Effect of the plot variability on the qualitative and quantitative characteristics of the berry's skins and seeds of grape cultivar Agiorgitiko (Vitis vinifera L.)

Victoria Verarou‡, Maritina Stavrakaki‡, Ioannis Daskalakis‡, Despoina Bouza‡, Katerina Biniari‡

‡ Laboratory of Viticulture, School of Agricultural Production, Infrastructure and Environment, Agricultural University of Athens, Athens, Greece

Abstract

Background

Soil properties, climatic conditions and cultivation techniques constitute significant variables, which affect the quality of the final product. In particular, soil data (soil texture, soil electrical conductivity etc.) and weather data (average temperature, humidity etc.) affect both crop quality data (sugar content, anthocyanins content, phenolic compounds concentrations etc.) and crop quantity data (crop yield, berry weight and size etc.).

The aim of this study was to investigate the variations of the microclimatic areas that exist within the same vineyard and their effect on the qualitative and quantitative characteristics of the berry skins and seeds of the grapes. These microclimatic areas could be identified and classified as those which could produce grapes for PDO wines and those which could be used for the production of other types of wines.
New information

The overall results of this study indicated important differences between the grapes of different sub-zones from the perspective of their chemical analyses, namely with notable differences identified between the grapes in the anthocyanin concentration and mainly in the concentration of malvidin, acetyl and coumaric esters of malvidin.

A significant variability was observed in the characters of the must and in berry mechanical properties. More specifically, higher weight of berries was observed in the lower part of the vineyard, based on its slope. In the north-eastern part of the vineyard, a higher concentration of polyphenolic compounds was recorded. The concentration of total anthocyanins was found to be positively correlated with the soil slope, while significant variability in the concentration of total anthocyanins was revealed.

Keywords
anthocyanins, phenolic compounds, tannins, flavanoids, flavanols, flavonols, flavones, skins, seeds

Introduction

One of the most important viticultural areas of Greece is that of the Peloponnese, which includes the very famous Protected Designation of Origin (PDO) region Nemea where ‘Agiorgitiko’, one of the noblest and oldest Greek grapevine cultivars, is cultivated (Ministry of Agriculture 2018). This region is characterised by a significant variation of soils, even within the same vineyards, resulting in the production of wines which do not comply with PDO specification.

The expansion of the vineyards from higher, sloped landscapes (higher than 900 m) to new cultivation areas has resulted in the location of many newer planted vineyards at lower elevations and more fertile soils typically located between 750 and 800 m. The climatic conditions in these areas, as well as the productive potential of the soils, demand greater attention to vine management, including microclimatic aspects affecting health and maturation of grapes (Ramos et al. 2015).

The process of acquiring and using data during the implementation of Precision Viticulture is constant and repetitive. Therefore, it is possible to determine the appropriate plots within a vineyard in order to obtain viticultural products of high quality through selective harvesting, based on zones of similar soil properties (Bramley and Hamilton 2004, Bramley et al. 2005).
General description

**Purpose:** The aim of this study was to investigate the variations of the microclimatic areas that exist within the same vineyard and their effect on the qualitative and quantitative characteristics of the grapes. These microclimatic areas could be identified and classified as those which could produce grapes for PDO wines and those which could be used for the production of other types of wines.

**Additional information:**

**Experimental design:**

The vineyard where the experiment took place is located in Nemea. The row orientation is northeast-southwest and the training/trellis system is VSP (vertical shoot positioned) - cane pruning, double Guyot (Fig. 1). The vines are all grafted on rootstock Richter 110; are bilateral cordon-trained (bilateral Royat) at 2.2 m x 1.2 m intervals; and are spur-pruned to 2-node spurs. The usual viticultural techniques are applied, i.e. fertilisation using 11-15-15 NPK at a dose 250 g/vine; canopy management techniques (shoot thinning, topping; girdling); and irrigation.

