VOL IX

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PESQUISA E INOVAÇÃO NAS CIÊNCIAS QUE ALIMENTAM O MUNDO

EDUARDO EUGÊNIO SPERS
(Organizador)

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APRESENTAÇÃO

As Ciências Agrárias são um campo de estudo multidisciplinar por excelência, e um dos mais profícuos em termos de pesquisas e aprimoramento técnico. A demanda mundial por alimentos e a crescente degradação ambiental impulsionam a busca constante por soluções sustentáveis de produção e por medidas visando à preservação e recuperação dos recursos naturais.

A obra **Agrárias: Pesquisa e Inovação nas Ciências que Alimentam o Mundo** compila pesquisas atuais e extremamente relevantes, apresentadas em linguagem científica de fácil entendimento. Na coletânea, o leitor encontrará textos que tratam dos sistemas produtivos em seus diversos aspectos, além de estudos que exploram diferentes perspectivas ou abordagens sobre a planta, o meio ambiente, o animal, o homem e a sociedade no ambiente rural.

É uma obra que fornece dados, informações e resultados de pesquisas tanto para pesquisadores e atuantes nas diversas áreas das Ciências Agrárias, como para o leitor que tenha a curiosidade de entender e expandir seus conhecimentos.

Este Volume IX traz 16 trabalhos de estudiosos de diversos países, divididos em dois eixos temáticos: *Eficiência e tecnologia na produção agrícola* e *Meio ambiente e produtividade agrícola.*

Desejo a todos uma proveitosa leitura!

Eduardo Eugênio Spers

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CHARACTERIZATION OF PHENOLOGICAL STAGES AND GRAPE QUALITY OF NINETEEN PORTUGUESE GRAPEVINE VARIETIES PRESENT IN THE DOURO REGION

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ABSTRACT: The present work aimed to evaluate the most suitable grapevine varieties in a specific site of the Douro Region, along two consecutive years characterized by different weather conditions. It was analyzed the mesoclimate in which the grapevine varieties were inserted through bioclimatic indexes. It was determined the Growing Degree Days (GDD) necessary for the occurrence and duration of following periods: from budburst to flowering; flowering; from flowering to veraison; veraison; and from veraison to harvest. For each grapevine variety, the variation of the

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Growing Degree Days in different periods was evaluated and classified as low, medium and high. Grape quality was assessed by the total soluble solids, the total polyphenols, the tannins and the total anthocyanins. The results explored differences between grapevine varieties on the Growing Degree Days along the growing season and also on the grape quality. Grapevine varieties with longer growing seasons, high GDD from veraison to harvest and a progressive maturation may be better adapted to the warming scenarios. Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca and Touriga Fêmea showed high GDD from veraison to harvest, which highlight their better adaptation to the warmer months, based on observed weather conditions of studied years. Roseira and Tinta Francisca presented the most balanced grape quality parameters, revealing to be suitable minor grapevine varieties in this specific site of the Douro Region, exposed to different weather conditions.
KEYWORDS: Minor grapevine varieties. Bioclimatic indexes. Growing Degree Days. Maturation.

CARACTERIZAÇÃO DOS ESTADOS FENOLÓGICOS E DA QUALIDADE DA UVA DE DEZANOVE CASTAS PORTUGUESAS PRESENTES NA REGIÃO DO DOURO

RESUMO: Este trabalho teve como objetivo avaliar as castas de videira mais adequadas num local específico da Região Demarcada do Douro, ao longo de dois anos consecutivos caracterizados por condições climáticas distintas. Foi analisado o mesoclima em que as castas estavam inseridas através de índices bioclimáticos. Foram determinados os Graus-Dia de crescimento (GDD) necessários para a ocorrência e a duração dos seguintes períodos: do abrolhamento à floração; floração; da floração ao pintor; pintor; e do pintor à vindima. Para cada casta avaliou-se a variação dos GDD em diferentes períodos e classificou-se em baixo, médio e alto. A qualidade da uva foi avaliada pelos sólidos solúveis totais, polifenóis totais, taninos e antocianinas totais. Os resultados exploraram diferenças entre castas nos GDD ao longo do ciclo vegetativo e também na qualidade da uva. As castas com períodos de crescimento mais longos, GDD mais elevados desde o pintor até à vindima e uma maturação progressiva podem adaptar-se melhor a cenários de aquecimento. Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca e Touriga Fêmea apresentaram GDD elevados desde o pintor até à vindima, o que destaca a sua melhor adaptação aos meses mais quentes, com base nas condições climáticas observadas nos anos estudados. Roseira e Tinta Francisca apresentaram os parâmetros de qualidade da uva mais equilibrados, revelando serem castas minoritárias aptas para este local específico da Região Demarcada do Douro, expostas a diferentes condições climáticas.
PALAVRAS-CHAVE: Castas minoritárias. Índices bioclimáticos. Graus-dia de crescimento. Maturação.

1 INTRODUCTION

Climate variability influences wine grape production, particularly in the Mediterranean region as the Douro Region, Portugal (Dinis *et al.,* 2014). However, global and regional model simulations to Portugal project a scenario of warming, increase of near surface temperature and dramatic changes of all temperature related climate indices.

