Hindawi
Journal of Food Quality
Volume 2019, Article ID 8672182, 11 pages
https://doi.org/10.1155/2019/8672182

Research Article

Implications of Aging Quality of Oak Shaving on Kyoho Wine Immersed with Residue of Cabernet Sauvignon

Lijun Nan,[1,2,3] **Xiaofang Zhang**,[1] **Yingxue Zhong**,[1] **Changwei Cui**,[1,2] **Na Ning**,[1] **Chengdong Xu**,[1,2] **Yashan Li**,[1,2] **and Jing Huang**[4]

[1]*School of Chemistry and Life Sciences, Chuxiong Normal University, Chuxiong 675000, China*
[2]*Engineering Technology Research Center of Grape and Wine for Advanced School in Yunnan, Chuxiong 675000, China*
[3]*Institute of Yunnan Food Safety, Kunming University of Science and Technology, Kunming 650550, China*
[4]*School of Mathematics and Statistics, Chuxiong Normal University, Chuxiong 675000, China*

Correspondence should be addressed to Yashan Li; li_yashan@126.com

Received 25 February 2019; Revised 17 April 2019; Accepted 24 April 2019; Published 4 June 2019

Academic Editor: Daniel Cozzolino

In order to study effect of oak sawdust on the quality of Kyoho wine immersed by fermented Cabernet Sauvignon residual, Kyoho wine aged without oak sawdust (KWO), including KWO1 and KWO2 according to immersed orders by fermented Cabernet Sauvignon residual, was taken as control to compare the effect of oak sawdust on quality of Kyoho wine (KO), including KO1 and KO2 according to aged orders by oak sawdust. During the 15 days of aging, physical and chemical indicators, such as chroma, tonality, and total phenol in wine were determined simultaneously by using a spectrophotometer, including tannin content by $KMnO_4$ titration, once every 3 days. The results showed that the chromaticities of Kyoho wine were 3.21, 3.02, 4.46, and 3.71 for KO1, KO2, KWO1, and KWO2, respectively. Similarly, the hues were in turn 0.73, 0.68, 0.97, and 0.72, respectively. Tannin contents were 1601.5 mg/L, 1517.3 mg/L, 337.2 mg/L, and 115.6 mg/L; total phenol contents were 277.67 mg/L, 222.1 mg/L, 64 mg/L, and 79.8 mg/L. Therefore, the contents of tannin and total phenol from KO1 wine were all the highest values. The chroma and tone of the four types of wine showed an upward trend of "S." The chromaticity and tone were the lowest for the KO2 wine and the highest for the KWO1 wine with the larger difference between KO2 and KWO1.

1. Introduction

Cabernet Sauvignon is a variety of grapes grown widely, originated in Bordeaux, France, with a strong adaptability to environment. Shangri-La is located in valleys among Lantsangesis, Salweense, and the Jinsha River, namely, the core areas of the "three parallel rivers" on the world natural heritage. About 1700–2800 m of elevation and the strong ultraviolet radiation in Shangri-La were beneficial to the accumulation of anthocyanins and flavonoids in Cabernet Sauvignon fruits [1] as well as total phenols and tannins in Cabernet Sauvignon wine [2, 3]. Cabernet Sauvignon peel residue after fermentation together with must was still rich in pigment and polyphenol substances, and especially the phenolic substance, anthocyanin, resveratrol, and flavonoid were present in the peel of Cabernet Sauvignon late-harvested in Shangri-La. These substances would affect the sensory characteristics of wine after being gradually transferred to wine through the impregnation process of skin residue again [4], which revealed a higher application value.

Kyoho grape, introduced from Japan, belongs to a hybrid variety of European and American. It had been planted in large areas and became a popular grape variety between the grower and consumer after being introduced in China in 1959. Thick-skinned and succulent fruit contained essential trace elements, including 16%–18% soluble solid and 6–8 g/L acidity, with fresh aroma of the flower and fruit, which supplied just general condition of wine-making [5]. Kyoho wine has rich nutrients but also defects such as light color and single structure of wine body. Fermented Cabernet Sauvignon skin residue is still rich in polyphenols, which can not only improve the structure and color of Kyoho wine but also realize the reuse of skin residue after impregnating

Kyoho wine. Therefore, this shows great significance to develop new products, meet market demand, utilize rationally existing resources, and reduce waste and production costs [6].

Impregnation can be carried out before or after fermentation. Cabernet Sauvignon skin residue after fermentation can improve the utilization of skin residue, enhance the color of Kyoho wine, and enrich the flavor substances of Kyoho wine. Impregnation during aging is an important factor affecting the quality of wine. Oak chips are the leftover waste after making oak barrels and oak blocks, with the larger specific surface area. Phenolic compounds in oak chips could promote the increase of tannin polymer and the degree of polymerization after transferring to wine [7]. Complex tannins, anthocyanins, lignin, and hemicellulose lixiviated and depolymerized from oak sawdust immersed in the wine were very important to improve the quality of wine [8]. Therefore, the immersion of oak sawdust in Kyoho wine during the aging could improve not only quickly the flavor and structure of Kyoho wine but also the oak sense of Kyoho wine except for reducing cost, compared with oak barrel and oak chip.

Storing wine in oak keeps the wine up to thousands of years. Oak barrel could improve the quality of wine, which was the key to determine the aging potential of wines. At present, the domestic researches on the selection and effect of oak products on the sensory quality of wine are still in the preliminary stage [9]. There are still many complementary contents on improving quality of Kyoho wine with oak products. Reaction of wine and oak product could endow wine with complex flavor and better quality.

Cerdán et al. [10] found that oak could enhance the stability and color of wine through the process of impregnation and natural clarification. Faria et al.; Puértolas et al., and Rustioni et al., [11–13] pointed out that aging could not only reduce anthocyanin content, hue, and chromaticity value but also increase the total phenol and tannin content in wine. Sáenz-Navajas et al. [8] found that the effect level of oak slices on the oak aroma of Cabernet Sauvignon wine was in the order of America > France > China in terms of the content of oak lactone. Aroma of wine could be improved by baking Chinese oak, but there was still a bigger difference compared with American oak and French oak, which could enhance the stability and aroma components of Kyoho wine.

There are many studies on ageing wine with oak. Li et al. [14] found 23 and 16 anthocyanins in the fresh peel of Kyoho and Cabernet Sauvignon, respectively, which indicated that peel of two excellent wine-making varieties of grapes was rich in anthocyanins. The study of Le Grottaglie et al. [15] found that oak fragments could promote higher tannin content in wine. Schumacher et al. [16] demonstrated that the types of oak could lead to difference in volatile phenols, vanillin, and oak lipids in wine. Therefore, fermented Cabernet Sauvignon peel residue could enrich the anthocyanin in Kyoho wine, and then, oak sawdust could increase the content of tannin in Kyoho wine.