![Vineyard where the experiment took place.](image)

Based on the phenotypic characteristics of the vines, as well as the soil differences in the different microclimatic areas of the vineyard, a section of the vineyard was divided in 3 plots (B, E, H) and each plot was divided into 5 cells (B01-B05, E01-E05 and H01-H05), which constituted the different types of treatments under study (Fig. 2). In these segments, measurements of photosynthesis and chlorophyll concentration took place during the different growth stages of the vines, as well as on harvest day (Table 6). Photosynthesis
concentration was measured using a portable photosynthesis system (Li-6400XT, Li-Cor, Lincoln Nebraska, USA), while chlorophyll concentration was measured on the same leaves using a SPAD 502 (Konica Minolta, Europe). Samples of grapes were collected in order to measure their mechanical properties, followed by chemical analyses of the grapes, berries and must.

| Plot | pH       | Total titratable acidity (g tartaric acid/L grape juice) | Sugars (Brix) |
|------|----------|----------------------------------------------------------|---------------|
| B01  | 4.08 ± 0.05bc | 3.55 ± 0.03de                                             | 23.27 ± 0.64b |
| B02  | 3.81 ± 0.02e  | 3.60 ± 0.12de                                             | 23.67 ± 0.29b |
| B03  | 4.10 ± 0.01b  | 3.75 ± 0.00de                                             | 25.20 ± 0.00a |
| B04  | 3.89 ± 0.00de  | 3.50 ± 0.12de                                             | 22.00 ± 0.00cd |
| B05  | 4.09 ± 0.00bc  | 3.75 ± 0.00de                                             | 23.40 ± 0.00b |
| E01  | 4.27 ± 0.00a  | 4.50 ± 0.00bc                                             | 17.87 ± 0.07g |
| E02  | 3.83 ± 0.01de  | 3.38 ± 0.22e                                              | 18.97 ± 0.03f |
| E03  | 4.28 ± 0.00a  | 4.38 ± 0.12c                                              | 21.80 ± 0.00cd |
| E04  | 3.87 ± 0.00de  | 3.38 ± 0.00e                                              | 18.20 ± 0.00fg |
| E05  | 3.91 ± 0.00d  | 3.50 ± 0.12de                                             | 20.00 ± 0.00c |
| H01  | 3.73 ± 0.00f  | 5.13 ± 0.12a                                              | 22.27 ± 0.07c |
| H02  | 4.09 ± 0.01b  | 4.13 ± 0.22cd                                             | 23.87 ± 0.07b |
| H03  | 4.08 ± 0.00b  | 4.63 ± 0.13abc                                            | 21.07 ± 0.07d |
| H04  | 3.89 ± 0.00de  | 5.00 ± 0.12ab                                             | 17.47 ± 0.07g |
| H05  | 4.02 ± 0.00c  | 4.63 ± 0.13abc                                            | 19.13 ± 0.07ef |

Table 1.
Characters of the grape juice

| Plot | pH       | Total titratable acidity (g tartaric acid/L grape juice) | Sugars (Brix) |
|------|----------|----------------------------------------------------------|---------------|
| B01  | 5124.25 ± 95.73e | 1173.48 ± 23.45f                                         | 3.49 ± 0.11def |
| B02  | 5123.15 ± 93.93e | 1164.78 ± 25.45f                                         | 3.50 ± 0.12def |
| B03  | 5403.04 ± 8.86cde | 1126.09 ± 79.84f                                         | 3.60 ± 0.05cdef |
| B04  | 4440.00 ± 91.99f | 1308.78 ± 6.98ef                                         | 3.99 ± 0.08bcd |
| B05  | 6739.96 ± 245.16a| 1777.17 ± 25.50b                                         | 4.34 ± 0.12bc |
| E01  | 5954.83 ± 106.74c | 1234.73 ± 17.95f                                         | 4.13 ± 0.20bcd |
| E02  | 6197.88 ± 112.78ab| 2130.10 ± 134.40a                                        | 4.50 ± 0.08b |
| E03  | 5160.03 ± 15.88de | 797.42 ± 27.54g                                          | 3.00 ± 0.13f |