Impacts are higher in summer and autumn and in the interior of the country (Miranda et al., 2002). Each site has its specific weather conditions which influence the type of wine that can be produced. The specificity of each site is called terroir, that is interaction between many factors, including climate, soil, variety and human practices (Van Leeuween and Seguin, 2006; Van Leeuween et al. 2004). The maturation time of variety must be adequate to each site weather conditions in such a way that full maturation is reached by the end of the growing season (Van Leeuween and Seguin, 2006). Within the weather conditions, the temperature have a high importance in the growing season, grapevine yield and grape quality (Barnuud *et al.,* 2014; Malheiro *et al.,* 2013; Santos *et al.*, 2013; Jones, 2012). Timing and duration of each phenological stage are influenced by air temperature and depends on grapevine varieties. The relation between temperature and phenological stages has been supported by several studies (Ramos *et al.* 2018; Ramos, 2017; Fraga *et al.,* 2016; Fraga *et al.,* 2015; Neumann *et al.,* 2014; Lopes *et al.,* 2008). The monthly maximum temperature that anticipates phenological stages, such as budburst and flowering, have a great influence at the date these events occur (Tomasi *et al.,* 2011). Fraga (2014a) indicated that the Growing Degree Days (GDD) throughout the growing season allow us to identify which varieties are better adapted to a given site and to define which more resistant to long periods of high temperatures. Therefore, varieties with low GDD have more adaptive difficulty to prolonged temperature increases over time. The same author described that varieties such as Touriga Franca and Tinto Cão would better adapt to a temperature increases, while varieties such as Vinhão will have less adaptability (Fraga, 2014a). The grapevine genetic regulation mechanisms, such as gene production and the adaptation mechanisms, such as self-regulation (Fraga *et al.,* 2012; Brito *et al.,* 2004) allows a high resistance to water and thermal stresses (Saleh *et al.*, 2018). Bioclimatic indexes can be used to assess whether the site is suitable for a good grapevine production (Barnuud *et al.,* 2014; Santos *et al.,* 2013; Jones, 2012; Malheiro *et al.*, 2010). The GDD is related to grapevines growth and development, wine production and its quality (Fraga *et al.*, 2016; Neumann *et al*., 2014). Considering base temperature at 10 °C, GDD values were pointed out for the growing season in the Douro Region, ranges from 1776 to 2241 (Magalhães *et al.*, 1995) and has estimated an increase of 600 by 2070 (Fraga, 2014a). The Huglin Index (HI) is used to evaluate the grapevine thermal needs to complete its phenological stages until maturation. It relates those needs to the thermal characterization of a given site, determining whether it meets the thermal needs of a particular grapevine variety (Jones *et al.*, 2005; Huglin, 1978). Santos *et al.* (2012) defined a minimum vegetative growth limit of 850 for GDD and 900 for HI. Lacona *et al.* (2012) verified that anthocyanins concentration decreased when GDD and HI increased, while tannins concentration increased when GDD and HI increased. The Hydrothermal Index of Branas (IBBL) combines the humidity effect (through precipitation) and temperature during the growing season to evaluate the susceptibility risk for diseases, such as downy mildew (Branas *et al.*, 1946). Lorenzo *et al.* (2012) registered HI values until 2200 and above 2000 for IBBL in Galiza (North of Spain). Same authors verified that when IBBL increased, production and quality decreased. They projected to future scenario a tendency to the increase of GDD and HI as well as the decrease of IBBL (Lorenzo *et al.,* 2012). The Cold night Index (CI) relates to the night minimum temperatures during the last month of maturation stage (Tonietto *et al.*, 2004). Fraga (2014a) reported an increase of night temperatures during the last month of maturation (usually in September), where monthly minimum temperatures can reach to 16 °C by 2070 in Douro Region. During the night, the optimal temperatures for maturation can be reached, having a significant effect in the anthocyanins' synthesis (Kliewer and Torres cited by Martínez de Toda, 2011). The optimal temperature for anthocyanins' synthesis ranges from 17 to 26 °C (Pirie cited Martínez de Toda, 2011; Sadras *et al.*, 2007). Temperatures above 30 °C can damage biosynthetic pathways, promoting the degradation of anthocyanins' components which decreases its concentration (Mori *et al.*, 2007). Temperatures above 35 °C inhibit the anthocyanin synthesis (Magalhães, 2008; Mori *et al.*, 2007; Lopes, 1994). Greer (2017) determined a maximum limit of 30 °C to biomass accumulation in bunches for Semillon grapevine variety. Several countries are currently recovering and characterizing autochthonous varieties, nearly extinct in some cases, as potential producers of quality wines (Loureiro *et al.*, 2017; Milella *et al.*, 2016; Dobrei *et al.*, 2015; Merkouropoulos et al., 2015). For example, Loureiro *et al.* (2017) referred that the prospection, recovery and study of minor grapevine varieties are important to preserve the genetic resources of a region. Additionally, the authors considered that the conservation of the existing varieties can allow to face the new challenges for the viticulture such as future warming scenarios (Loureiro *et al.,* 2017). The present work aimed to evaluate the most suitable grapevine varieties in a specific site of the Douro Region, along two consecutive years characterized by different weather conditions. The GDD needed to reach some growing season periods of 19 grapevine varieties was assessed and related to the grape quality. The vineyard mesoclimate was analysed by several bioclimatic indexes. The GDD values were calculated for the following periods: from budburst to flowering; flowering; from flowering to veraison; veraison; and from veraison to harvest. The variation of GDD in the different growing season periods was evaluated for each grapevine variety and were classified as low, medium and high. The grape quality was measured as total soluble solids, total polyphenols, tannins, and total anthocyanins.