Skins, pedicels, and seeds of late-harvested Cabernet Sauvignon in Shangri-La contained high-quality anthocyanins, tannin, and aromatic substances. Fermented Cabernet Sauvignon pomace could enhance the color and taste of Kyoho wine by maceration and also bring about defect including rough feeling; however, oak sawdust could improve the rough feeling of wine. Additionally, the polyphenol and aroma component in fermented Cabernet Sauvignon skin could still be absorbed partly by Kyoho wine through soaking, which, on the one hand, improved the quality of Kyoho wine and on the other hand, realized reduction of waste by reasonable use of Cabernet Sauvignon skins. Phenol and tannin could be increased in Kyoho wine by impregnating Cabernet Sauvignon residue, which contributed a harmonious body, stable color, rich aroma, and complete sensory quality through aging with oak sawdust again in a shorter time. Oak sawdust aging played an important role in improving the quality of wine. Slow oxidation between oak and wine could improve color, aroma, and palate fullness of wine. Therefore, wine aged by oak could be accepted by most people [17]. In order to improve the roughness of Kyoho wine, new products of Kyoho wine with better color and taste should be developed to meet the demand of consumers, increase the market share, and diversify the products.

2. Materials and Methods

2.1. Materials

2.1.1. Experimental Design. The whole idea of this experiment was as follows:

As shown in Figure 1, on June 25, 2017, Kyoho grapes bought from Chuxiong supermarket were brewed into Kyoho wine, which was aged at room temperature. On December 4, 2017, after the wines were labeled as KW1 KW2 and KW3 KW4 according to color similarity, respectively, fermented late-harvesting Cabernet Sauvignon pomace in Shangri-La were dipped in KW1 KW2 wine first (the same repetition is named "KWO1"); the above fermented residue was impregnated into KW3 and KW4 (another same repetition is named "KWO2") wine again on December 11, 2017. The above wines were bottled in a similar color, 4 bottles each, and labeled accordingly, on December 28, 2017. On April 28, 2018, oak chips were added to two bottles of KWO1, labeled KO1, while the other two bottles were still labelled as KWO1. KWO2 was processed and labeled in the same way.

2.1.2. Wine Samples. Four hundred kilograms of Kyoho grapes with uniform color and ripeness from the local market were divided into 20 copies of equal weight before being brewed into dry red wines in twenty 25-kilogram glass pots according to the conventional technology, respectively. Wines were then stored in the dark under room temperature until the following treatment on June 25, 2017. The conventional technology was as follows:

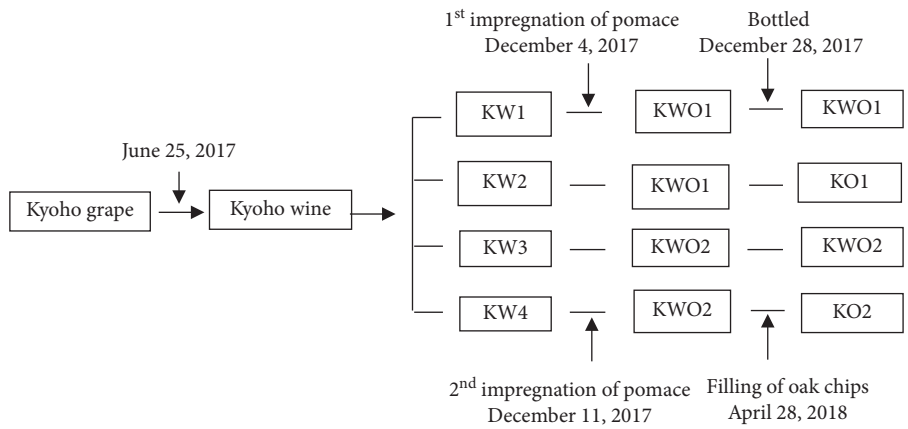

Figure 1: Flow diagram of the treatment.

Kyoho grape

⟶ stem removal with hand

⟶ slight crush with hand

⟶ addition of pectinase and SO_2 respectively

⟶ alcoholic fermentation

⟶ transferring tank and pressing peel residue with hand

⟶ raw wine

⟶ storage. (1)

It is worth noting that the pressed wine and first automatically separated wine were combined together as raw wine.

2.1.3. Experimental Materials. Cabernet Sauvignon pomace originated from castoff after soaking and fermenting late-harvested Cabernet Sauvignon in Shangri-La on December 4, 2017.

Pectinase, yeast, and sulfite were provided by Shangri-La Wine Industry Co., Ltd

Oak chips, moderately baked, were from Seguin Moreau, France

2.2. Method

2.2.1. Impregnation of Pomace. On December 4, 2017, the above Kyoho wine was divided and stored in four 20 liters of glass jars according to the color similarity as the experimental material for impregnation of pomace, which was numbered as Kyoho wines 1, 2, 3, and 4 (KW1, KW2, KW3, and KW4) one by one. KW1 and KW2 as well as KW3 and KW4 were thought of as the same repetitions, respectively. The wine was analyzed in duplicate. Then, the residual of Cabernet Sauvignon in Shangri-La after fermentation was soaked in KW1 and KW2 wines for the first time, all named "KWO1." After 7 days, the other KW3 and KW4 wines were also soaked with the above drained residue for the same 7 days, all named "KWO2."

2.2.2. Ageing of Oak Chips. On December 28, 2017, the above KWO1 and KWO2 were stored in four 750 mL bottles labeled first according to the color similarity, respectively. On April 28, 2018, 300 mg oak chips were put into two bottles of KWO1 wine and named as "KO1;" the other two bottles were thought of as control of KO1, labeled as KWO1. Similarly, 300 mg oak chips were also put into two bottles of KWO2 wine successively, marked as KO2, and the other two bottles were thought of as control of KO2, flagged as KWO2.

2.2.3. Determination of Ageing Index. The physical and chemical indexes of Kyoho wine, within the GB 15037 2016 (Table 1), were measured before adding oak sawdust.

Reducing sugar: Fehling reagent titration

Titrated acid: potentiometric titration

Alcohol and dry extract: thermostatic bottle

Total SO_2 and free SO_2: iodometry

After adding oak chips, the wine was aged for 15 days at room temperature. The following experiments were simultaneously conducted.

Tannin ($KMnO_4$ titration), chroma and hue (spectrophotometry), and total phenol (Folin phenol method) were measured once every three days.

2.2.4. Sensory evaluation. After 15 days of aging under oak clastic, 25 students with the intermediate certificate of SWET wine taster were invited to examine the 4 wines. The sensory characteristics were determined finally by the evaluation and score given.

2.2.5. Statistical Analyses. All analyses were done at least in triplicate, which were then presented as average values along with standard derivations. Data were analyzed using the Excel 2010 software. Statistical comparisons were performed with one way analysis of variance, and p values < 0.05 were regarded as significant.

Table 1: Basic physical and chemical indicators of raw wine KWO1 and KWO2.

