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Data Paper

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.)

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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.

Figure 1. doi

Vineyard where the experiment took place.

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.

Table 1.
Characters of the grape juice

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 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)
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 ± 106.74bc	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

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 ± 0.24bcde
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 ± 17.21 def	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 ± 6.49bcd	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 ± 0.04bcde	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

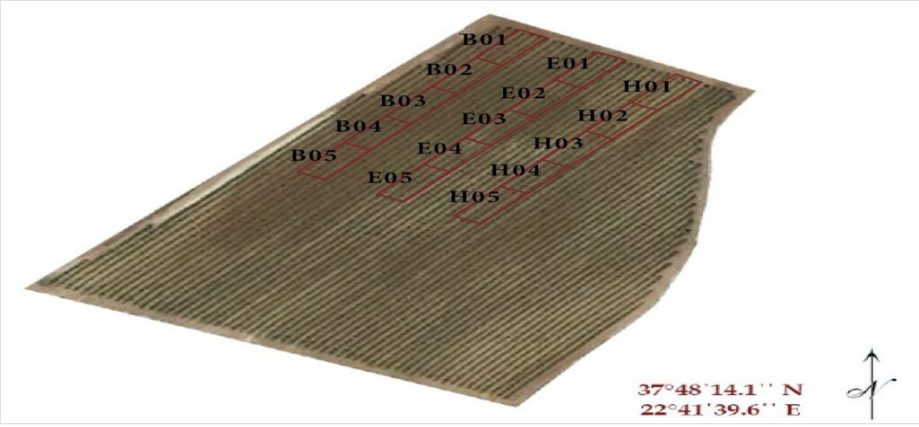

Figure 2. doi

Division of the vineyard in plots.

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 flavononoids, 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).

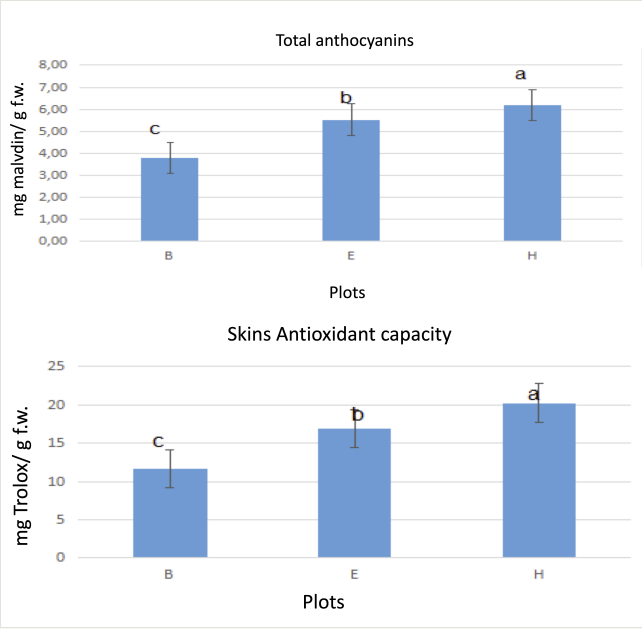

Figure 3. doi

Skins total anthocyanins and antioxidant capacity comparison per plot.

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: 2018-1-01 - 2018-10-31.

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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

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 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

Delphinidin-3-O-glucoside (mg/g fresh tissue)	Individual anthocyanin delphinidin of berry skin measured in mg delfinidin/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

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Supplementary material

Suppl. material 1: Agiorgitiko quality characteristics measurements doi

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)