2 MATERIAL AND METHODS

2.1 DESCRIPTION OF THE STUDY SITE AND THE PLANT MATERIAL

Data were collected on a vineyard with a grapevine collection located in Pinhão (41°10'26.28''N, 7°31'47.03''W; 375 m) at Cima-Corgo, Douro Region (Northern Portugal) during two consecutive years (2017 and 2018). The vineyard is exposed to the north (northeast direction). The soil was characterized by silty-loam, low organic matter content (below 1%) and acid pH. The temperature and precipitation values were monitored by an automatic weather station (IMT280, iMETOS, Weiz, Austria) located near the vineyard (41°10'47.36''N, 7°32'05.79''W; 230m). The vineyard was systematized by traditional terraces and grafted in 1940 on *Rupestris du Lot* rootstock. The grapevines, spaced 1 m within and 1.20 m between rows, were pruned to a short 2-bud spurs. The data were obtained from 56 selected grapevines, where 19 red varieties (*Vitis vinifera*) were identified by SSR (simple sequence repeat) markers: Aragonez, Camarate, Casculho, Castelão, Cornifesto, Malvasia Preta, Marufo, Mourisco de Semente, Nevoeira, Roseira, Tinta Carvalha, Tinta da Barca, Tinta Francisca, Tinto Cão, Touriga Fêmea, Touriga Franca, Touriga Nacional, Trincadeira and Vinhão. According to IVV ranking of varieties most planted in Portugal (IVV, 2018), Camarate, Casculho, Cornifesto, Malvasia Preta, Mourisco de Semente, Nevoeira, Roseira, Tinta Carvalha, Tinta da Barca, Tinta Francisca and Touriga Fêmea were considered minor grapevine varieties, since they are not included in the first 20 ranking positions. According to Eiras-Dias *et al.* (2016), minor grapevine varieties are those that were not planted over a long period and consequently are mainly present old vineyards.

2.2 EXPERIMENTAL DESIGN

The experimental design was composed by 56 grapevines selected in vineyard through different ampelographic characteristics and subjected to genetic identification. These 56 grapevines were selected based on the potential of production and quality described by the farmer. The study identified 19 grapevine varieties. All determinations were performed to the 56 grapevines (3 grapevines per variety) and data were treated for each grapevine. The samples to analyse the grape quality had 10 random berries per grapevine. All grapevine varieties were subjected to the same weather and soil conditions. Grapevines were managed without irrigation. Cultural practices and phytosanitary treatments were the same to all grapevines.

2.3 PHENOLOGICAL PERIODS ANALYSED AND BIOCLIMATIC INDEXES CALCULATED

The phenological stages of each grapevine from budburst to harvest were monitored and determined by the visual observation using the Baggiolini scale. Five periods of the growing season were considered: from budburst to flowering (B-I); flowering (I); from flowering to veraison (I-M); veraison (M); and from veraison to harvest. Considering vegetative zero at 10 °C, calculations of bioclimatic indexes (Table 1) were performed through minimum, mean and maximum temperatures; precipitation and insolation (INMG, 1988).

Table 1. Bioclimatic indexes used for the weather characterization.

GDD (Winkler, 1974)	**HI** (Huglin, 1978)
$\boldsymbol{GDD} = \sum_{1apr}^{30set} (T - 10)$ T: daily mean temperature (°C).	$\boldsymbol{HI} = \sum_{1apr}^{30set} \left[\frac{(T - 10) + (Tmax - 10)}{2}\right] K$ T: daily mean temperature (°C); Tmax: daily maximum temperature (°C); K: coefficient of 40° latitude.
IBBL (Branas *et al.,* 1946)	**CI (**Tonietto *et al.,* 2004)
$\boldsymbol{IBBL} = \sum_{apr}^{set} P\ Tm$ P: monthly precipitation (mm); Tm: monthly mean temperature (°C).	**CI** = Tmin of last month of maturation Tmin: monthly minimum temperature (°C).
Other indexes used	
HTC (Selianinov, 1928)	**LTI** (Kenny and Shao, 1992)
$\boldsymbol{HTC} = \left[\sum_{apr}^{set} P\ / X\right] 10$ P: monthly precipitation (mm); X: sum of Winkler (°C).	**LTI** = MTWM (75 – latitude) MTWM: daily mean temperature of the hottest month (°C); 40° latitude.
PH (Branas *et al.,* 1946)	
PH = X H 10^{-6} X: sum of Winkler (°C); H: sum of monthly insolation (hours).	

GDD - Growing Degree Days, index of the sum of Winkler active temperatures, **HI** - Heliothermic Index of Huglin; **IBBL** - Branas Hydrothermal Index; **CI** - Cold night Index; **HTC** - Selianinov Hydrothermal Coefficient; **LTI** - Latitude-Temperature Index; **PH** - Heliothermic Product of Branas.

For the five periods considered, the GDD values of each variety were calculated. After that, three equal intervals between the maximum and minimum GDD were used to classify the varieties about GDD required for each period in the two years. These intervals were presented in Table 2.

Table 2. Intervals used by collected data to classify the varieties according to the GDD required in the five periods within the growing season. Values presented (in degree-days) were obtained by average of the two studied years.