	Reducing sugar ($g \cdot L^{-1}$, glucose)	Titrable acid ($g \cdot L^{-1}$, tartaric acid)	Alcohol (%)	Dry extract ($g \cdot L^{-1}$)	Free SO_2 ($mg \cdot L^{-1}$)	Total SO_2 ($mg \cdot L^{-1}$)
KWO1	3.5 ± 0.1	5.925 ± 0.1	12.01 ± 0.3	24.2 ± 0.2	5.4 ± 0.1	23.7 ± 0.3
KWO2	3.0 ± 0.2	6.450 ± 0.2	11.78 ± 0.1	23.4 ± 0.2	4.8 ± 0.2	22.0 ± 0.1
GB 15037-2006	≤4.0	—	≥7.0	≥18.0	—	—

The values of KWO1 in the first, third, and sixth columns are significant at 5% probability level. The values of KWO2 in the first and third columns are significant at 1% probability level and those in the fourth and sixth columns are significant at 5% probability level.

3. Results and Discussion

3.1. Basic Physical and Chemical Indexes of Original Wine. According to the datum in Table 1, the basic physicochemical indexes of KWO1 and KWO2 accorded with GB 15037 2006, respectively. Therefore, the two wines belonged to the qualified wine products and could be aged by adding oak chips directly.

3.2. Effect of Oak Chips on Kyoho Wine

3.2.1. Effect of Oak Chips on Tannin Content. Most of the tannin in wine originated from grape skin, while a few of which were supplied by grape seeds and oak sawdust; poor-quality tannin made young wine bitter and astringent, and high-quality tannin softened wine with maturation and oak aging [18]. The boost of ethanol content in wine during the aging was accompanied by a decline of wine color and hoist of tannin, which lowered the tannin's bitterness and roughness gradually [19].

It could be seen from Figure 2 that the tannin content of Kyoho original wine (KWO1 and KWO2) had no obvious variation; the KWO1 level was higher than KWO2 one, which indicated that the tannin contents in Cabernet Sauvignon waste and aged Kyoho wine (KWO1 and KWO2) were relatively stable or the tannin in Cabernet Sauvignon castoff could be polymerized into stable polymer with the components of Kyoho wine in favour of the stability of tannin. The tannin content in the KWO1 wine was always higher than that in the KWO2, implying that the tannin content in the dreg would be less and less with the increase of soaking frequency.

Before adding oak sawdust, the tannin content was $338.2\,mg \cdot L^{-1}$ in KWO1 wine and $116.4\,mg \cdot L^{-1}$ in KWO2 one, respectively. After 15 days of soaking with oak sawdust, both the tannin content increased to $1601.5\,mg \cdot L^{-1}$ and $1517.3\,mg \cdot L^{-1}$, respectively. While the tannin content of another two Kyoho wines (KO1 and KO2) increased always with the aging time and increased rapidly in the first three days before aging. Further, the tannin content of the KO1 wine increased faster than that of the KO2 wine, rising to $1122.4\,mg \cdot L^{-1}$ and $623.6\,mg \cdot L^{-1}$, respectively. In Figure 2, the tannin content of the two wines reached the maximum, approaching one another, $1601.5\,mg \cdot L^{-1}$ and $1517.3\,mg \cdot L^{-1}$, respectively, after 15 days of aging from slow increase aboriginally, which demonstrated that Kyoho wine lacked a large amount of tannin, and at the initial stage of immersion, tannin in Cabernet Sauvignon pomace could be quickly immersed in Kyoho wine. Soon afterwards, tannin content in Cabernet Sauvignon rejected material decreased gradually when the tannin level in Kyoho wine slowly approached saturation. Therefore, impregnation effect of tannin could be adjusted jointly by the saturation level of Kyoho wine and released potential and content of tannin in Cabernet Sauvignon material by immersion time. The results were the same as those of Pérez-Magariño et al. [20]. The study of Paredes-López et al. [21] on the effect of different aging methods on tannin content found that tannin content showed an increasing trend.

Tannin in oak sawdust extracted by depolymerization could enter Kyoho wine [8], which, on the one hand, brought bitterness and astringency to Kyoho wine, and on the other hand, could enhance the structure and gentle taste and improve the quality with the gradual advance of aging time of Kyoho wine. The first impregnation of oak chips had the most significant effect on tannin content in wine. According to Figure 2, tannin content increased with aging time. When tannin content reached $1600\,mg \cdot L^{-1}$, the curve began to flatten. Faria et al., Puértolas et al., and Rustioni et al. [11–13] found that the content of tannin in Cabernet Sauvignon dry red wine upgraded to $2200\,mg \cdot L^{-1}$, which was quite different from the result of this experiment. There were many reasons among which three aspects must be mainly mentioned here: the grape variety, the residue, and the species and content of oak. Fresh Kyoho grape was used in this experiment, while Faria et la., Puértolas et al., and Rustioni et al. [11–13] used *Vitis vinifera* Cabernet Sauvignon with excellent brewing characteristics that were rich tannin and phenolic substances beseeming for aging in the pericarp compared to fresh grape. Then, Cabernet Sauvignon offscum enhanced more tannin content in Kyoho wine, but Kyoho wine had a diluted effect to tannin and the tannin content in Cabernet Sauvignon skin residue had been reduced a lot after dipping and fermentation, which led to still higher tannin content of Cabernet Sauvignon wines than Kyoho wine although dipped by Cabernet Sauvignon waste. In addition, the species and content of oak were thought on the other hand. Content of oak lipid, vanilla aldehyde, and eugenol depended on kinds and use of oak, effect of which on wine was discrepant when aging. This experiment considered mainly the latter factor. The addition of oak chips in this experiment was $300\,mg \cdot L^{-1}$, whereas the best amount to add was considered $10\,g \cdot L^{-1}$ in experiments of Faria et al., Puértolas et al., and Rustioni et al. [11–13]. These reasons differentiated tannin content in wine. In addition, the results showed that the quality of wine could be improved by soaking pomace and aging of oak sawdust, but it was necessary to adopt the fine one [22–24]. Categories, contents, and qualities of tannin hinged on varieties, sources, and baking degrees of oak sawdust, which also had different effects on tannin of wine [25–27].

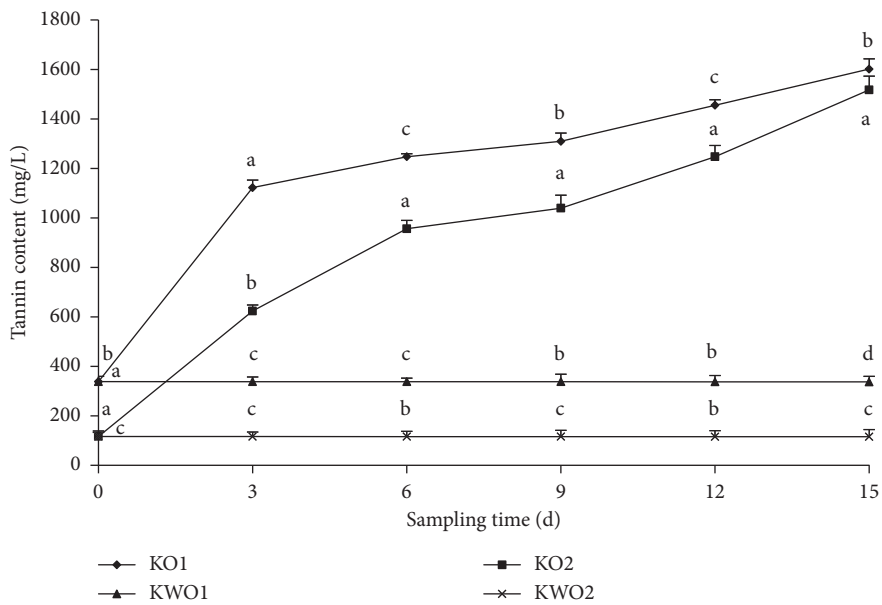

Figure 2: Effect of oak shavings on tannins. Different letters in each bar indicate significant differences between mean values (≤0.05).

