MOLDOVA'S WINES IN THE CONTEXT OF CLIMATE CHANGE

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ABSTRACT: The aims of this work is to characterize the physico-chemical characteristics of grape varieties and wines from the wine region of Moldova under current climate change conditions. The musts from the varieties Busuioaca de Bohotin, Fetească neagră, Muscat Ottonel and Pinot gris showed values of sugars between 198 g / L and 254 g / L, acidity 5.04 g / L H₂SO₄ and 7.92 g / L H₂SO₄, the total nitrogen was between 0.91 g / L and 1.54 g / L. The wines obtained were characterized by alcohol concentration and sulfur dioxide with values falling within standards, total acidity on average lower than the musts with one unit, and the dry non-reducing extract ranged from 22.1 g / L to 32, 4 g / L. It has been found that climate change, especially rising temperatures, leads to an accumulation of sugars and extract in musts and wines from the Moldova Vineyards.

KEY WORDS: climate change, musts, physical-chemical analysis, wines

1. INTRODUCTION

The grape varieties in our country have undergone a series of changes in their morpho-chemical structure over time, due to evolutionary, climatic or under the influence of the cultivator. Specialists in the field are constantly looking for those varieties with resistance to pests, high yield in processing or those with higher aromatic potential. The wine-growing potential of many regions is constantly changing due to the climatic changes that have occurred in the last period and adapting the different varieties is a challenge for the specialists (Costea et al. 2019). Studies show that in recent years the climatic data collected in the wine regions of our country have undergone relevant changes, changes with a major impact on the wine and the quality of the varieties. Thus, in 2018, Irimia and her colleagues published a study that analyzes the average daily temperatures, precipitation and amplitude of the solar rays over a period of 52 years, with data taken from about 150 weather stations in Romania. The correlation between climate and wine production was expressed by the oenoclimatic aptitude index (IAOe), which integrates the influence of temperature, sun duration and precipitation on wines. The results of this study reveal an extension of the climate zone suitable for wine production in Romania; also it was found that due to the climatic factors the wines can be cultivated at higher altitudes, specifying that these changes favor the cultivation of mainly red soils (Tonietto et al. 2004, Bojariu et al. 2015, Irimia et al. 2018). The study allows an in-depth analysis from a spatial perspective of the changes caused by climate change in the wine-growing areas, constituting a solid support for the development of the strategies of adaptation of the viticulture to the new climatic context (Irimia et al. 2018, Cichi 2006)

The climatic fit for the wine production determines the possibility of growing the wines, the assortments of grape varieties in the wine regions and their types of wine. Climate suitability is a stable feature of a wine-growing area over time, with slight variations from year to year, and yet unable to modify the specific type of wine production in a wine-growing region. In the context of climate change, this feature of the wine regions changes significantly, which leads to important consequences: changes in the phenology of wines, early maturation of grapes,

higher alcoholic potential and lower total acidity of grape must, color changes appear and aromatic and sensory profile of wines (Irimia et al. 2014, Irimia et al. 2015, Jones et al. 2005, Vișan et al. 2017, Sadras et al. 2013).

Changing the climate suitability for wine production is manifesting globally, with harmful consequences in the warmer Mediterranean areas and positive consequences for the northern wine regions with a colder climate, which can diversify their wine types. Projections based on climate models predict the extension of the area suitable for growing wines beyond the northern and southern limits of the wine-growing surface globally, as well as the transition to higher altitudes (Irimia et al. 2018, Irimia et al. 2017).

The Moldova area is mainly sought after because of the high quality grapes, which can lead to obtaining elite wines, the potential wine-viticulture of the area being well known. An increasingly important segment of the population focuses on the consumption of aromatic or semi-aromatic wines, red or rosé, their share exceeding by 25% the consumption of the 90s. The pedo-climatic indicators, the area of origin are usually an important factor of selection and discrimination of the varieties, their value being reflected in the quality of the wines obtained (Cotea et al. 2008, Hidalgo Togores 2003, Burzo 2014, Lengyel 2012). The wines from this area have characteristics described in specialized studies (Bichescu et al. 2018, Coarfă et al. 2018) focusing in particular on aromatic, sensory, but also physico-chemical characters (Duchene et al. 2005, Lengyel 2015, Rotaru et al. 2013, Tartian et al. 2015).