	B - F	**F**	**F - V**	**V**	**V - H**
Interval	**294 - 368**	**83 - 163**	**765 - 996**	**183 -392**	**499 - 747**
Low	<319	<110	<842	<253	<582
Medium	319≤ GDD ≤344	110≤ GDD ≤136	842≤ GDD ≤919	253≤ GDD ≤323	582≤ GDD ≤664
High	>344	>136	>919	>323	>664

B - F: from budburst to flowering; **F**: flowering; **F - V**: from flowering to veraison; **V**: veraison; **V - H**: from veraison to harvest.

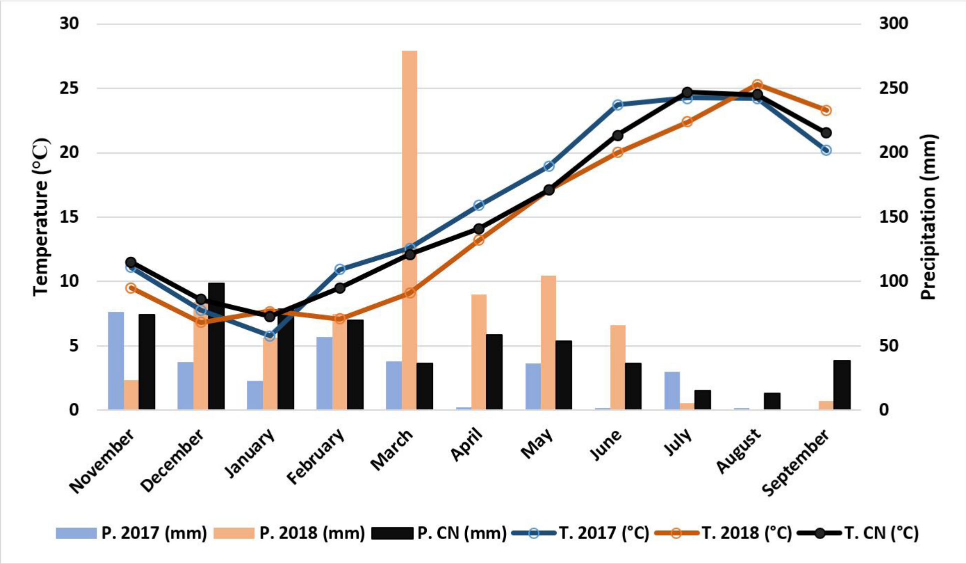
2.4 GRAPE QUALITY

The grape quality was assessed by the total soluble solids on the homogenate pulp, while the total polyphenols, the tannins and the total anthocyanins were measured in the seeds and skins, following OIV methods (2006). Total polyphenols and tannins values are expressed in mg of epicatechin per gram of berry and total anthocyanins values are expressed in mg of malvidine-3-glucoside per gram of berry. Results are showed as average values of the two years ± standard deviation. The quality parameters were compared for each grapevine variety, applying a linear projection represented by the radial visualization (RadViz) (Matias, 2017; Rubio-Sánchez *et al.,* 2015).

3 RESULTS AND DISCUSSION

The old vineyards in the Douro Region are characterized by the high diversity of varieties and its heterogeneous distribution. Thus, a study focusing on the old vineyards in the Douro can be limited by the not exist single-varietal vineyards on the same soil-climatic conditions. Furthermore, the number of vineyards with the same age, diversity of varieties and soil-climatic conditions in the Douro Region is scarce. Therefore, and although in this study the number of grapevines per variety can be considered insufficient, this reflects the old vineyards' composition in the Douro region. Concerning the weather conditions of studied site presented in Figure 1, 2017 and 2018 presented differences in the monthly temperature and precipitation values. Along the growing season, 2017 was warmer and drier than 2018, with the exception of August and September temperatures.

Figure 1 - Temperature and precipitation values for 2017 and 2018. CN: Climatological normal “1971-2000”.



The growing season average temperature of 2017 was 21.2 °C, while in 2018 was 20.2 °C. These average temperatures were higher than those indicated by Jones (2013) for Cima-Corgo (Douro Region). Precipitation values from April to September, were 72.6 mm for 2017 and 274.2 mm for 2018. Comparing these with the Climatological Normal “1971-2000” that registered 20.6 °C and 215.8 mm, these two consecutive years demonstrated the different weather conditions existing in the Douro Region. The phenological stages in 2017 were two or three weeks earlier than 2018, which could be explained by the higher temperature values registered in 2017. From the beginning of veraison to harvest, were observed seventeen days above 35 °C in 2017 and twelve days in 2018. According to the bioclimatic indexes presented in Table 3, the grapevines from the two years were exposed to similar warmer conditions and different water circumstances.

Table 3. Bioclimatic indexes calculated for the weather characterization.

Bioclimatic Index	2017	2018	Value ranges	Classification
GDD	2055	1881	1850 < GDD < 2120	Hot
HI	2821	2571	2400 < HI < 3000	Warm
IBBL	1545	4608	IBBL< 3000; GDD > 1550	Exceptional quality
			4000 < IBBL < 5000; GDD > 1550	Good quality

Bioclimatic Index	2017	2018	Value ranges	Classification
CI	16.6	16.3	14 < CI < 18 °C	Temperate nights
HTC	0.35	1.46	HTC < 0.4	Extreme drought
			HTC > 1	No drought
LTI	849	886	LTI > 700	Hot climate grape
PH	3.2	2.9	PH > 2,6	Production viable zone

GDD - Growing degree-days, index of the sum of Winkler active temperatures, **HI** - Heliothermic Index of Huglin; **IBBL** - Branas Hydrothermal Index; **CI** - Cold night Index; **HTC** - Selianinov Hydrothermal Coefficient; **LTI** - Latitude-Temperature Index; **PH** - Heliothermic Product of Branas.