Table 2.
Individual acid concentration in grape juice
| Plot | Tartaric acid (mg tartaric acid/L grape juice) | Malic acid (mg malic acid/L grape juice) | Succinic acid (mg succinic acid/L grape juice) |
|------|-----------------------------------------------|------------------------------------------|-----------------------------------------------|
| E04  | 5071.27 ± 155.01ef                            | 841.80 ± 10.22g                         | 3.19 ± 0.05ef                                 |
| E05  | 6143.66 ± 100.45ab                            | 1717.57 ± 21.47bc                       | 3.91 ± 0.24bcd                                |
| H01  | 6363.03 ± 109.89ab                            | 1237.47 ± 1.50f                         | 3.42 ± 0.01def                                |
| H02  | 6058.85 ± 100.50b                             | 1582.80 ± 41.30bcd                      | 3.71 ± 0.18cdef                               |
| H03  | 6726.75 ± 116.15a                             | 1518.93 ± 24.35cde                      | 4.51 ± 0.01b                                 |
| H04  | 6438.62 ± 134.51ab                            | 1495.05 ± 19.61cde                      | 4.49 ± 0.23b                                 |
| H05  | 5801.22 ± 184.65bcd                           | 1362.69 ± 17.21def                      | 5.72 ± 0.20a                                 |

Table 3.
Seeds and skins total phenolics concentration

| Plot | Seed total phenolics (mg gallic acid/g f.w.) | Skin total phenolics (mg gallic acid/g f.w.) |
|------|---------------------------------------------|----------------------------------------------|
| B01  | 27.25 ± 0.61cd                              | 7.23 ± 0.20bc                               |
| B02  | 27.56 ± 0.48cd                              | 6.95 ± 0.09bcd                              |
| B03  | 26.42 ± 0.78cd                              | 6.97 ± 0.11bcd                              |
| B04  | 25.99 ± 0.39cd                              | 6.25 ± 0.23def                              |
| B05  | 27.46 ± 0.76cd                              | 6.71 ± 0.20cd                               |
| E01  | 28.70b ± 1.84bc                             | 7.53 ± 0.08b                                |
| E02  | 24.57 ± 0.85cd                              | 9.30 ± 0.26a                                |
| E03  | 26.51 ± 0.09cd                              | 9.15 ± 0.08a                                |
| E04  | 27.72 ± 1.27cd                              | 5.84 ± 0.02efg                              |
| E05  | 27.51 ± 1.39cd                              | 6.23 ± 0.11def                              |
| H01  | 24.64 ± 0.84cd                              | 4.58 ± 0.04h                                |
| H02  | 22.79 ± 0.85d                               | 5.82 ± 0.17fg                               |
| H03  | 33.71 ± 1.89ab                              | 5.24 ± 0.12gh                               |
| H04  | 38.64 ± 0.48a                               | 6.65 ± 0.29cde                              |
| H05  | 28.28 ± 1.55bcd                             | 7.23 ± 0.04bc                               |

Table 4.
Seeds and skins total tannins concentration

| Plot | Seed tannins (mg catechin/g f.w.) | Skin tannins (mg catechin/g f.w.) |
|------|----------------------------------|-----------------------------------|
| B01  | 77.90 ± 3.59e                    | 19.00 ± 2.14de                   |
| B02  | 77.90 ± 1.45e                    | 19.00 ± 0.37de                   |
| B03  | 94.79 ± 0.83bcd                  | 16.78 ± 0.88def                  |
| B04  | 113.02 ± 1.34a                   | 25.01 ± 1.29b                    |
| Plot | Seed tannins (mg catechin/g f.w.) | Skin tannins (mg catechin/g f.w.) |
|------|----------------------------------|---------------------------------|
| B05  | 106.62 ± 1.60ab                  | 25.03 ± 0.37b                   |
| E01  | 100.10 ± 4.23bc                  | 33.10 ± 0.35a                   |
| E02  | 95.65 ± 6.49bcde                 | 24.74 ± 0.17bc                  |
| E03  | 98.51 ± 2.06bcd                  | 18.15 ± 0.65def                 |
| E04  | 86.10 ± 0.22de                   | 18.79 ± 0.83de                  |
| E05  | 101.66 ± 1.05abc                 | 16.35 ± 0.43f                   |
| H01  | 93.61 ± 1.40cd                   | 16.30 ± 0.10ef                  |
| H02  | 73.79 ± 1.71e                    | 14.40 ± 0.56f                   |
| H03  | 77.32 ± 0.55e                    | 20.86 ± 0.00cd                  |
| H04  | 77.32 ± 0.22e                    | 23.56 ± 0.35bc                  |
| H05  | 94.40 ± 0.72bcd                   | 18.98 ± 0.00de                  |

