

# Phenolic Characteristics and Antioxidant Activity of Merlot and Cabernet Sauvignon Wines Increase with Vineyard Altitude in a High-altitude Region

Xiao-duo Jin, X. Wu, X. Liu\*

College of Oenology, Northwest A&F University, Yangling 712100, China

Submitted for publication: October 2016

Accepted for publication: March 2017

Key words: Wine, phenolic characteristics, antioxidant activity, terroir, high-altitude region

**Altitude, as an important factor in the expression of terroir, may affect wine quality. We evaluated the effect of altitude and its related climatic conditions on the phenolic characteristics and antioxidant activity of red wines made from grapes originating from high-altitude areas. The content of total phenolic compounds, total flavonoids and total anthocyanins increased with altitude in Merlot (ME) and Cabernet Sauvignon (CS) wines. Cabernet Sauvignon wines showed richer tannins with increasing altitude. Merlot and CS wines from higher altitude vineyards, showed a greater antioxidant capacity. Salicylic acid, syringic acid, caffeic acid, (+)-catechin, (–)-epicatechin, and the sum of individual phenolic compounds in the wines increased with altitude based on the results of HPLC. The scores of the sensory evaluation of ME wines increased with higher altitude. The highest score was determined for CS wine originating from 2 608 m. A clear grouping of wines according to grape cultivar and vineyard altitude was observed by principal component analysis. Regression analysis showed that altitude, followed by sunshine hours, made the greatest contribution to differences in the phenolic characteristics and antioxidant activity of red wines at different sites in a high-altitude region.**

## INTRODUCTION

Environmental factors such as light and field management practices have a combined effect on grapevine physiology and wine quality (Spayd *et al.*, 2002; Feng *et al.*, 2017). The French term “terroir” is used to define the geographical and environmental origin of grapes grown and harvested during a certain vintage (Deloire *et al.*, 2008). This term includes all regional parameters, such as soil type, climate and orography (Douglas *et al.*, 2001). Terroir is an important factor affecting grape and wine composition (Roullier-Gall *et al.*, 2014).

Altitude is usually considered an indirect control on the environmental conditions affecting plant metabolism (Kumar *et al.*, 2006). Therefore, altitude may have a strong effect on climatic conditions that affect grape development and wine quality (Mateus *et al.*, 2002). In particular, altitude gradient may reflect the integrated variation in temperature, humidity and solar radiation in a mountainous region with high vertical zonality (Zhang *et al.*, 2005).

Phenolic compounds contribute to a wine’s organoleptic characteristics, such as mouthfeel and colour, and are associated with anti-cancer and cardiovascular protection and antioxidant activity (Burns *et al.*, 2000; Skerget *et al.*,

2004). The phenolic compound concentrations of grapes are affected by time of harvest and grape ripeness levels, thereby affecting the flavour and quality of the resulting wine. Phenolic compound concentrations are also affected by genotypes, viticultural practices and environmental conditions (Downey *et al.*, 2006). Variation in phenolic characteristics of wine grapes has often been observed at different altitudes and also has been characterised by regional differences (Mateus *et al.*, 2001, 2002; Liang *et al.*, 2014). Higher altitudes synchronise with a lower temperature and higher humidity, which may be beneficial to carotenoid accumulation (Oliveira *et al.*, 2004). An increase in ultraviolet (UV) intensity, with an increase in altitude, promotes anthocyanin biosynthesis in Malbec grape skin via upregulating the genes encoding phenylalanine ammonia lyase (PAL) and chalcone synthase (CHS) (Berli *et al.*, 2015).

The effect of vineyard altitude on wine quality has not been reported extensively (Jiang *et al.*, 2015; Yue *et al.*, 2015). Touriga Nacional wine made from grapes harvested at higher altitudes – ranging from 300 m to 350 m – showed a higher level of anthocyanins (Mateus *et al.*, 2002). The

\*Corresponding author: E-mail address: liuxu@nwsuaf.edu.cn [Tel.: +86-29-87092107; Fax: +86-29-87092107]

Acknowledgements: This study was supported by the National Natural Science Foundation of China (31401819), the China Agriculture Research System for the Grape Industry (CARS-30-zp-09), the Special Fund for Agro-scientific Research in the Public Interest (201203035), and the Key Science and Technology Programme of Shaanxi Province, China (2014K01-08-01)























