5-3 had relatively low sediment concentration. The results showed that the sediment concentration had an important effect on the fruit quality of Merlot.

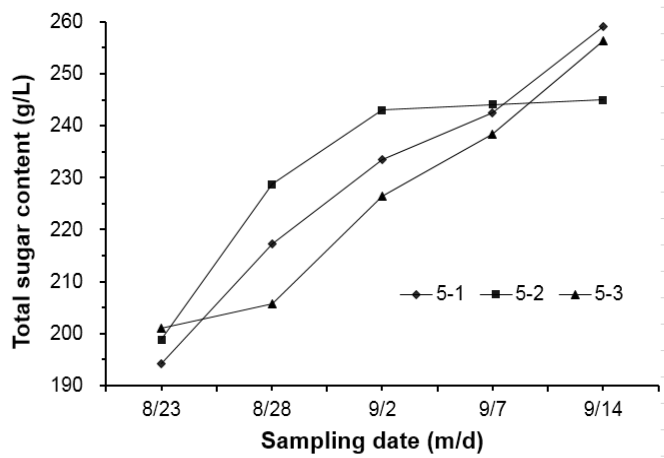

FIGURE 1. Change of total sugar content.

Total Acid

The difference of total acid content between different grape varieties and different region was the large. The total acid content of the three blocks showed a downward trend. In Fig. 2, The variation range of the total acid content of the 5-3 blocks was 9.3-4.6 g/L, which showed a significant downward trend between August 23 and August 28. The variation range of the other two blocks was about 7.5-5 g/L, and the variation trend was relatively similar. The decline of plot 5-3 grape was particularly rapid from August 23 to August 28, which was mainly caused by the dilution effect of the increase in grape fruit volume on the acid concentration and the cyclic metabolic consumption of tricarboxylic acid [20-21]. Therefore, the volume of grape fruits in plot 5-3 increased rapidly during this period, which was caused by the rapid metabolism of tricarboxylic acid cycle.

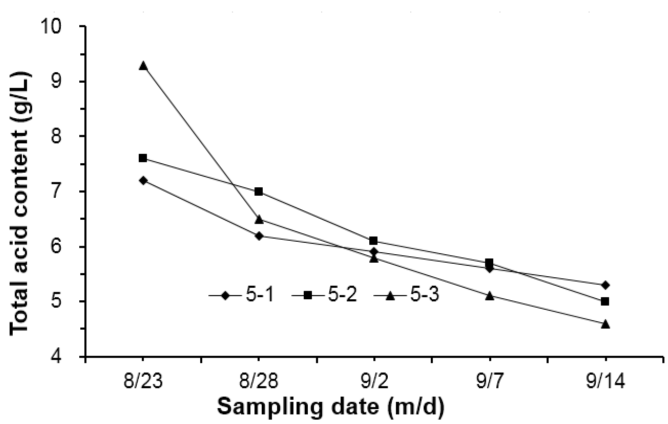

FIGURE 2. Change of total acid content.

PH

The pH of grapes represented the strength of the acid in the grape juice and the log Kow of the concentration of H^+ ions in the solution, while the H^+ ions in grapes were from the organic acids in the grape berries. The influence of grape pH on anthocyanin was very large [22]. As shown in Fig. 3, there was a large difference in pH among the three plots. The pH value of block 5-1 fruit was on the rise, and the variation range was 3.4-3.8. PH of 5-2 berries increased after decrease. The pH of 5-3 showed a nearly linear upward trend with a range of 3.39-3.83. The pH value of plot 5-2 dropped before August 28. On the one hand, the rainfall during this period diluted the organic acid in grape juice, and reduced the ground temperature (Fig. 3). On the other hand, the clay with higher content in block 5-2 could not timely remove more rain water from the soil, thus reducing the pH value. The pH value of block 5-3 increased steadily during the whole experiment, mainly because the soil in the block could keep warm the heat absorbed during the day. Therefore, despite the rainfall, the effect of the ground temperature on the block was not obvious.

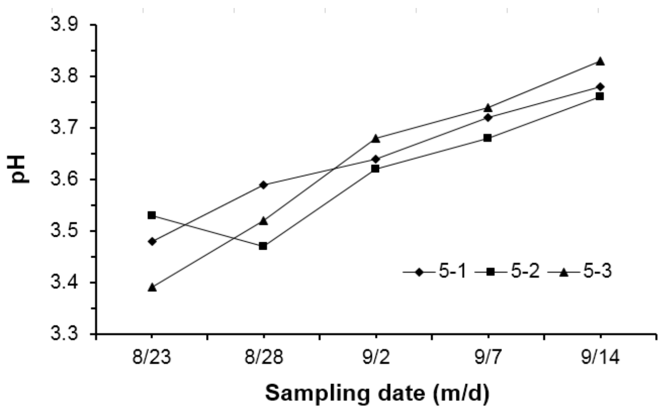

FIGURE 3. Change in pH.