3.2.2. Effect of Oak Chips on Chroma. Consumers would normally observe the color of wine first when buying a wine, so the effect of color on the wine was very important. However, color was determined mainly by tannin, phenol, and anthocyanins [28].

According to Figure 3, the chromaticity of KWO1 and KWO2 wines, despite the value of KWO1 being greater than that of KWO2, was in parallel, maintained at about 4.56 and 3.73, respectively, during the entire aging. The chromaticity of KO1 and KO2 wines decreased with the aging time under oak sawdust (a downward trend eventually including increase slowly after decreasing gently). However, the chromacity of KO1 wine was higher than that of KO2, indicating that oak sawdust had a certain stimulative role on reducing the color of wine owing to the adsorption function of oak sawdust. Furthermore, the order of dipping had obvious effect on chroma. The chromaticity of KWO1 wine was higher, 4.58, because the residue of Cabernet Sauvignon late-harvested in Shangri-La possessed rich vestigital in pigments and polyphenol after the fermentation [2, 3] and most of them were dissolved finally in the KO1 wine.

In the first nine days of aging, the chromaticity of the two wines showed a gentle declining trend until the lowest value together on the ninth day, mainly because tannin in oak sawdust interacted with anthocyanins to form polymeric anthocyanins, which decreased the pigment content of the wine [11–13]. After the ninth day, the chromaticity of the two wines began to fluctuate slightly and slowly. The upward trend relied on the release of anthocyanin and slowly reversible decomposition of polymerized anthocyanin in oak chip (including those adsorbed into oak chip and own). The tannin content in KO1 was always higher than that in KO2, which confirmed the prominent influence of the impregnation order of oak chips on the chroma further. Research of Paredes-López et al. [21] found that tannin content increased always on the basis of the effect of different aging methods. Generally speaking, the chroma would always decrease with the aging time at the beginning period under the adsorption and microoxidation function of oak sawdust. However, chromaticity would increase slowly with the aging time and stabilize finally by falling to a certain range [11–13], mainly because the oak sawdust in wine had reached saturation owing to adsorption role. Just then, wine no longer dissolved the active ingredients in oak, and the active ingredients related to chromaticity in the wine were no more absorbed by the oak. Research also discovered that when the oxygen was exhausted, the pigments began to be released from the oak fragments and the microoxidation reaction was turned into microreduction reaction in the oak chippings [29–31], which was a reversible process. Therefore, through the reversible process of reciprocating, the influence of oak shavings on chromaticity would eventually stabilize, which was generally shown in wines requiring long-term storage and with aging potential. It could also be judged that the best time for oak sawdust to affect the color of wine began from the ninth day after the oak sawdust aging.

3.2.3. Influence of Oak Chips on Tone. Hue could indicate the maturity of wine. Due to the action of anthocyanins, young dry red wine showed usually purple hue, but purple could disappear gradually when anthocyanins combined with other substances including tannin as the wine matured; meanwhile, the yellow hue would increase and became brick red eventually [32].

According to Figure 4, the hue of KWO1 and KWO2 did not change within 15 days and the KWO1 value was higher than the KWO2 one, about 0.97 and 0.72, respectively. General trend of the hue in the KO1 and KO2 wines decreased (increase after decrease and tended to stabilize finally) with the aging time. The hue of the KO1 wine was higher than that of the KO2, demonstrating that there was a

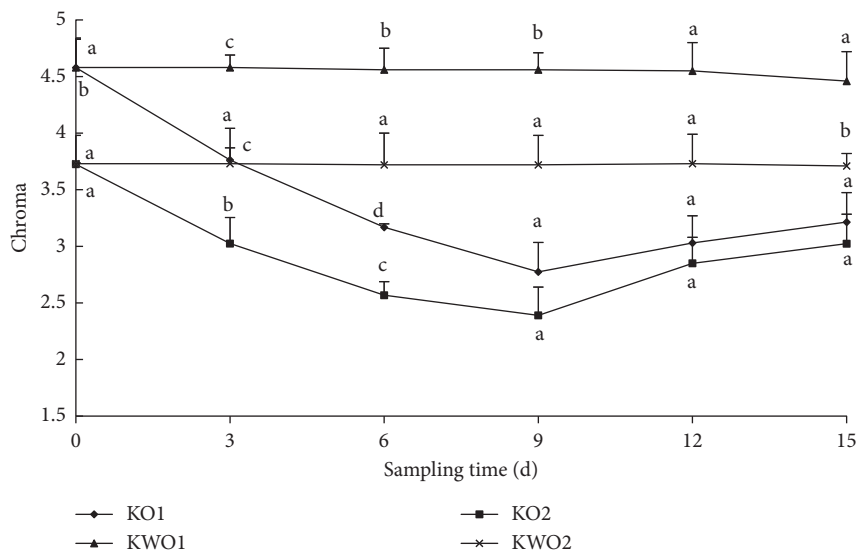

Figure 3: Effect of oak shavings on chroma. Different letters in each bar indicate significant differences between mean values (≤0.05).

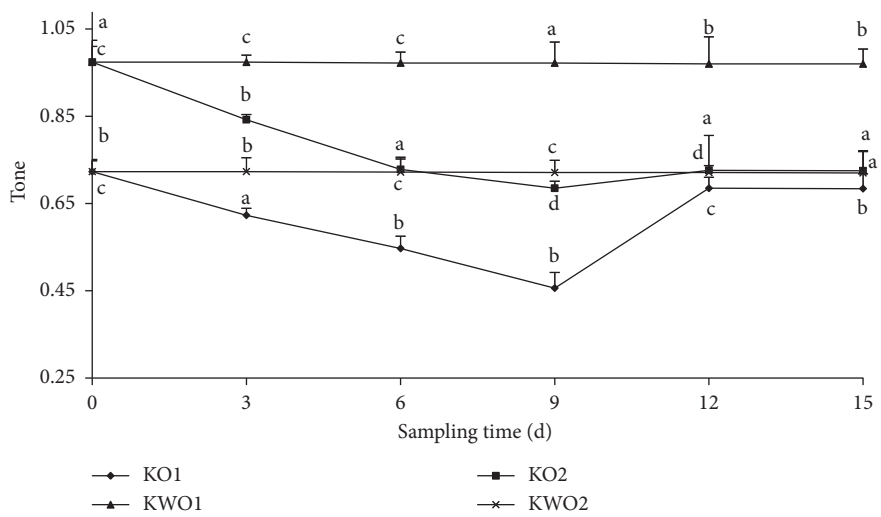

Figure 4: Effect of oak shavings on tone. Different letters in each bar indicate significant differences between mean values (≤0.05).