The GDD values of vineyard were within those presented by Magalhães *et al.* (1995) for the Douro Region and more specifically within the values for the Cima-Corgo indicated by Jones (2013). The HI showed higher values those presented by Jones (2013) for Cima-Corgo, caused by the higher temperatures registered in the studied years. The CI exhibited above 16 °C to monthly minimum temperature what reached the conditions predicted for 2070 in the Douro Region pointed out by Fraga (2014a). The HTC values corroborate the dryness in 2017. Among the two years, comparing HTC with IBBL on grape quality, it was evident the influence of the different weather conditions on grapevine varieties. For the two years, the GDD from budburst to harvest were similar for all varieties, ranging from 1820 (Nevoeira) to 1850 (Malvasia Preta). The GDD values of different periods are presented in Figures 2 and 3. GDD values did not showed a strong relationship between the growing season periods' duration. For example, a short period from budburst to flowering does not imply a short period from flowering to veraison, which was also verified by Tomasi *et al.* (2011). For the majority of grapevine varieties, the period with highest GDD was from flowering to veraison. Ramos (2017) also found that this period had the highest GDD values. Comparing the shorter periods (flowering and veraison), the period with lowest GDD values was the flowering for the majority of grapevines analysed (Figure 3).

Figure 2. Chronological evolution in growing season of the periods: from budburst to flowering; from flowering to veraison; from veraison to harvest with the corresponding GDD. Data are presented for 2017 and 2018.

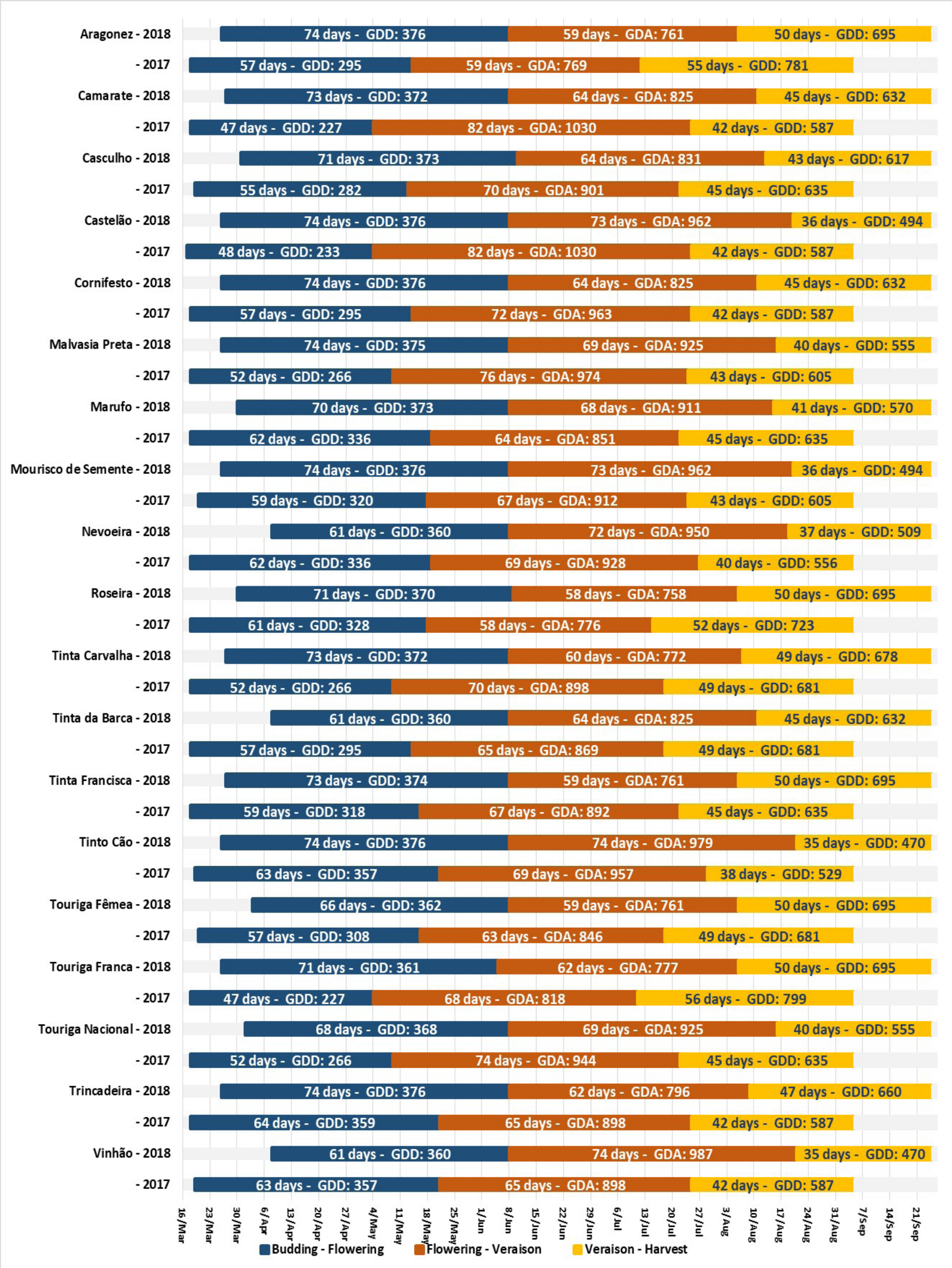
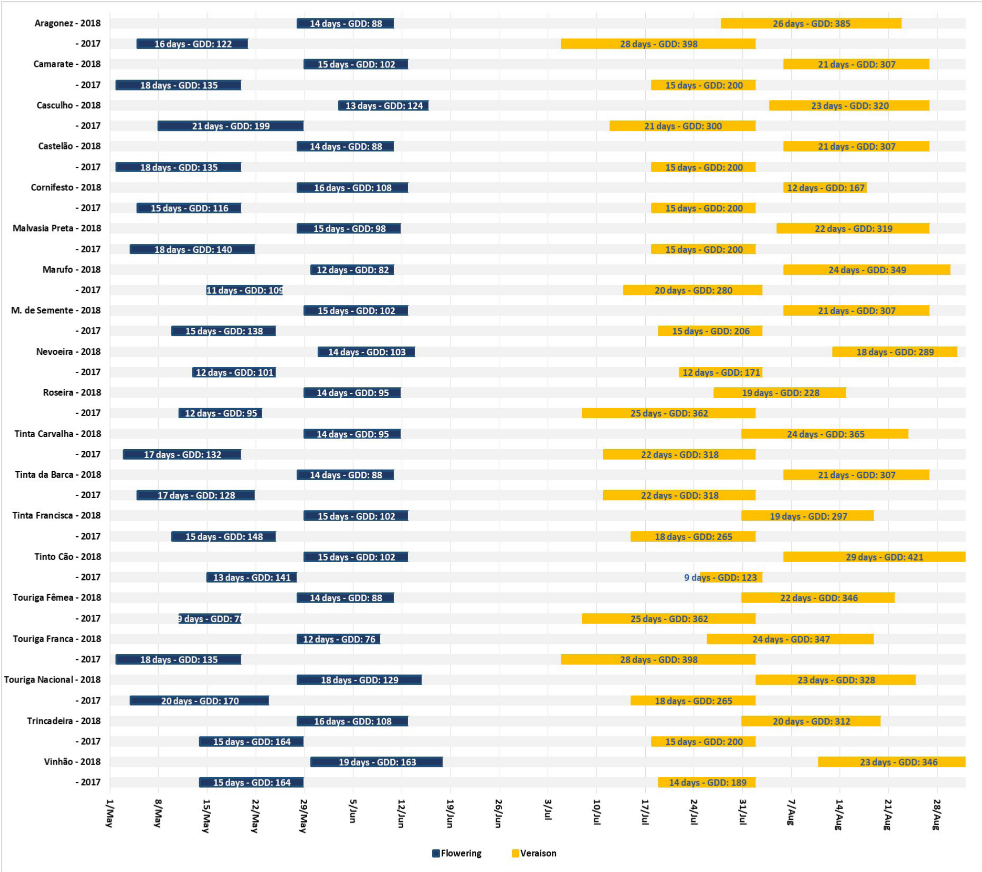


