



DISTINGUISHING RED WINES FROM NORTHWEST CHINA BY COLOUR-FLAVOUR RELATED PHYSICO-CHEMICAL INDEXES

Yu Zhao¹, Guojie Jin¹, Jiao Jiang¹, Shijin Xue¹, Kai Hu^{1*}, Yongsheng Tao^{1,2*}

¹College of Enology, Northwest A&F University, Yangling, Shaanxi 712100, China

²Shaanxi Engineering Research Center for Viti-viniculture, Yangling, Shaanxi 712100, China

* Corresponding authors: taoyongsheng@nwsuaf.edu.cn (Y.-S. Tao); kh@nwafu.edu.cn (K. Hu)

Abstract

Aim: Northwest China occupies an important position in China's wine regions due to its superior geographical conditions with dry climate and sufficient sunlight. In this work, we aimed to investigate the physico-chemical colour and flavour characteristics of red wine in Northwest China.

Methods and Results: A total of 196 commercial dry red wines from Ningxia autonomous region, Gansu province and Xinjiang autonomous region in Northwest China were sampled. Spectro-analysis and chemical titration were used to quantify physico-chemical indicators related to wine colour and flavour, including total anthocyanins, co-pigments, monomeric anthocyanins, polymeric anthocyanins, ionisation index, CIE color space, total phenols, flavonol, ethanol index, total tannin, gelatin index, HCl index, DPPH antioxidant activity, tartrate ester, titratable acid, and pH value. Principal Component Analysis (PCA) of the data showed that wine samples in Ningxia, Gansu and Xinjiang region had obvious clustering phenomena. Among them, total anthocyanin and polymeric anthocyanins in Ningxia wines were higher compared to other wines. Ningxia wines also had the highest total acids and lighter colour whereas Gansu wines had greater amounts of monomeric anthocyanins, co-pigments and phenolic indexes. Gansu wines were darker in colour with the highest pH values. The parameters of Xinjiang wines were ranged between Ningxia wines and Gansu wines. PCA also showed good discriminant results on wine vintages. Wines older than 3 years had more polymeric anthocyanins and stable colour whilst younger wines had more total anthocyanin and monomeric anthocyanin with brighter colour. In addition, younger wines had the highest phenolics. Grape cultivars also contributed to the difference of colour and flavour associated indexes. Among them, Cabernet Sauvignon wines displayed distinct characteristics compared to other wines. Values of total anthocyanins, DPPH antioxidant activity, ionisation index, C_{ab} and HCl acid indexes of Cabernet Sauvignon wines were higher than those of other wines. Finally, a convolutional neural network model was used to discriminate and analyses the categorical data of wines. These data were standardized and analysed using TensorFlow. The corresponding fitness indexes were 99.14%, 90.52%, and 89.66% from Northwest China based on region, cultivar, and vintage.

Conclusions: Colour and flavour associated indexes of wines from Northwest China are strongly impacted by wine regions, cultivars, and vintages.

Significance and Impact of the Study: Wine regions in Northwest China are developing drastically in recent decades, however relevant criteria of colour-flavour quality to help manipulate winemaking practices are lacking in local wineries to ensure the quality of wine style. Our results highlighted the possibility of establishing such wine quality criteria specially for Northwest China based on building a discrimination model on wine physico-chemical related indicators.

Keywords: Wine region, spectro-analysis, discrimination analysis, neural network analysis, colour-flavour physico-chemical indicators

Yu Zhao¹, Guojie Jin¹, Jiao Jiang¹, Shijin Xue¹, Kai Hu^{1,*}, Yongsheng Tao^{1,2,*}

¹ College of Enology, Northwest A&F University, Yangling, Shaanxi 712100, China

² Shaanxi Engineering Research Center for Viti-viniculture, Yangling, Shaanxi 712100, China

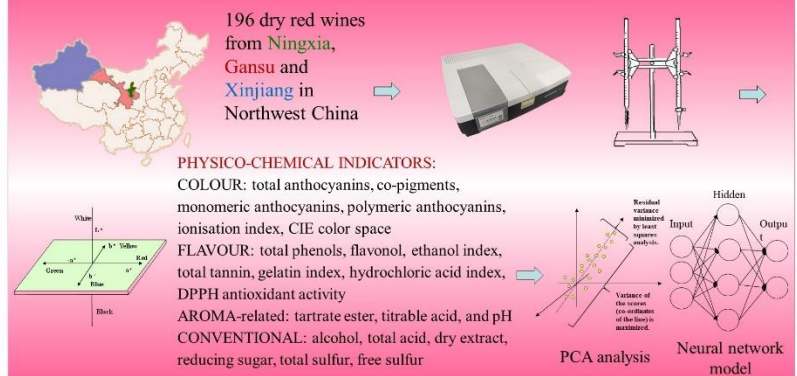
*Corresponding author, Email: taoyongsheng@nwsuaf.edu.cn (Y.-S. Tao), kh@nwafu.edu.cn (K. Hu).

Introduction

Wine regions of Northwest China are developing drastically in recent decades. However, relevant criteria to monitor winemaking technology is lacked in local wineries, and the evaluation of wine quality characteristics is mostly carried out by professional reviewers through sensory evaluation, which is not objective. Furthermore, the current methods to discriminate and analyze the quality characteristics of wine accurately are complex and expensive, which makes it difficult to conduct in enterprises.