Tannins

Tannin is an important substance in red wine. Tannin content in grapes decreased after color transformation. Changes in tannin content in grapes were closely related to grape varieties [23]. Tannin content in the three monitored plots showed a downward trend (Fig. 4). The tannin content of plot 5-1 decreased rapidly, and whose variation range was 6.24-2.08 mg/g during the monitoring period. The variation range of 5-3 tannin content during the monitoring period was 4.16-2.08 mg/g, and that of 5-2 was 5.20-1.04 mg/g. It had to do with the soil structure.

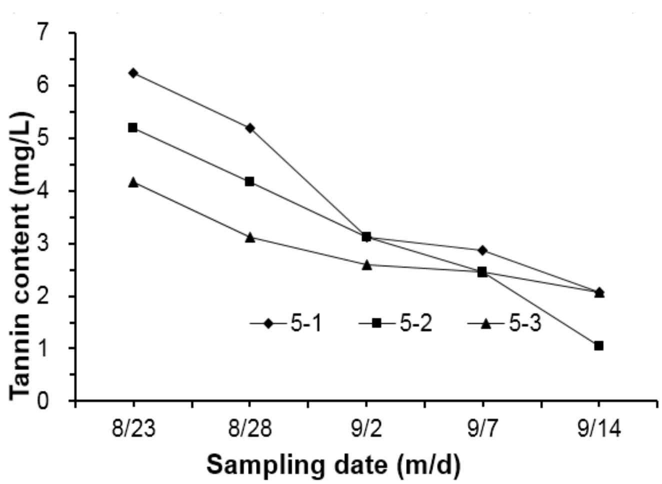

FIGURE 4. Change in tannin content.

5-1 had more sand, which was beneficial to the accumulation of tannin. The soil content of 5-2 was second only to 5-1, so the tannin content of grape in plot 5-2 was always lower than 5-1. For 5-3, clay content was higher than sandy soil, so tannin content was lower than 5-1 and 5-2. However, after August 28, the change was relatively gentle, mainly because the clay could store the heat radiated to the soil by the sun during the day, so accumulation of tannin content was more low and slower. Tannin mainly existed in grape skins and grape seeds [24], which would be converted into other compounds in the ripening process of grapes, which led to declining trend of tannin content.

Total Phenols

Phenolic substances were the skeletal components of wine and the main functional substance of wine health function [25-26]. The phenolic compounds in grape mainly existed in the skins and grape seeds. The content of total phenols in all three plots showed a tendency of fall after rising, and the total phenolic content in plots 5-1 and 5-3 grapes were much lower than 5-2 at the beginning of the transferring color period (23 August), but the total phenol content of 5-2 was accumulated rapidly during the growth process (Fig. 5) . It is mainly because the sandy soil content and clay content of the 5-2 block were more abundant, not only could absorb the heat in high temperature season, but also retain some heat in the cooling season, which allowed the grapes in the 5-2 site to maintain a relatively balanced total phenolic content throughout the experiment. It could be seen that the total phenolic content of the three plots on 2 September was the peak for the entire monitoring period, indicating that both the sandy soil and the clay were beneficial to the accumulation of total phenols, although their accumulation mechanism was different. When phenolic substances accumulated at the beginning of the conversion phase and reach their peak, their content decreased due to the conversion of a portion of the phenolic material to other substances, some of which are hydrolyzed, so the content of total phenols in the three plots tended to decrease after ascending first, and the difference of soil structure resulted in the difference of total phenolic content

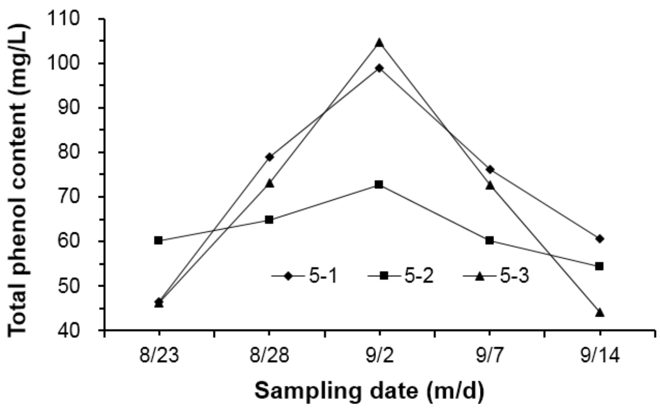

FIGURE 5. Change in total phenol content.

Anthocyanin

The content of anthocyanin in block 5-1 was always increased. The variational interval was 52-111 mg/L during the monitoring period, indicating that the rapid accumulation of anthocyanins in sandy soil could delay the accumulation of anthocyanins to the highest peak (Fig. 6). The content of anthocyanins in 5-2 and 5-3 sites showed a steady decline after ascending, peaking on 28 August, which indicated that a certain proportion of clay was beneficial to the accumulation of anthocyanins and that too much clay was not conducive to the accumulation of anthocyanins, so 5-2 grapes had more anthocyanins than 5-3. Anthocyanins were soluble in water, and other factors, such as strong light and high temperature were favorable to the accumulation of anthocyanins [27-29]. The anthocyanins in the grape increased to the peak, and decreased due to the hydrolysis of water again. So the rain after August 28 slowed the accumulation of anthocyanins. The effect of pH on anthocyanins was very large, and the color of anthocyanin was significantly different under different pH. Low pH increased anthocyanin content (Fig. 3 and 6). Therefore, the difference reason of anthocyanin content in the three plots was due to the difference of water, light and pH.