Table 5.
Individual anthocyanins

| Plot | mg malvidin/g f.w. | mg acetyl ester malvidin/g f.w. | mg coumaric ester malvidin/g f.w. |
|------|--------------------|----------------------------------|----------------------------------|
| B01  | 0.89 ± 0.02cde     | 0.05 ± 0.00cde                   | 0.01 ± 0.01f                     |
| B02  | 0.89 ± 0.02cde     | 0.05 ± 0.00cde                   | 0.01 ± 0.01f                     |
| B03  | 0.87 ± 0.00cde     | 0.05 ± 0.01cde                   | 0.01 ± 0.00f                     |
| B04  | 0.78 ± 0.00e       | 0.02 ± 0.00f                     | 0.01 ± 0.00f                     |
| B05  | 0.67 ± 0.00ef      | 0.03 ± 0.00ef                    | 0.02 ± 0.00ef                    |
| E01  | 0.81 ± 0.08de      | 0.04 ± 0.00def                   | 0.12 ± 0.03def                   |
| E02  | 0.46 ± 0.02f       | 0.03 ± 0.00f                     | 0.16 ± 0.00d                     |
| E03  | 1.06 ± 0.07bcd     | 0.06 ± 0.01bcd                   | 0.58 ± 0.05b                     |
| E04  | 1.11 ± 0.02bc      | 0.05 ± 0.00cde                   | 0.58 ± 0.02b                     |
| E05  | 1.06 ± 0.03bcd     | 0.05 ± 0.00cde                   | 0.15 ± 0.02de                    |
| H01  | 1.06 ± 0.09bcd     | 0.06 ± 0.01bc                    | 0.21 ± 0.01cd                    |
| H02  | 0.93 ± 0.04bcdde   | 0.05 ± 0.00cde                   | 0.34 ± 0.01c                     |
| H03  | 1.17 ± 0.07b       | 0.08 ± 0.00b                     | 0.62 ± 0.01b                     |
| H04  | 1.09 ± 0.02bc      | 0.08 ± 0.01b                     | 0.68 ± 0.05b                     |
| H05  | 1.44 ± 0.10a       | 0.12 ± 0.01a                     | 1.01 ± 0.06a                     |

Table 6.
Chlorophyll, photosynthesis and leaf temperature on harvest day

| Plot | Chlorophyll | Photosynthesis | Temp -leaf |
|------|-------------|----------------|------------|
| B01  | 25.6        | 7.33           | 25.9       |
| Plot | Chlorophyll | Photosynthesis | Temp -leaf |
|------|-------------|----------------|------------|
| B02  | 24.3        | 8.14           | 25.7       |
| B03  | 23.9        | 10.25          | 25.7       |
| B04  | 27.3        | 11.63          | 25.4       |
| B05  | 26.6        | 9.16           | 25.4       |
| E01  | 29.0        | 6.03           | 25.8       |
| E02  | 25.1        | 8.26           | 25.8       |
| E03  | 28.0        | 9.26           | 25.9       |
| E04  | 26.7        | 8.3            | 25.6       |
| E05  | 29.6        | 5.99           | 25.6       |
| H01  | 24.9        | 5.87           | 25.7       |
| H02  | 23.4        | 10.77          | 25.6       |
| H03  | 26.5        | 9.33           | 26.1       |
| H04  | 29.5        | 4.14           | 26.4       |
| H05  | 28.9        | 4.65           | 26.2       |

**Results**

The results showed that there are qualitative and quantitative differences in the grapes produced in the different microclimatic areas. The polyphenolic profile is affected even within the same grape variety by a series of variable factors, amongst which are the soil and climatic conditions of a given vineyard.
More specifically for this experiment, segment H5 (see Fig. 2) recorded the highest concentration in total anthocyanins and particularly malvidin, in skins total flavanols, skins total flavonoids, skins and seeds total flavones and flavonols with statistically significant difference compared to the other segments. Segment B3 recorded the highest concentration in total soluble solids and segment H3 recorded the highest concentration in total titratable acidity, with a statistically significant difference compared to the other segments. The highest concentration in tartaric acid was recorded in segments B5 and H3, while segment E2 scored the highest concentration in malic acid. Segment E1 presented the highest concentration in skins total tannins and B4 scored the highest concentration in seeds total tannins, with a statistically significant difference, respectively, compared to all other segments (Tables 1, 2, 3, 4, 5, Fig. 3, Suppl. material 1).

