

The Level of Sulfites in Kosovo Wines

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Received January 28, 2025; Revised July 4, 2025; Accepted July 23, 2025

Cite This Paper in the Following Citation Styles

(a): [1] Violeta Lajqi, Urata Krasniqi, Flutura C. Ajazi, Sami Makolli, Ibrahim Mehmeti, "The Level of Sulfites in Kosovo Wines," *Food Science and Technology*, Vol. 13, No. 3, pp. 274 - 279, 2025. DOI: 10.13189/fst.2025.130304.

(b): Violeta Lajqi, Urata Krasniqi, Flutura C. Ajazi, Sami Makolli, Ibrahim Mehmeti (2025). *The Level of Sulfites in Kosovo Wines*. *Food Science and Technology*, 13(3), 274 - 279. DOI: 10.13189/fst.2025.130304.

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Abstract Wine as an alcoholic drink made from different fruits is produced very highly in Kosovo. Sulfites, as a physico-chemical parameter play an important role in determining the quality of the wine. Sulfites have been used since ancient times to stabilize and preserve wine, yet concerns about possible negative effects on consumer health still exist and are part of the ongoing discussion in the wine industry. The benefit of their antioxidant and antimicrobial properties makes it possible for sulfur dioxide to be widely used in wine technology. This study examines the role of sulfur dioxide (free and total) in maintaining wine quality, with a specific focus on local varieties made in different wine yards in traditional forms. Free and total sulfur dioxides are measured by using the aeration/oxidation method or the Monier/Williams or Rankine/Pocock method. Results show that, the level of free and total sulfur dioxide is different and it ranges from 5 to 40 mg/ml and 25 to 113 mg/ml, respectively. Interestingly, at the same time, different wine yards around Kosovo produce wine from the same type of grapes, but the levels of sulfur dioxide are different. This is an indication showing that processing, starter cultures, or machinery need to be comparable if we need the product to be patented and consumed all around the world.

Keywords Sulfites, Chemical Analysis, Wine Quality, Public Health

1. Introduction

Sulfites, which have played a vital role in the preservation and stabilization of wine for decades, remain a major topic of debate in the wine industry [1]. While these

compounds are known for their ability to prevent oxidation and microbial spoilage [2], there are also concerns about their potential negative effects on consumer health, particularly for those sensitive to sulfites [3]. Sulfide, in addition to playing an intermediate role in the biosynthesis of sulfur-containing amino acids, also has important functions in population signaling, detoxification, and the extension of cellular life [3,4,5]. Recently, it has been observed that, in mammalian cells, polysulfides play an intermediary role because their degradation allows the release of H₂S [5,6]. In the sensory aspect of wine, the effects of polysulfides have attracted a lot of attention recently, because they contribute to flint and mineral aromas in wine [7]. On the other hand, misconceptions about the health effects of sulfites, such as the belief that they cause headaches or, result from wine consumption—have raised public concern. However, these effects are often linked to other components of wine, such as histamines, flavonoids, or alcohol content [1]. The debate around the use of sulfites in wine production has led to new research aimed at better understanding their effects on wine quality and consumer health [8,9,10]. In previous work, the average level of sulfites in wine was around 80 mg/liter, with higher amounts typically found in white wines compared to red wines. The use of sulfites in wine is regulated by EU standards, with maximum allowable levels set at 150 mg/l for red wines, 200 mg/l for white wines, and up to 400 mg/l for sweet wines, depending to wine type and sweetness level [10]; Under EU regulations, any wine that contains more than 10 milligrams per liter (mg/l) must be labeled 'contains sulfites' or 'contains SO₂'. Modern enological practices have focused on reducing the use of sulfur dioxide through technologies such as cooling, thermal treatments, and protected fermentation processes. According to Noviello and collaborators [7], the addition

of vine extract to red and rosé wines can serve as a partial or complete alternative to SO₂, being considered an effective strategy for reducing this allergen. Furthermore, chitosan has emerged as an antioxidant alternative to sulfites in enology, offering new opportunities for winemakers to reduce the use of sulfur dioxide (SO₂) while maintaining wine quality [11, 12].