In this study, the UV spectrophotometer of low-cost and easy-to-operate was used to detect the physico-chemical indicators of wine. Region, cultivar and vintage of wine samples were classified by physico-chemical indicators, and established a mathematical model to realize the traceability of the wine origin in Northwest China. Our researches were expected to build a technical system of physico-chemical characterization of wine style and quality characteristics in Northwest China, and it provide theoretical and data support for the establishment of its standard system.

Materials and methods



Results and discussion

1. PCA analysis of physico-chemical indicators

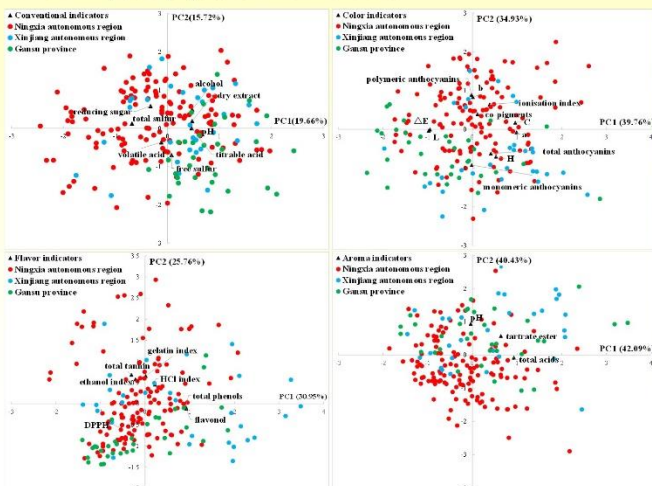


Figure 1. PCA of conventional, color, flavor and aroma indices of wine samples obtained from different regions

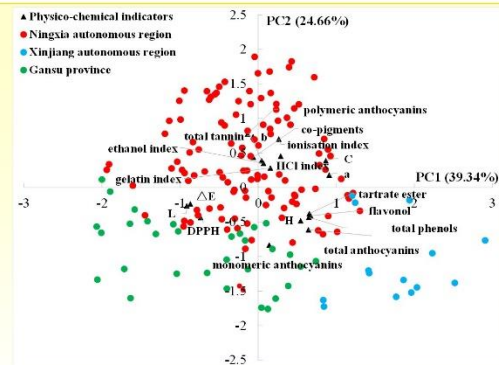


Figure 2. PCA of physico-chemical indices of wine samples obtained from different regions

According to Figure 1, PCA analysis of conventional, color, flavor and aroma physico-chemical indicators showed the clustering effect was poor, while by colour-flavour physico-chemical indicators could better distinguish wine samples from different regions in Figure 2. The data shows that total anthocyanin and polymeric anthocyanins in Ningxia wines were significantly higher compared to other wines. Ningxia wines also had the highest total acids and lighter colour whereas Gansu wines had greater amounts of monomeric anthocyanins, co-pigments and phenolic indexes. Gansu wines were also darker in colour with the highest pH values. The parameters of Xinjiang wines were ranged between Ningxia wines and Gansu wines in Figure 2.

2. Analysis physico-chemical indexes vintages and varieties

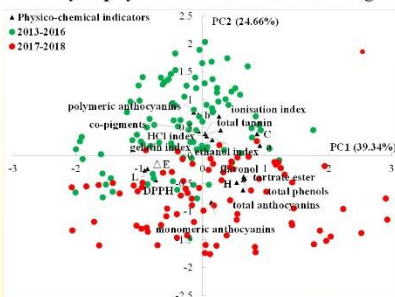


Figure 3. PCA of physico-chemical indices of wine samples obtained from different vintages

PCA also shows good discriminant results on wine vintages and varieties. Wines older than 3 years had more polymeric anthocyanins and stable colour whilst younger wines had more total anthocyanin and monomeric anthocyanin with brighter colour. In addition, younger wines had the highest phenolics in Figure 3. Values of total anthocyanins, DPPH antioxidant activity, ionisation index, C_{660} and HCl acid indexes of Cabernet Sauvignon wines were higher than those of other wines in Figure 4.

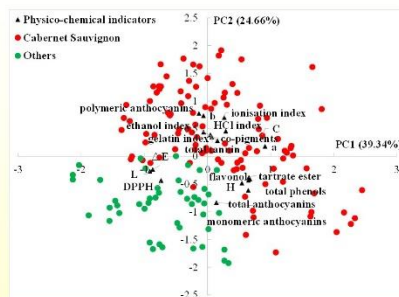


Figure 4. PCA of physico-chemical indices of wine samples obtained from different cultivars

3. Discriminant analysis of region, cultivar and vintage by convolutional neural network

	Colour-flavour indicators	Colour indicators	Flavour indicators	Aroma-related indicators
Region	99.14%	94.78%	82.91%	83.33%
Cultivar	90.52%	81.20%	72.41%	61.74%
Vintage	89.66%	79.49%	54.31%	47.79%

Convolutional neural network (CNN) model was used to discriminate and analyse the categorical data of wines. These data were standardized and analysed using TensorFlow. The accuracy of colour-flavour indicators was the highest that 99.14%, 90.52% and 89.66% from Northwest China based on region, cultivar, and vintage.

Conclusion

- Wine samples from Ningxia, Gansu and Xinjiang had obvious clustering phenomenon on region, cultivar and vintage.
- A neural network model could be used to discriminate and analyze wines from Northwest China based on region, cultivar and vintage.

Acknowledgements

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