Figure 3. Chronological evolution of flowering and veraison periods with the corresponding GDD. Data are presented for 2017 and 2018.



The classification of the growing season periods were applied to the two years, the results are illustrated in Table 4. According to this classification, Vinhão, Nevoeira or Marufo varieties showed high GDD values in budburst-flowering period and simultaneously, had a later flowering in both years (Figure 2 and 3). Touriga Franca and Castelão showed, at the same time, low GDD values in budburst-flowering period (Table 4) and an early flowering (Figure 2 and 3). During budburst-flowering period, Lopes *et al.* (2008) observed similar results, with Vinhão having a high GDD and Touriga Franca a low GDD. Concerning the duration of flowering, Touriga Nacional exhibited longest flowering in both years.

Table 4. Classification of GDD in the five growing season periods, with ranges of values considered for each period (average of the two studied years).

	B - F	F	F - V	V	V – H
Aragonez	Medium	Low	Low	High	High
Camarate	Low	Medium	High	Medium	Medium
Casculho	Medium	High	Medium	Medium	Medium
Castelão	Low	Medium	High	Medium	Low
Cornifesto	Medium	Medium	Medium	Low	Medium
Malvasia Preta	Medium	Medium	High	Medium	Low
Marufo	High	Low	Medium	Medium	Medium
Mourisco de Semente	High	Medium	High	Medium	Low
Nevoeira	High	Low	High	Low	Low
Roseira	High	Low	Low	Medium	High
Tinta Carvalha	Low	Medium	Low	High	High
Tinta da Barca	Medium	Low	Medium	Medium	Medium
Tinta Francisca	High	Medium	Low	Medium	High
Tinto Cão	High	Medium	High	Medium	Low
Touriga Fêmea	Medium	Low	Low	High	High
Touriga Franca	Low	Low	Low	High	High
Touriga Nacional	Low	High	High	Medium	Medium
Trincadeira	High	Medium	Medium	Medium	Medium
Vinhão	High	High	High	Medium	Low

B - F: from budburst to flowering; **F**: flowering; **F - V**: from flowering to veraison; **V**: veraison; **V - H**: from veraison to harvest.