Kosovo is a young country located in the Balkan region, with a long tradition of grape cultivation and wine production, dating back to ancient times. Favorable climatic conditions and its geographical location have contributed to several regions of Kosovo, which produce several types of high-quality wines. Wine is grouped as an alcoholic drink made from the fermentation processes of different sugars contained in grapes or grape juice, and is made at different times, in different countries, and in different product forms [13, 14]. In Kosovo, from ancient times to the present day, wine production has been a very popular and profitable sector. Seeing its importance, with especial focus in some of the regions such as Rahoveci and Theranda, after the 1990s, the development of the wine sector faced significant challenges due to political turmoil and economic difficulties [15]. Despite this, the wine sector holds great potential for economic growth, creating export opportunities and playing an important role in local and regional markets [16]. The Dukagjin Plain, particularly Rahovec, Theranda, Prizren, Gjakova, and Malisheva (Figure 1) - remains a hub for high-quality grape and wine production, benefiting from Kosovo's Mediterranean continental climate and hilly terrains [17]. Based on our information, Kosovo has approximately 32 different varieties, including 12 red wine grapes, 11 table grape varieties, and 9 white wine grapes varieties [17].

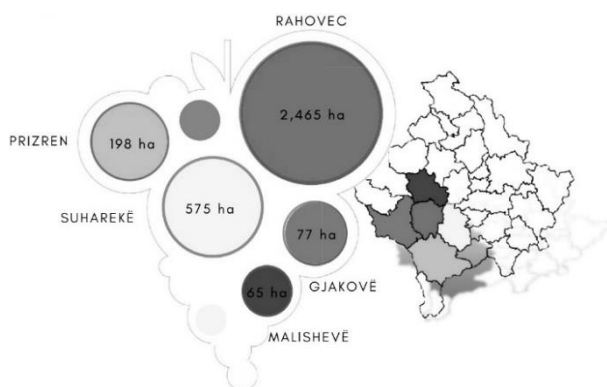


Figure 1. The Territories and Surface Area of Grape Cultivation in Kosovo modified By Report of Ministry of Agriculture in Kosovo [18]

Acceptable levels of sulfites in wine are regulated in many regions, including the EU, but in Kosovo, little research has been conducted on this issue. The growing wine industry in Kosovo lacks detailed information on the sulfite content in its products, and whether these levels comply with safety standards remains unclear [18]. Considering the importance of balancing the use of sulfites

to maintain wine quality and ensure consumer safety, the main objective of this study is focused on the analysis of sulfite levels in local wines, using advanced analytical methods to assess their impact on both wine quality and consumer health.

2. Material and Methods

This study focuses on analyzing local wines to measure sulfite levels and assess their impact on wine quality. Samples from various red and white wines were collected across Kosovo and stored under controlled conditions to avoid contamination. A total of 20 different types of wine variety have been analyzed, which have been produced all around Kosovo, named: Cabernet Sauvignon, Alba, Fleurtaï, Cabernet Volos, Gamay, Gresa Red, Kallamet, Pino Blanc, Gresa e Bardhë Merlot, Pinot Noir, Rizling Italian, Chardonnay, Sauvignon Blanc, Shered, She White, Traminer, Tramonto, Vranac, and Rose, used from different markets around Kosovo. To compare results between each other, we recognize that three different types of the wine are produced mostly in Kosovo and that we have used them to compare between each other. These three different types of wine are Vranac, Chardonnay, and Rizling Italian from five different wine yard coded: RKS 1, RKS2, RKS3, RKS4, and RKS5. Each of the samples has been used in triplicate as a biological replicate, and each of them has been analyzed three times to remove technical problems (like technical replicate). To check the advanced analytical techniques, they were used to measure sulfite concentrations and their effects on organoleptic properties. The samples were kept in a sterile plastic box and transported in an ice box (4 °C–8 °C) to the laboratory, and the samples were immediately processed for further analyses.

The pH, total titratable acidity [19], sulfate level, total volatile acidity [20], and alcohol content were investigated throughout the experiment. Briefly, pH was measured using a pH meter (Orion Star™ A211 Benchtop pH Meter Thermo Scientific™, United States). Titratable acidity and volatile activity of wine samples (by titration with 0.1 N NaOH) were determined as citric acid and acetic acid [21]. From wine samples, volatile acids were separated by steam distillation before titration using sodium hydroxide, to a pink endpoint indicated by phenolphthalein solution. Alcohol concentration was measured using gas chromatography (Chromosorb-103, GC4000; GL Sciences, Tokyo, Japan). The TSS was investigated at 20°C using a hand refractometer (RHB-32ATC), reported as Brix for soluble solid contents.

Total SO₂ is measured using the aeration/oxidation method (AO), sometimes also called the Monier/ Williams or Rankine/Pocock method, and is approved by the International Organization of Vine and Wine (OIV) methods (OIV-MA-AS323-04A) [22]. All measurements were conducted in triplicate. Primary data were obtained through laboratory analyses measuring pH, Brix, titratable

acidity, sulfur levels, volatile acidity, and alcohol content. Statistical analyses were carried out using SPSS Software v. 20.0 (IBM Analytics, New York, NY, USA). The mean values and standard deviation from three different biological replicates have been considered as a group. Mean values and standard deviation have been analyzed. A two-way analysis of variance (ANOVA) was applied to evaluate the significant differences and mean values, followed by Tukey's test. Statistical significance was defined when a p-value was below 0.05.