Sampling methods

Sampling description: The collection of the grapes took place during the technological maturity of each cell. Grapes were randomly selected from three different vines of each cell. The grapes were collected from the main shoots of different positions. In each sampling, ten grapes were collected. Each sampling constituted one replication. A total of three replications per treatment (cell) took place. The sampling process and samples preparation for spectrophotometric and HPLC analyses, as well as the data analysis
described in Stavrakaki et al. (2018), were followed for the needs of this experiment. The reagents and chemicals used were the same as in Biniari et al. (2018).

**Step description:** Measurements:

- Bunch and berry morphological properties (weight, length, width)
- Total soluble solids, pH and total titratable acidity of grape juice
- Total polyphenol content in berry skins and seeds
- Total and individual anthocyanins in berry skins
- Total flavonoid content and total flavanols in berry skins and seeds
- Flavone and flavonol content in berry skins and seeds
- Individual organic acids in grape juice

**Geographic coverage**

**Description:** The vineyard is located in the area of Archaia Nemea (37°48’14.1”N, 22°41’39.6”E).

**Temporal coverage**

**Data range:** 2018-01-01 - 2018-10-31.

**Usage rights**

**Use license:** Creative Commons Public Domain Waiver (CC-Zero)

**Data resources**

**Data package title:** 'Agiorgitiko' quality characteristics measurements

**Number of data sets:** 1

**Data set name:** 'Agiorgitiko' quality characteristics measurements in the different plots

| Column label                      | Column description                                      |
|-----------------------------------|---------------------------------------------------------|
| Samples                           | Samples collected from the different plots of the vineyard |
| Bunch weight (g)                  | Bunch weight measured in g                              |
| Bunch width (cm)                  | Bunch width measured in cm                              |
| Berry length (mm) (avg. of 10 berries) | Average length of 10 berries measured in mm             |
| Berry width (mm) (avg. of 10 berries) | Average width of 10 berries measured in mm              |
| Weight of 30 berries (g)          | Weight of 30 berries measured in g                      |
| Parameter                                      | Measurement                                      |
|-----------------------------------------------|--------------------------------------------------|
| pH of grape juice                             | Measurement: pH                                  |
| Total Acidity of grape juice                  | Total titratable acidity measured in g tartaric acid/L must |
| Sugars of grape juice                         | Total soluble solids measured in Brix             |
| Total phenolics seeds (mg gallic acid/g fresh tissue) | Total phenolics of berry seeds measured in mg gallic acid/g fresh tissue |
| Total phenolics skins (mg gallic acid/g fresh tissue) | Total phenolics of berry skin measured in mg gallic acid/g fresh tissue |
| Total flavanols skins (mg catechin/g fresh tissue) | Total flavanols of berry skin measured in mg catechin/g fresh tissue |
| Total flavanols seeds (mg catechin/g fresh tissue) | Total flavanols of berry seeds measured in mg catechin/g fresh tissue |
| Total flavononoids skins (mg catechin/g fresh tissue) | Total flavononoids of berry skin measured in mg catechin/g fresh tissue |
| Total flavononoids seeds (mg catechin/g fresh tissue) | Total flavononoids of berry seeds measured in mg catechin/g fresh tissue |
| Total flavones and flavonols skins (mg rutin/g fresh tissue) | Total flavones and flavonols of berry skin measured in mg rutin/g fresh tissue |
| Total flavones and flavonols seeds (mg rutin/g fresh tissue) | Total flavones and flavonols of berry seeds measured in mg rutin/g fresh tissue |
| Total tannins skins (mg catechin/g fresh tissue) | Total tannins of berry skin measured in mg catechin/g fresh tissue |
| Total tannins seeds (mg catechin/g fresh tissue) | Total tannins of berry seeds measured in mg catechin/g fresh tissue |
| Tartaric acid in grape juice (g/L)            | Individual tartaric acid of grape juice measured in g tartaric acid/L must |
| Malic acid in grape juice (g/L)               | Individual malic acid of grape juice measured in g malic acid/L must |
| Ascorbic acid in grape juice (g/L)            | Individual ascorbic acid of grape juice measured in g ascorbic acid/L must |
| Succinic acid in grape juice (g/L)            | Individual succinic acid of grape juice measured in g succinic acid/L must |
| Fumaric acid in grape juice (g/L)             | Individual fumaric acid of grape juice measured in g fumaric acid/L must |
| Total anthocyanins (mg malvidin/g fresh tissue) | Total anthocyanins of berry skin measured in mg malvidin/g fresh tissue |
| Anthocyanin Name                             | Description                                                                 |
|---------------------------------------------|-----------------------------------------------------------------------------|
| Delphinidin-3-O-glucoside (mg/g fresh tissue) | Individual anthocyanin delphinidin of berry skin measured in mg delphinidin/g fresh tissue |
| Cyanidin-3-O-glucoside (mg/g fresh tissue)   | Individual anthocyanin cyanidin of berry skin measured in mg cyanidin/g fresh tissue |
| Petunidin-3-O-glucoside (mg/g fresh tissue)  | Individual anthocyanin petunidin of berry skin measured in mg petunidin/g fresh tissue |
| Peonidin-3-O-glucoside (mg/g fresh tissue)   | Individual anthocyanin peonidin of berry skin measured in mg peonidin/g fresh tissue |
| Malvidin-3-O-glucoside (mg/g fresh tissue)   | Individual anthocyanin malvidin of berry skin measured in mg malvidin/g fresh tissue |
| Malvidin-3-O-glucoside-acetate (mg/g fresh tissue) | Acetic ester of malvidin measured in mg acetic ester malvidin/ g fresh tissue |
| Malvidin-3-O-glucoside-coumarate (mg/g fresh tissue) | Coumaric ester of malvidin measured in mg coumaric ester malvidin/ g fresh tissue |