significant effect of oak sawdust on the wine hue by the role of immersion, adsorption, and oxidation as well as the immersion order. Then, the color tones of the KO1 and KO2 wine decreased linearly with the aging time and reached the lowest level on the 9th day, mainly due to the rapid oxidation of free anthocyanins with oxygen through natural corks, which resulted in the rapid decrease of purple color in wine [11–13]. Tonality was accumulated again after the 9th day because the substances extracted from oak and in wine consumed the weak oxygen in oak sawdust, which helped the wine in a relatively lower oxygenic or anaerobic reduction state and part of bound anthocyanins to reduce into free anthocyanins increasing color further. Still, the rising speed of the KO2 tone was higher than that of the KO1 tone, which indicated that the oxygen content in the second soaking dregs was lower than that of the first, and the reducibility of corresponding wine was stronger than oxidizing. However, the wine tone remained stable after the 12th day, making clear that the anthocyanin was in a relatively stable state, and the chromaticity tended to be of gentle status under the redox role of wine in equilibrium after 12 days of oak sawdust immersion, whereas the study result of Paredes-López et al. [21] was not obvious.

In Figures 3 and 4, the hue and tonality of KO1 and KO2 decreased together with the aging time but however increased again after 9 days. The influence of oak sawdust impregnation on hue and tonality was not significant, which relied on the shorter aging time, and wine with aging potential was generally apt to oak aging. Kyoho wine was impregnated by fermented Cabernet Sauvignon dreg with limited pigment and phenolic substances, which prompted the not-obvious effect of aging on hue and tonality.

3.2.4. Effect of Oak Chips on Total phenol Content. The standard solutions, 0 mg·L^{-1}, 50 mg·L^{-1}, 100 mg·L^{-1},

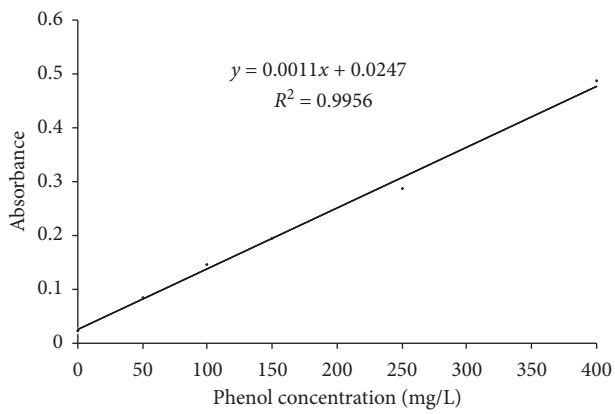

Figure 5: Standard curve of total phenol.

150 mg·L^{-1}, 250 mg·L^{-1}, and 400 mg·L^{-1}, were prepared with the standard sample of gallic acid, respectively. The standard curve was drawn by absorbance values measured at 765 nm.

According to Figure 5, the equation of the standard curve was $y = 0.0011x + 0.0247$ ($R^2 = 0.9956$). The total phenol content of the sample was calculated according to the standard curve and the absorbance value of the sample.

Phenols were important factors determining the structure, taste, and flavor of wine. The abundant phenolic substances would endow wine an advantage in color, aroma, and taste [33]. There was distinct discrepancy of total phenolic content from different grape varieties. The aroma component and body of wine would be greatly affected by total phenolic substances soaking into wine. Similarly, phenolic substances in oak shavings would be impregnated into wine by the method of adding oak, which could affect wine quality.

As could be seen from Figure 6, the total phenolic content of KWO1 and KWO2 remained without variation within 15 days. The total phenolic level of KWO2 wine was higher than that of KWO1 at about 64 and 80 mg·L^{-1}, respectively, which testified that Cabernet Sauvignon pomace could increase the total phenolic content of the wine unless extraction was taken for a long time [34, 35]. With the extension of aging time, the total phenol content of Kyoho wine with oak sawdust would also increase in the trial. The total phenolic content increased slowly during the first six days of aging before increasing rapidly, which was related to the physical and chemical properties, with the easy oxidization, of the total phenolic content. The total phenolic content of KO1 wine showed a trend of express increase after fleet increase, and the maximum appeared on the 15th day, while the KO2 wine showed a rapid increase in 6–9 days before slow rise. The total phenolic content in the KO1 wine was lower than that in the KO2 before the 13th day of aging, and then showed the opposite result, which was related to the dipping effect and oxidation ability of phenolic substances. Oxidation reduced the accumulation of phenolic substances.

After the 13 days of aging, the total phenol content of the two wines were the same. The main reason was obvious that the total phenolic contents in KWO1 wine and KWO2 wine, with KWO2 wine having more phenolic content than KWO1, were reduced under oak sawdust, respectively, which was similar to results of Zahri et al. and Del Alamo Sanza et al. [36, 37]. Total phenol content of oak extractives, mainly vescalagin, castalagin, ellagic acid, and gallic acid, would decrease after the maximal exposure time; castalagin and gallic acid were destroyed after aging 216 h and vescalagin and ellagic acid after aging 72 h. So, the total phenol in KWO2 wine was higher than that in KWO1. With the aging continuation, the total phenolic content was decreasing but the content decreased slowly in the KO1 wine, compared to rapid decrease in the KO2 wine, which accelerated the total phenolic content of the two to tend to the same level on the 13th day. However, there was an opposite trend with the continued impregnation. The total phenolic content in the KO1 wine exceeded that of the KO2, whereas the KO1 wine was highly antioxidant for long-term aging. The weak oxygen entered the bottle through a natural plug to oxidize and decompose the polyphenolic substances dissolved from oak sawdust during the period. The aggregate substance remained basically in equilibrium finally [38, 39]. The result of Fu et al. and Mekoue Nguela et al. [38, 39] showed that the total phenolic content increased after decreasing and tended finally to placidity with the aging time, mainly because of the different types of oak, grape varieties, and aging time.

The total phenolic substances in red wine included mainly pigment and tannin [40]. The results showed that tannin were generally on the rise, resulting in a corresponding increase in total phenolic content in Figure 6. But, tannin content showed a trend of slow increase after rapid ascent, while total phenol displayed a curve of slow lifting before rapid elevation (Figures 2 and 6), which was related to the accumulation of pigment substances and the adsorption of oak sawdust. Oak sawdust could adsorb quickly pigments, excluding weak adsorption, and even release tannin, so the tannin content was up in the whole experiment (Figure 2); while the chroma and hue content decreased before increasing (Figures 3 and 4), the total phenol content increased rapidly after doing slowly (Figure 6). The total phenolic content of both wines was steady after 13 days of aging. After 15 days, the total phenolic content of KO2 wine tended to be gentle, while the content of KO1 wine continued to increase because the KO1 wine absorbed more components in the Cabernet Sauvignon skin residue compared with KO2 one, which possessed basically some aging advantages of Cabernet Sauvignon. The phenolic substance in oak chips was dissolved rapidly, higher than that during the second soaking and during the first soaking, which reached the highest value in advance. On the contrary, the absorption capacity of the second soaking was slower, the peak was delayed.