3. Results and Discussion

Wine is widely consumed these days. It is considered an alcoholic beverage prepared by fermenting grapes and other fermented products. On the other hand, wine is a good source of antioxidants, and wine intake may protect against heart disease, diabetes, and even cancer [1, 2]. Wine is very important to analyse and study the quality and standard of this product. The grapes are produced very much in our country and the wine production level increased every time systematically. Based on the importance of the products, the aim of this study was to study the level of sulfites in different types of wine produced in several winemakers in Kosovo. To check the quality of wine in general, several

parameters such as pH, total titratable volatile acidity, and alcohol content were investigated throughout the experiment. In general, results show that, the level of these parameters (data not shown) is in lines with previous parameters reported [23].

When the basic parameters are below the normal permitted limits, we analysed for each product the sulfite load in this product. This is because sulfites are of great importance in wine in several ways. Sulfites help preserve the freshness and aroma of wine, and extend its shelf life [23]. They also play a role in fermentation processes at a specific point during the production process, or as a preservative to prevent spoilage and oxidation, and protect against bacteria [23]. This product in our country is quite popular and consumed quite a lot. There are many companies that deal with the production of wines. Grapes are considered one of the raw materials to produce wines in our country. Based on the importance of use, there are several varieties from which wines are produced. In our study, we analyse twenty different varieties of grapes and study the level of free SO₂ and total level of SO₂ (Table 1).

Sulfur dioxide (SO₂) levels were measured using the OIV-MA-AS323-04A method, commonly used for determining total level in wine. The research methods were based on scientific literature (primary sources), while laboratory data served as secondary sources.

Table 1. Level of Sulfur dioxide (SO₂) in various grape varieties from different companies produced in Kosovo

Variety of wine	Free SO ₂ (mg/l) ±SD	Total SO ₂ (mg/l) ±SD	Groups
CABERNET SAUVIGNON	32±1.31	85±4.13	III
ALBA	25±1.84	80±4.94	II
FLEURTAI	20±0.84	89±3.80	II
CABERNET VOLOS	40±2.64	82±4.61	III
GAMAY	36±2.25	72±4.56	III
GRESA RED	27±1.19	90±6.02	III
KALLAMET	33±1.26	82±5.48	III
PINO BLANC	32±1.97	87±6.00	III
GRESA E BARDHË	23±1.29	82±3.92	II
MERLOT	35±2.21	113±8.01	III
PINOT NOIR	18±1.34	83±4.76	II
RIZLING ITALIAN	18±1.11	89±3.59	II
CHARDONNAY	15±0.84	57±3.66	I
SAUVIGNON BLANC	23±1.33	62±2.71	II
SHERED	15±0.61	84±4.17	I
SHE WHITE	26±1.44	80±4.69	III
TRAMINER	5±0.32	25±1.34	I
TRAMONTO	25±0.86	89±1.22	II
VRANAC	28±1.11	72±2.84	III
ROSE	26±1.03	92±4.72	III

*All samples with free SO₂ (mg/l) from 5-15 mg/l belongs to group I; group II: 15.1-25.0 mg/L and group III more than 21.1 mg/L

All results analysed in this study meet the legal limits established by the Republic of Kosovo Law No. 08/L-211, Article 32. This law stipulates that SO₂ in wines (excluding sparkling and liqueur wines) must not exceed 150 mg/l for red wines and 200 mg/l for white and rosé wines. For wines with a sugar content of at least 5 mg/l (expressed as glucose and fructose), the maximum allowed SO₂ is 200 mg/l for red wines and 250 mg/l for white and rosé wines (The wine law no. 08/L-211, 2024) [24]. Levels of free SO₂ in grapes varieties are in level from 5-40 mg/l while the total level of SO₂ in these varieties is in range from 25-113 mg/l. The results indicate a variation in SO₂ content across different grape varieties (Table 1). Red grape varieties consistently show higher SO₂ concentrations, contributing to enhanced taste preservation and overall wine stability. The free level of SO₂ between each of variety is significantly different between each other and that in variety of Traminer is 5mg/L followed by other types of the variety. However, the variety of cabernet volos level of free SO₂ is 40 mg/l. It means that it is eight time higher than another type. To make it easier to read and to show the level of SO₂ based on variety we have to try to separate in three groups of variety based on the free SO₂ level. In first group, they are in range between 5-15 mg/l, the second group between 15.1-25.0 mg/l and the third group more than 25.1 and higher. Result shows that in first group there are three types of variety, followed by group II which are seven types of variety and last group are most of the variety (ten types) (More details see Table 1). Interestingly, our result shows significant differences between each type of variety in both levels of free and total SO₂. It shows that, technological processes need to be studied more in detail and adapted between each other or to study more in detail the differences of type of grapes.