During flowering-veraison period, Vinhão, and Nevoeira presented, simultaneously, high GDD (Table 4) and later veraison (Figure 2 and 3). On contrary, varieties such as Aragonez, Touriga Franca and Roseira showed a low GDD and an early veraison. For the same period, Lopes *et al.* (2008) mentioned that Aragonez and Touriga Franca had low GDD, considering Touriga Franca as a variety with an earlier veraison. Concerning the duration of veraison in the present study, Aragonez and Touriga Franca exhibited a longer veraison in both years. Although no relationship between the growing season periods could be established, it seems to be relevant that varieties presenting high GDD during veraison (Aragonez, Tinta Carvalha, Touriga Fêmea and Touriga Franca), had low GDD in flowering-veraison period. These varieties did not present high GDD variability between the two years in flowering-veraison and veraison periods, which may mean that these varieties were poorly affected by the different weather conditions in these periods. During the veraison-harvest period, Aragonez, Touriga Franca, Roseira, Tinta Francisca, Touriga

Fêmea and Tinta Carvalha presented high GDD. Similarly, Lopes *et al.* (2008) also showed that Touriga Franca had high GDD during the same period. Varieties as Vinhão, Castelão, Tinto Cão, Malvasia Preta, Nevoeira and Mourisco de Semente demonstrated low GDD in veraison-harvest period. In this period, the varieties that showed the higher GDD variability between the two years were Vinhão, Touriga Franca and Mourisco de Semente. During the warmer months the accumulation of GDD was higher and the future scenarios' projections indicate an increase of temperatures, especially in summer, where the maturation will occur under increasingly warm conditions being likely to accelerate it (Duchene *et al.*, 2005; Miranda et al., 2002). Table 5 shows the quality parameters analysed of all varieties and the variability of the two years, observed by the standard deviation.

Table 5. Quality parameters of 19 grapevine varieties (average of the two studied years).

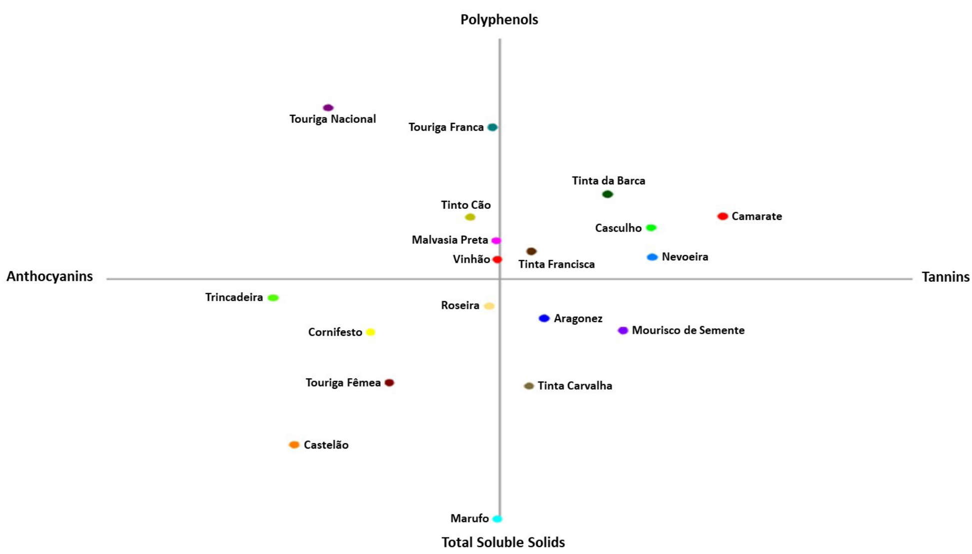
	TSS (°Brix)	**Polyphenols (mg/g)**	**Tannins (mg/g)**	**Anthocyanins (mg/g)**
Aragonez	24.3±0.6	13.1±2.1	5.2±0.7	1.7±0.3
Camarate	19.1±1.4	10.3±2.2	4.3±0.2	1.0±0.1
Casculho	18.0±0.4	9.3±1.2	4.0±1.0	1.0±0.2
Castelão	22.3±0.6	8.1±1.8	2.2±0.4	1.3±0.3
Cornifesto	20.9±0.4	9.6±2.0	3.6±0.1	1.3±0.3
Malvasia Preta	21.3±1.5	12.6±2.4	4.3±1.6	1.6±0.4
Marufo	24.3±1.0	5.6±0.9	2.0±0.5	0.4±0.0
Mourisco de Semente	19.6±0.3	8.2±1.9	3.7±1.6	0.6±0.2
Nevoeira	18.2±0.2	9.0±1.9	3.9±0.9	0.7±0.2
Roseira	20.6±0.6	10.2±2.6	3.8±0.7	1.2±0.4
Tinta Carvalha	20.6±1.1	8.0±1.1	3.5±1.6	0.6±0.3
Tinta da Barca	19.6±0.1	11.7±0.9	4.2±1.6	1.1±0.1
Tinta Francisca	19.9±0.1	10.5±1.9	3.8±0.8	1.0±0.1
Tinto Cão	21.9±0.3	20.7±2.5	5.0±1.4	1.9±0.5
Touriga Fêmea	24.1±0.5	10.4±2.5	3.5±0.9	1.2±0.3
Touriga Franca	19.4±0.2	14.1±2.0	4.3±1.9	1.6±0.3
Touriga Nacional	21.2±1.7	12.5±2.5	3.9±1.2	1.7±0.4
Trincadeira	21.6±0.0	10.6±3.0	3.3±0.6	1.6±0.1
Vinhão	22.6±1.6	19.1±3.6	5.8±1.3	3.1±0.3

TSS- total soluble solids. **Total polyphenols and tannins**: mg epicatechin / g berry; **total anthocyanins**: mg malvidine /g berry.