3.4. Sensory Evaluation. The color, aroma, and taste were important factors determining the sensory quality of wine. The sensory evaluation was usually divided into three aspects, such as vision, smell, and taste, which were analyzed and evaluated by the color, aroma, and taste of wine, respectively. Through sensory evaluation and verbal description, wine could be given objective and correct evaluation. The average score given by 25 students with Intermediate Certificate of SWET Wine Taster was as follows.

Table 2 shows the comments with abovementioned certified students to four samples of Kyoho wine.

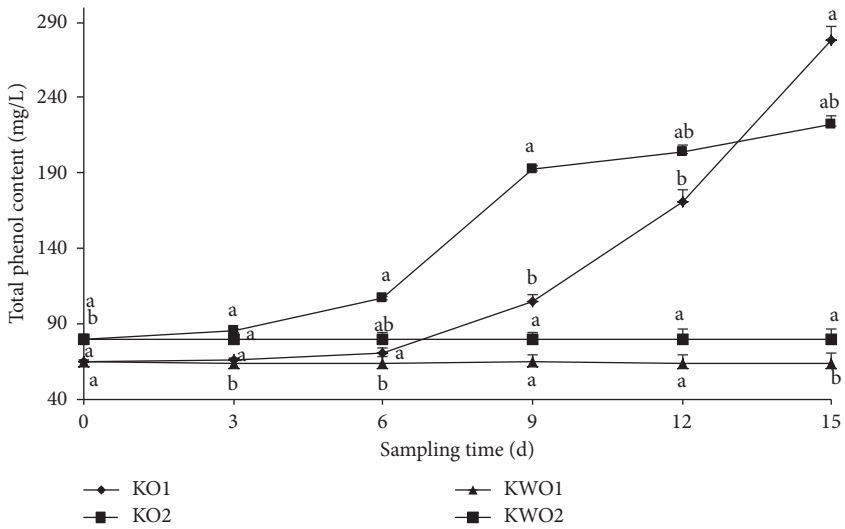

Figure 6: Effect of aging of oak chips on total phenolics. Different letters in each bar indicate significant differences between mean values (≤0.05).

Table 2: Comments of Kyoho wine.

	Comments
KWO2	Light brick red, turbid, slightly fruity, sour, oxidizing, hard taste
KWO1	Ruby red, clear and transparent, aromatic, high acidity, general structure, long after taste
KO2	Brick red, dull, fruity and floral, not full-bodied, rough in body, thin in structure, general typicality
KO1	Purplish red, clear and bright, fruity, mellow, acidic, uniform structure, moderate in style

Table 3: Average scores of Kyoho wine.

	Color (20 score)	Fragrance (20 score)	Taste (40 score)	Structure (10 score)	Typicality (10 score)	Total points (100 score)
KWO2	10.0 ± 0.1	12.0 ± 0.2	30.0 ± 0.1	6.5 ± 0.1	4.5 ± 0.3	63.0 ± 0.2
KWO1	16.5 ± 0.2	14.0 ± 0.3	33.0 ± 0.2	7.0 ± 0.1a	5.0 ± 0.1	75.5 ± 0.3
KO2	15.5 ± 0.1	16.5 ± 0.2	32.5 ± 0.1	7.5 ± 0.3	6.5 ± 0.2	78.5 ± 0.1
KO1	18.5 ± 0.2	17.5 ± 0.3	35.0 ± 0.1	8.0 ± 0.2	7.0 ± 0.1	86.0 ± 0.2

Note. The values of KWO2 in the first, third, and sixth columns are significant at 5% probability level. The values of KWO1 in the first, second, and third columns are significant at 1% probability level, and that in the sixth column is significant at 5% probability level. The values of KO2 in the first and sixth columns are significant at 5% probability level. The values of KO1 in the second and third columns are significant at 1% probability level, and those in the fourth and sixth columns are significant at 5% probability level.

According to Table 3, KO1 Kyoho wine was popular owe to the highest score. Table 2 showed that both wines were all dull in color before and after the second immersion, while the first immersion of wine had brilliant color because of the combination of protein and phenolic substance during fermentation and aging [41]. With the extension of aging time under oak sawdust, the purple tone of Kyoho wine began to decrease, accompanied by the increased yellow tone [42]. The second impregnation of KWO2 wine base scented even sour due to untight sealing during the storage period; the wine body was oxidized by oxygen entering the wine, but sour rot and oxidized taste disappeared under the oak scrap, manifesting that oak sawdust could not restore the wine quality to the original level even though could improve wine flavor (e.g., KO2 rough body, thin structure and general typicality). Because of the difference caused by impregnation of Cabernet Sauvignon residue, there was still a sharp discrepancy after being treated by the same kind of oak sawdust. The two wine bases were impregnated with fermented Cabernet Sauvignon residue, while oak sawdust impregnated preferentially KWO1 wine. Therefore, the color and phenolic substance of KO1 wine were higher than those of the KO2 one, which led to better color and taste in the KO1 wine than those in the KO2 wine.

Therefore, the physicochemical indexes and sensory characteristics of Kyoho wine aged with oak sawdust had changed to a certain extent compared with those without oak sawdust. Although the change trend of physicochemical indexes was not significant, the different sensory characteristics were quite prominent. Tannin and total phenol were increasing during the aging. Hue showed a downward trend (Figure 3) but began to rise after 15 days of aging and decline after 25 days of aging again [43] or 14 months of storage [44], which certified that replacement of hue hinged on aging time.

4. Conclusions

The tannin, total phenol, chroma, and hue of KO1 wine were 1601.5 mg·L^{-1}, 277.67 mg·L^{-1}, 3.21, and 0.72, respectively; the control group had 337.2 mg·L^{-1} tannin, 64 mg·L^{-1} total phenol, 4.46 chroma, and 0.97 hue, respectively. The KO2 had 1517.3 mg·L^{-1} tannin, 222.1 mg·L^{-1} total phenol, 3.02 color, and 0.68 in hue, respectively; the control had tannin 115.6 mg·L^{-1}, total phenol 79.8 mg·L^{-1}, chroma 3.71, and tone 0.72, respectively. Therefore, oak chip aging could increase obviously the tannin, total phenol, chroma, and hue content in Kyoho wine; the influence of KO1 to tannin, total phenol, chromaticity, and color in Kyoho wine was more obvious than the effect of KO2 on them, but the tannin and total phenol in KO2 were higher than those of KWO1 and chromaticity and tone were lower than those of KWO1, which showed that the KO2 was also beneficial to the improvement of the tannin and total phenol. Tannin, chroma, and tonality in the KWO1 were higher than those in the KWO2, whereas total phenol in the KWO1 was lower than that in the KWO2, but these values were much lower than those in the KO1 and KO2. Taking all these factors into account, the impregnation of Cabernet Sauvignon pomace could improve the tannin, total phenol, chroma, and tone content of Kyoho wine, which, however, was negligible compared to effect of oak chip. In other words, the impregnation of oak chip accelerated the accumulation of tannin, total phenol, chroma, and tone. In terms of flavor substances, Kyoho wine aged with oak sawdust was not only brighter in color, fuller and softer in taste but also of much better quality than Kyoho wine aged without oak sawdust. Therefore, the quality of Kyoho wine could be improved by aging with oak sawdust after being soaked with Cabernet Sauvignon residue, which had important value for developing new products and meeting the market demand.