Wine production in Kosovo varies from year to year. Results from 2018 until 2022 show that the average production of wine was from 9.1 million liters to 11.8 million liters [18]. This difference is reported to be due to the variety of climatic conditions, the appearance of any diseases, or damage to vineyards from natural disasters [25]. Sometimes food technology is shown to be that several companies produce the same production while the nutritional parameters or processing, aroma or color are shown to be different [25]. To see the level of sulfur

dioxide in wine from different vineyards in Kosovo, we have analyzed five different companies around Kosovo that produce wine.

The results show that different types of wines have different levels of free and total SO₂ (Table 2). Interestingly, a similar type of wine, but from different producers, shows significant differences in level of free and total SO₂. The same differences it shows are even within the same type of grape, and the amount of both total and free SO₂ is different. This is not only in one type of wine, but is in all the types. These probably need to check the process of making a wine in proper and similar conditions and technologies. On the other hand, it is documented that, in addition to the positive effects that SO₂ has on human health, it is also argued that the form, technological processes, or method of wine production affects the level of these compounds. Since the type of grape is the same, only the technological aspect or the addition of an additive could have influenced this level to be different. Our results have a positive side because, although the level of SO₂ is different, this level is still in accordance with the permissible norms. The differences of this compound level from different types of wine are an indication that it will help to make a general recipe in wine production. Having patented recipes for our local wine makers it will increase the credibility of local products in international markets. On the other hand, in some of the wine yards, the level of SO₂ is close to go out the international limitation. This is a recommendation that, if Kosovo's products aim to enter international markets, it is essential to comply with relevant rules and regulations by strengthening the inspection system and ensuring their strict enforcement. The literature also shows that physicochemical parameters in wine indicate the level of SO₂ [18]. One of them is level of pH, which plays an important role on the SO₂ concentration. If the pH level is low in wine, it is an indication to increase the level of SO₂. Acidity of wine is also an indication in SO₂. If the acidity is lower the level of SO₂ is less [18]. To have good quality wine, all physical and chemical parameters must conform to the allowed limits. In some of the countries around the world, different preservatives are used to play a similar level as a SO₂ [2]. Maybe this can be one of the alternatives which our producers can try, test and analyze.

Table 2. Comparative Analysis of SO₂ levels in five different wine yards from three different grapes variety

Wine yards code	Varieties					
	Vranac		Chardonnay		Rizling Italian	
	Free SO ₂	Total SO ₂	Free SO ₂	Total SO ₂	Free SO ₂	Total SO ₂
RKS 1	28±1.10	72±2.80	15±0.80	57±3.50	18±1.00	89±3.60
RKS 2	19±1.30	104±6.4	34±2.20	114±7.50	DP	DP
RKS 3	48±2.50	84±4.10	DP	DP	55±3.00	170±9.00
RKS 4	60±3.00	98±5.10	DP	DP	15±1.00	59±3.00
RKS 5	DP	DP	18±1.10	110±6.40	DP	DP

DP-doesn't produce the wine with this variety.

4. Conclusions

This research assessed the sulfite content in local wines in Kosovo, emphasizing their essential role in maintaining wine quality through antioxidant and antimicrobial properties. Kosovo's growing wine industry, supported by modern technologies and favorable climatic conditions, has aligned itself with global market standards. The study revealed variations in sulfur dioxide (free and total) levels across different wine yards, however, these levels remain within the legal limits established by Kosovo's regulations. Continuous monitoring is crucial to ensure that local wines meet both safety and quality requirements. The recommendations of this study suggest that wine producers in Kosovo should continue the controlled use of sulfites within legal limits, ensuring quality preservation without exceeding allowable levels. To optimize wine quality, it is necessary to invest in advanced technologies for the management and reduction of SO₂. Making a patented recipe will increase quality, make it easier to control, and increase interest in entering markets around the world and it will be easier to position as an international product of our country. Additionally, harmonizing practices among wineries would contribute to compliance with international standards and support the sustainable development of the industry. Continuous monitoring of sulfite content will ensure product quality in both local and international markets. Given the importance of wine, there is a great need for the standardization of this product and quality assurance practices, with special emphasis on sulfur levels.

Acknowledgements

We are very grateful to the Department of Viticulture and Enology in Rahovec and the staff of the Theranda winery for providing us with the opportunity to conduct analyses in their laboratories and for their appropriate and constructive suggestions to improve this paper.

Conflict of Interest

Nothing to declare.

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