Considering the two years, varieties with low GDD during maturation such as Castelão, Malvasia Preta, Tinto Cão and Vinhão showed a fast evolution of quality parameters such as the total soluble solids. This fast evolution may demonstrate the influence that high temperatures had on these varieties during maturation in these two years. It should be highlighted that Vinhão presented later veraison, as previously described. Vinhão and Tinto Cão showed long growing season periods until veraison, with high GDD. The same occurred with Malvasia Preta, specifically from flowering to veraison. Fraga (2014a) indicated Tinto Cão and Malvasia Preta as varieties with good adaptability to different climatic conditions. The author analysed the same adaptability aspects in several grapevines varieties, concluding that Touriga Franca also presented a good adaptability to different climatic conditions, moreover higher GDD mean values than Tinto Cão and Malvasia Preta (Fraga, 2014a). In the present study, the GDD mean values did not showed significant differences between the grapevine varieties, as observed by Fraga (2014a). The values observed in this study indicate close GDD values for all varieties between 2017 and 2018, including Malvasia Preta (1850), Touriga Franca (1838) and Tinto Cão (1833). As previously described, Touriga Franca presented high GDD from veraison to harvest and among the varieties with high GDD in this period, was the variety that exhibited the higher phenolic maturation simultaneously with Aragonez. However, Aragonez presented higher total soluble solids and seems to be at its ideal maturation. According to the quality parameters of 2017 and 2018, defined in this study, the prospect of increasing temperatures in the maturation period may cause higher changes in the Aragonez quality profile, when compared to Touriga Franca. Touriga Franca's quality can still be improved through a longer maturation period, since it exhibited a low value of total soluble solids. Among the varieties with high GDD in veraison-harvest period, Tinta Carvalha had the lower phenolic maturation. Other varieties, such as Marufo and Touriga Fêmea, also presented elevated total soluble solids. However, at the same time, Marufo showed lower phenolic richness and lower GDD from veraison to harvest compared to Touriga Fêmea. Marufo was referred by Fraga et al. (2015) as being a variety with low adaptability in warm regions, as in accordance with the results obtained for the present study. Touriga Fêmea had a phenolic composition similar to Tinta Francisca and Roseira. Tinta Francisca and Roseira showed similar GDD behaviours during the growing season with high GDD in maturation. Furthermore, the balance between total soluble solids and phenolic composition may reveal a good resistance potential to the prospects of warming future scenarios. Comparing the varieties with high GDD in veraison-harvest period, Tinta Francisca presented the lowest quality parameters variability between the two years, according to the standard deviation. Regarding all varieties in study, Marufo demonstrated to be the lowest affected by the different weather conditions between 2017 and 2018.

Camarate, Casculho, Mourisco de Semente, Nevoeira and Tinta da Barca could benefit from a longer maturation period, leading to a complete phenolic maturation, an important advantage to obtain higher quality. Since Mourisco de Semente and Nevoeira also demonstrated a longer growing season until veraison, could be interesting to study their GDD until ideal maturation to evaluate if maturation is progressive. Figure 4 shows a linear projection applied to the quality parameters and represented by the radial visualization (RadViz). This data visualization allowed the identification of the most influencer parameters for each variety. The proximity between the data point and the parameters (total soluble solids, total polyphenols, tannins and total anthocyanins) highlights the influence of a parameter on the grapevine variety.

Figure 4. Linear projection relating four vectors: total soluble solids, total polyphenols, tannins and total anthocyanins.



Marufo was mostly influenced by the total soluble solids parameter, having low values for the remaining ones. Touriga Franca demonstrated to be more influenced by the total polyphenols. Trincadeira was the variety where the anthocyanins mostly stood out when compared with the other parameters. The same happened with the tannins for the Camarate. In the varieties Vinhão, Malvasia Preta, Tinta Francisca and Roseira the quality parameters were balanced.

4 CONCLUSIONS

This study analysed 19 Portuguese grapevine varieties during two consecutive years, revealing differences on GDD values in the growing season periods and also on the grape quality. The data was obtained from a specific site (Pinhão, Douro Region) with the same weather conditions. According to this study, it can be pointed out the grapevine varieties with longer growing seasons, high GDD from veraison to harvest and finally with a progressive maturation. These balanced characteristics may provide a better adaptation to the warming scenarios. Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca and Touriga Fêmea showed high GDD from veraison to harvest, which highlight their better adaptation to the warmer months, based on observed weather conditions of studied years. However, according to the total soluble solids values, Aragonez and Touriga Fêmea seemed to be at their ideal maturation, possible indicating a higher grape quality vulnerability with the increase of temperature. Among the most adapted grapevine varieties pointed out in this study (Aragonez, Roseira, Tinta Carvalha, Tinta Francisca, Touriga Franca and Touriga Fêmea), Roseira and Tinta Francisca presented the most balanced grape quality parameters, revealing to be suitable minor grapevine varieties in this specific site of the Douro Region, exposed to different weather conditions.

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SOBRE O ORGANIZADOR

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ÍNDICE REMISSIVO

A

B

C

D