Data Availability

The data used to support the findings of this study are available from the corresponding author and co-corresponding author upon request.

Additional Points

Practical Applications. Adding the oak chip to aged Kyoho wine is a technology that can contribute to the pale wine of industrial development as an alternative to color processing and flavor improvement. It is an ecofriendly and a time-saving process that improves the stability of wine quality and compounds and prolongs the shelf life to obtain safe and high-quality wine products by preventing undesirable changes in the sensory, physicochemical, and nutritional properties of wines.

Conflicts of Interest

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article.

Acknowledgments

This study was financially supported by the Engineering Technology Research Center of Grape and Wine for Advanced School in Yunnan, 12th Five-Year Degree Authorized Construction Discipline in Biology of Yunnan Province, University-level Academic Backbone Training Project for Chuxiong Normal College (XJGG1603), Youth Project of Yunnan Applied Basic Research Projects (2016FD088), key major construction projects on "biotechnology" for Chuxiong Normal College, Scientific Research Fund Major Special Projects for Education Department of Yunnan Province (ZD2015016), support plan of scientific and technological innovation team for Research and Development of Characteristic Plant Resources in Colleges and Universities in Yunnan Province (IRTSTYN), and Research on Key Techniques of Production of Characteristic Ice Wine in Yunnan Plateau.

References

[1] T.-X. Yue, M. Chi, C.-Z. Song et al., "Aroma characterization of Cabernet Sauvignon wine from the plateau of Yunnan (China) with different altitudes using SPME-GC/MS," *International Journal of Food Properties*, vol. 18, no. 7, pp. 1584–1596, 2015.

[2] X. Wang, X. Xie, N. Chen, H. Wang, and H. Li, "Study on current status and climatic characteristics of wine regions in China," *Vitis: Journal of Grapevine Research*, vol. 57, no. 1, pp. 9–16, 2018.

[3] R. R. Xing, F. He, H. L. Xiao, C. Q. Duan, and Q. H. Pan, "Accumulation pattern of flavonoids in Cabernet Sauvignon grapes grown in a low-latitude and high-altitude region," *South African Journal of Enology and Viticulture*, vol. 36, no. 1, pp. 32–43, 2015.

[4] N. de Andrade Neves, L. de Araújo Pantoja, and A. S. Dos Santos, "Thermovinification of grapes from the Cabernet Sauvignon and Pinot Noir varieties using immobilized yeasts," *European Food Research and Technology*, vol. 238, no. 1, pp. 79–84, 2014.

[5] H. Li, H. Wang, L. P. Liu, Z. Q. Wang, and Y. Shu, "Analysis of aroma components of ecolly dry white wine by gas chromatography/mass spectrometry," *Scientia Agricultura Sinica*, vol. 38, no. 6, pp. 1250–1254, 2005.

[6] P. Sun, J.-L. Liang, L.-Z. Kang et al., "Increased resveratrol production in wines using engineered wine strains Saccharomyces cerevisiaeEC1118 and relaxed antibiotic or auxotrophic selection," *Biotechnology Progress*, vol. 31, no. 3, pp. 650–655, 2015.

[7] B. Zhang, J. Cai, C. Q. Duan, M. J. Reeves, and F. He, "A review of polyphenolics in oak woods," *International Journal of Molecular Sciences*, vol. 16, no. 4, pp. 6978–7014, 2015.

[8] M. P. Sáenz-Navajas, C. Martín-López, V. Ferreira, and P. Fernandez-Zurbano, "Sensory properties of premium Spanish red wines and their implication in wine quality perception," *Australian Journal of Grape and Wine Research*, vol. 17, no. 1, pp. 9–19, 2011.

[9] A. M. Martínez-Gil, T. Garde-Cerdán, A. Zalacain, A. I. Pardo-García, and M. R. Salinas, "Applications of an oak extract on Petit Verdot grapevines. Influence on grape and wine volatile compounds," *Food Chemistry*, vol. 132, no. 4, pp. 1836–1845, 2012.

[10] T. G. Cerdán, S. R. Mozaz, and C. A. Azpilicueta, "Volatile composition of aged wine in used barrels of French oak and of American oak," *Food Research International*, vol. 35, no. 7, pp. 603–610, 2002.

[11] A. Faria, J. Oliveira, P. Neves et al., "Antioxidant properties of prepared blueberry (*Vaccinium myrtillus*) extracts," *Journal of Agricultural and Food Chemistry*, vol. 53, no. 17, pp. 6896–6902, 2005.

[12] E. Puértolas, P. Hernández-Orte, G. Sladaña, I. Álvarez, and J. Raso, "Improvement of wine making process using pulsed electric fields at pilot-plant scale. Evolution of chromatic parameters and phenolic content of Cabernet Sauvignon red wines," *Food Research International*, vol. 43, no. 3, pp. 761–766, 2010.

[13] L. Rustioni, G. Cola, J. Vander Weide, P. Murad, O. Failla, and P. Sabbatini, "Utilization of a freeze-thaw treatment to enhance phenolic ripening and tannin oxidation of grape seeds in red (*Vitis vinifera L.*) cultivars," *Food Chemistry*, vol. 259, pp. 139–146, 2018.

[14] Y. Li, R. J. Ma, Z. Z. Xu et al., "Identification and quantification of anthocyanins in Kyoho grape juice-making pomace, Cabernet Sauvignon grape wine making pomace and their fresh skin," *Journal of the Science of Food and Agriculture*, vol. 93, no. 6, pp. 135–138, 2013.

[15] L. Le Grottaglie, I. García-Estévez, R. Romano et al., "Effect of size and toasting degree of oak chips used for wine making on the ellagitannin content and on the acutissimin formation," *LWT-Food Science and Technology*, vol. 60, no. 2, pp. 934–940, 2015.

[16] R. Schumacher, M. E. Alañón, L. Castro-Vázquez, M. S. Pérez-Coello, and M. C. Díaz-Maroto, "Evaluation of oak chips treatment on volatile composition and sensory characteristics of merlot wine," *Journal of Food Quality*, vol. 36, no. 1, pp. 1–9, 2013.

[17] E. Puértolas, G. Saldaña, I. Alvarez, and J. Raso, "Effect of pulsed electric field processing of red grapes on wine chromatic and phenolic characteristics during aging in oak barrels," *Journal of Agricultural and Food Chemistry*, vol. 58, no. 4, pp. 2351–2357, 2010.

[18] M. J. Herderich and P. A. Smith, "Analysis of grape and wine tannins: methods, applications and challenges," *Australian Journal of Grape and Wine Research*, vol. 11, no. 2, pp. 205–214, 2005.

[19] M. D. Mercurio, R. G. Dambergs, M. J. Herderich, and P. A. Smith, "High throughput analysis of red wine and grape phenolics adaptation and validation of methyl cellulose precipitable tannin assay and modified somers color assay to a rapid 96 well plate format," *Journal of Agricultural and Food Chemistry*, vol. 55, no. 12, pp. 4651–4657, 2007.