References

- Biniari K, Gerogiannis O, Daskalakis I, Bouza D, Stavrakaki M (2018) Study of some qualitative and quantitative characters of the grapes of indigenous Greek grapevine varieties (*Vitis vinifera* L.) using HPLC and spectrophotometric analyses. Notulae Botanicae Horti Agrobotanici 46 (1): 97-106. [https://doi.org/10.15835/nbha4611008](https://doi.org/10.15835/nbha4611008)
- Bramley RG, Hamilton RP (2004) Understanding variability in winegrape production systems 1. Within vineyard variation in yield over several vintages. Australian Journal of Grape and Wine Research 10 (1): 32-45. [https://doi.org/10.1111/j.1755-0238.2004.tb00006.x](https://doi.org/10.1111/j.1755-0238.2004.tb00006.x)
- Bramley RG, Proffitt AP, Hinze CJ, Pearse B, Hamilton RP (2005) Generating benefits from Precision Viticulture through selective harvesting. In: Stafford JV (Ed.) Precision Agriculture '05. Papers presented at the 5th European Conference on Precision Agriculture. 5th European Conference on Precision Agriculture, Uppsala, Sweden, 2005. Wageningen Academic Publishers, Wageningen, Netherlands, 891-898 pp. [In English]. URL: [http://hdl.handle.net/102.100.100/182109?index=1](http://hdl.handle.net/102.100.100/182109?index=1)
- Ramos MC, Jones GV, Yuste J (2015) Spatial and temporal variability of cv. Tempranillo phenology and grape quality within the Ribera del Duero DO (Spain) and relationships with climate. International Journal of Biometeorology 59 (12): 1849-1860. [https://doi.org/10.1007/s00484-015-0992-z](https://doi.org/10.1007/s00484-015-0992-z)
- Stavrakaki M, Biniari K, Daskalakis I, Bouza D (2018) Polyphenol content and antioxidant capacity of berries from seven biotypes of the Greek grapevine cultivar Korinthiaki Staphis (*Vitis vinifera* L.). Australian Journal of Crop Science 12 (12): 1927-1936. [https://doi.org/10.21475/ajcs.18.12.12.p1261](https://doi.org/10.21475/ajcs.18.12.12.p1261)
Supplementary material

Suppl. material 1: Agiorgitiko quality characteristics measurements

Authors: Victoria Verarou, Maritina Stavrakaki, Despoina Bouza, Ioannis Daskalakis, Katerina Biniari

Data type: Excel file of the samples collected and the measurements performed

Brief description: This is the raw dataset of the measurements performed on the samples collected from grapevine cultivar 'Agiorgitiko' in the different sub-zones of the vineyard. There are three repetitions per measurement and no statistical analysis has been performed.

Download file (33.02 kb)