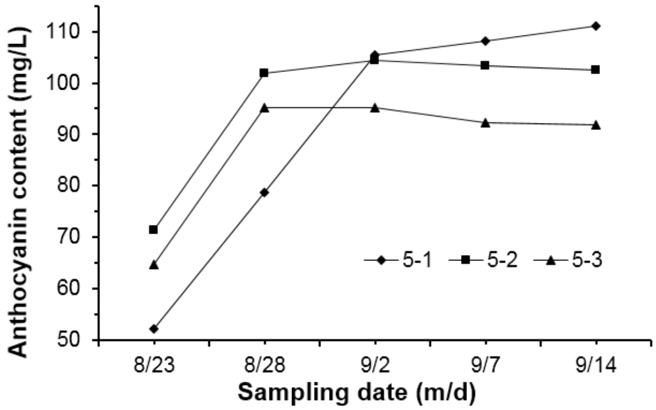

FIGURE 6. Change in anthocyanin content.

Chromaticity

Chromaticity, as an evaluation index of grape and wine, was related to the variety and content of anthocyanins in grapes [30-31]. The variation of grape chroma in the three plots showed a tendency to decrease after rising. The initial value of the three chromas (23 August) was similar, but the 5-1 color increased rapidly in the maturation process, far exceeding the other two plots, followed by 5-2 and 5-3, which showed that the sandy soil was favorable to the accumulation of grape chroma. They peaked on September 2, and then began to fall, mainly because rainfall during the period cooled the temperature, resulting in a decrease in chroma. Level of Chromaticity was similar to the content of anthocyanins, but there were still some differences. For example, the anthocyanins of the 5-1 plot showed a rapid increase trend after 2 September (Fig. 6), while chromaticity declined (Fig. 7), and the changes in chroma and anthocyanins in the other two plots were not entirely consistent (Fig. 6 and 7), it was shown that the change of chromaticity was not only related to the accumulation of anthocyanins, but also related to the accumulation of other components, which required study further. In addition, the difference between the rise and fall of Chroma was also related to the accumulation of sugar and the synthesis of anthocyanins in each plot [32].

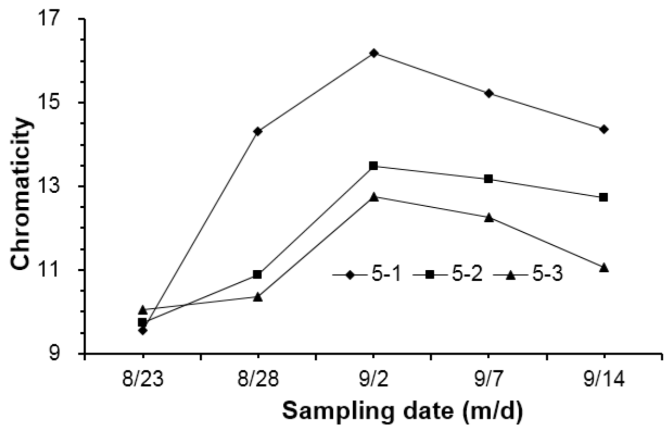

FIGURE 7. Change in chromaticity.

CONCLUSIONS

The fruit quality of Merlot grapes in 5-1, 5-2, 5-3 plots in Shihezi from the transition period to the mature period (23 August to 7 September) was analyzed on 23 August to 7 September, 2017 and 2018, respectively. The results showed that the sugar content of the three plots increased with the ripening of grape, and the total sugar change from color to maturity was 194.2-259.1 g/L (in glucose), especially the total sugar content of 5-1 was the highest. The total acid content was decreased, the range of which was 9.3-4.6 g/L (in tartaric acid). PH value of 5-2 decrease after increase, while the pH value of the other two plots continued to rise, but overall, the pH of the three plots increased with the ripening of grape. Tannin content decreased continuously with the ripening of grape, the range of the contents varied from 6.14 mg/L to 1.04 mg/L, and the content of total phenol decrease after rising. The content of anthocyanins and chromaticity also tended to rise and fall no less than total phenol, and the value of 5-1 was the larger.

The results showed that the content of total sugar, anthocyanin and chromaticity value of grape in the 5-1 plot from 23 August to 7 September were higher compared with other plots (23 August to 7 September), the content of total acid and tannin was also moderate, which was related to the soil structure, the sandy content of 5-1 was the largest with the loose soil of suitable for grape growth. 5-3 block contained more clay than sandy soil, while 5-2 block included more clay than sand, but its sand content was lower than 5-1. Therefore, the soil characteristics of the plots suitable for Merlot grape planting were arranged in order of 5-1, 5-2 and 5-3.

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