[20] S. Pérez-Magariño, M. Ortega-Heras, E. Cano-Mozo, and M. L. González-Sanjosé, "The influence of oak wood chips, micro-oxygenation treatment, and grape variety on colour, and anthocyanin and phenolic composition of red wines," *Journal of Food Composition and Analysis*, vol. 22, no. 3, pp. 204–211, 2009.

[21] O. Paredes-López, M. L. Cervantes-Ceja, M. Vigna-Pérez, and T. Hernández-Pérez, "Berries: improving human health and healthy aging, and promoting quality life-a review," *Plant Foods for Human Nutrition*, vol. 65, no. 3, pp. 299–308, 2010.

[22] E. M. Díaz-Plaza, J. R. Reyero, F. Pardo, G. L. Alonso, and M. R. Salinas, "Influence of oak wood on the aromatic composition and quality of wines with different tannin contents," *Journal of Agricultural and Food Chemistry*, vol. 50, no. 9, pp. 2622–2626, 2002.

[23] H. Fulcrand, C. Benabdeljalil, J. Rigaud, V. Cheynier, and M. Moutounet, "A new class of wine pigments generated by reaction between pyruvic acid and grape anthocyanins," *Phytochemistry*, vol. 47, no. 7, pp. 1401–1407, 1998.

[24] H. K. Yildirim, Y. D. Akcay, U. Guvenc, A. Altindisli, and E. Y. Sozmen, "Antioxidant activities of organic grape, pomace, juice, must, wine and their correlation with phenolic content," *International Journal of Food Science and Technology*, vol. 40, no. 2, pp. 133–142, 2005.

[25] M. P. D. de la Torre, F. Priego-Capote, and M. D. Luque de Castro, "Evaluation of the composition of vine shoots and oak chips for oenological purposes by superheated liquid extraction and high-resolution liquid chromatography-time-of-flight/mass spectrometry analysis," *Journal of Agricultural and Food Chemistry*, vol. 60, no. 13, pp. 3409–3417, 2012.

[26] O. A. Young, M. Kaushal, J. D. Robertson, H. Burns, and S. J. Nunns, "Use of species other than oak to flavor wine: an exploratory survey," *Journal of Food Science*, vol. 75, no. 9, pp. S490–S498, 2010.

[27] I. Cutzach, P. Chatonnet, R. Henry, and D. Dubourdieu, "Identification of volatile compounds with a "toasty" aroma in heated oak used in barrelmaking," *Journal of Agricultural and Food Chemistry*, vol. 45, no. 6, pp. 2217–2224, 1997.

[28] M. A. Cliff, M. C. King, and J. Schlosser, "Anthocyanin, phenolic composition, colour measurement and sensory analysis of BC commercial red wines," *Food Research International*, vol. 40, no. 1, pp. 92–100, 2007.

[29] L. M. Schmidtke, A. C. Clark, and G. R. Scollary, "Micro-oxygenation of red wine: techniques, applications, and outcomes," *Critical Reviews in Food Science and Nutrition*, vol. 51, no. 2, pp. 115–131, 2011.

[30] R. R. Dickison, "The scholar and the future of microfilm," *American Documentation*, vol. 17, no. 4, pp. 178-179, 1996.

[31] D. C. Scharf, "Quantum measurement and the program for the unity of science," *Philosophy of Science*, vol. 56, no. 4, pp. 601–623, 1989.

[32] S. Pérez-Magariño and M. L. González-San José, "Polyphenols and colour variability of red wines made from grapes harvested at different ripeness grade," *Food Chemistry*, vol. 96, no. 2, pp. 197–208, 2006.

[33] M. Monagas, B. Bartolomé, and C. Gómez-cordovés, "Updated knowledge about the presence of phenolic compounds in wine," *Critical Reviews in Food Science and Nutrition*, vol. 45, no. 2, pp. 85–118, 2005.

[34] E. Gómez-Plaza, R. Gil-Muñoz, J. M. López-Roca, A. Martínez-Cutillas, and J. I. Fernández-Fernández, "Phenolic compounds and color stability of red wines: effect of skin maceration time," *American Journal of Enology and Viticulture*, vol. 52, no. 3, pp. 266–270, 2001.

[35] M. Auw, J. V. Blanco, S. F. O'keefe, and C. A. Sims, "Effect of processing on the phenolics and color of Cabernet Sauvignon, Chambourcin, and Noble wines and juices," *American Journal of Enology and Viticulture*, vol. 47, no. 3, pp. 279–286, 1996.

[36] S. Zahri, C. Belloncle, F. Charrier, P. Pardon, S. Quideau, and B. Charrier, "UV light impact on ellagitannins and wood surface colour of European oak (*Quercus petraea* and *Quercus robur*)," *Applied Surface Science*, vol. 253, no. 11, pp. 4985–4989, 2007.

[37] M. Del Alamo Sanza, J. A. F. Escudero, and R. De Castro Torío, "Changes in phenolic compounds and colour parameters of red wine aged with oak chips and in oak barrels," *Food Science and Technology International*, vol. 10, no. 4, pp. 233–241, 2004.

[38] Y. Fu, L. T. Lim, and P. D. McNicholas, "Changes on enological parameters of white wine packaged in bag-in-box during secondary shelf life," *Journal of Food Science*, vol. 74, no. 8, pp. 608–618, 2009.

[39] J. Mekoue Nguela, A. Vernhet, N. Sieczkowski, and J.-M. Brillouet, "Interactions of condensed tannins with *Saccharomyces cerevisiae* yeast cells and cell walls: tannin location by microscopy," *Journal of Agricultural and Food Chemistry*, vol. 63, no. 34, pp. 7539–7545, 2015.

[40] D. Cozzolino, M. J. Kwiatkowski, M. Parker et al., "Prediction of phenolic compounds in red wine fermentations by visible and near infrared spectroscopy," *Analytica Chimica Acta*, vol. 513, no. 1, pp. 73–80, 2004.

[41] J. Lachman, M. Sulc, K. Faitová, and V. Pivec, "Major factors influencing antioxidant contents and antioxidant activity in grape sand wines," *International Journal of Wine Research*, vol. 1, pp. 101–121, 2009.

[42] J. Y. Yun and J. S. Ha, "The color image of the early 20th century in the present cinema costume: focusing on "chicago" and "the English patient"," *International Journal of Costume and Fashion*, vol. 5, no. 1, pp. 42–58, 2005.

[43] J. Bakker, A. Picinelli, and P. Bridle, "Model wine solutions: colour and composition changes during ageing," *Vitis*, vol. 32, no. 2, pp. 111–118, 2008.

[44] J. X. Castillo-Sánchez, M. S. García-Falcón, J. Garrido, E. Martínez-Carballo, L. R. Martins-Dias, and X. C. Mejuto, "Phenolic compounds and colour stability of Vinhão wines: influence of wine-making protocol and fining agents," *Food Chemistry*, vol. 106, no. 1, pp. 18–26, 2008.