2. MATERIALES AND METHODES

- grapes from the varieties Busuioaca de Bohotin, Fetească neagră, Muscat Ottonel, Pinot gris, harvests of the years 2016, 2017, 2018, from the vineyards: Bohotin, Cotești, Cotnari, Huși and Iași, selected and pressed in must (the varieties were noted with acronyms: Busuioaca de Bohotin: BB, Fetească neagră: FN, Muscat Ottonel: MO, Pinot gris: PG)

- in the characterization of these grape varieties was followed:

- sugar concentration (g / L)

- the concentration of titratable organic acids (g / L sulfuric acid)

- concentration of nitrogenous substances: total nitrogen (mg / L)

- wines obtained from the varieties Busuioaca de Bohotin, Fetească neagră, Muscat Ottonel, Pinot gris, harvests of 2016, 2017, 2018, from the vineyards: Bohotin, Cotești, Cotnari, Huși and Iași. The wines were obtained by the classic technology, specific to the selected vineyard (DOC Specification)

- for the characterization of these wines the following analyzes were performed:

- determination of alcohol concentration (% vol)

-determining the reducing sugar (g / L)

- determination of total acidity (g / L sulfuric acid)

-determining the non-reducing dry extract (g / L)

The working methods were those accredited by the International Wine Organization (OIV) in the field

(<http://www.oiv.int/en/technical-standards-and-documents/methods-of-analysis/compendium-of-international-methods-of-analysis-of-wines-and-musts>)

3. RESULTS AND DISCUSSIONS

3.1. Physico-chemical qualities of musts

The accumulation of sugars in grapes (Figure 1) usually takes place at full maturity, when they have reached maximum weight, overmaturation being indicated rather for the selected wines, chosen, where the quality prevails in front of the quantity. In the five vineyards selected the grapes were harvested at the beginning of september, when the method of 200 grains per 200 buds showed that this is recommended. The calculated bioclimatic indices, especially the Oeclimatic Aptitude, have been ascending since 2016, being specific in each vineyard. There are higher values in the Huși, Iași and Cotnari vineyards where they exceed 4800 compared to the Bohotin Vineyard, Cotești where they are located between 3800-4300. Thus, it was observed that in 2016 the Busuioaca de Bohotin variety presented a maximum concentration of 238 g/L sugars, in Iași vineyard, followed by Huși with 231 g/L, and the lowest values were registered in Bohotin and Cotești Vineyards with 223 g/L. Feteasca neagră variety has accumulated a maximum of 225 g/L sugars in Iasi Vineyard, and a minimum of 198 g/L in Cotești Vineyard. The Muscat Ottonel variety was noted with a remarkable accumulation in the Huși Vineyard, with 239 g/L,

followed by Iasi with 236 g/L, Bohotin with 234 g/L, and the lowest value was recorded at Cotnari of 222 g/L. As for the grapes from the Pinot gris variety, they presented close values in three vineyards, namely: Bohotin, 232 g/L, Cotești and Iași 233 g/L, the maximum level being identified in the case of Cotnari Vineyard.

The year 2017 was noted by a slight warming, the values of the sugars ranging from one vineyard to another. For the Busuioaca de Bohotin variety, the acetate ranged between 213 g/L in Cotești Vineyard and 237 g/L in Huși. Intermediate values showed the Bohotin Vineyard with 223 g/L, Cotnari with 221 g/L and Iași with 232 g/L. The grapes from the Feteasca neagra variety were noted by sugar accumulations at concentrations of 203 g/L at Cotnari, 204 g/L at Cotești and a maximum of 221 g/L at Iasi, 220 g/L at Bohotin and 217 g/L to Huși. Muscat Ottonel variety accumulates in the same period sugars reaching 242 g/L at Iași Vineyard, followed by Bohotin with 234 g/L, Cotești and Huși with 228 g/L and 229 g/L respectively, and the lowest value was noted in Cotnari Vineyard with 218 g/L. In the same year the Pinot gris variety shows variations in the accumulation of sugars starting from 224 g/L in the Bohotin Vineyard and reaches a value of 239 g/L in the Iasi Vineyard. In Huși and Cotești Vineyards, sugars accumulated in concentrations of 236 g/L respectively 237 g/L, and in Cotnari the values did not exceed 231 g/L. In the year 2018, overall values of sugar in all these vineyards are noted, ranging from 222 g/L to 254 g/L. Thus, it is observed that the Busuioaca de Bohotin variety has sugar concentrations that are at a minimum of 229 g/L in Cotnari and a maximum of 248 g/L in Bohotin and Huși. Values of 247 g/L were highlighted in the case of Iași Vineyard and 232 g/L in the case of Cotești. The values of sugars identified in the case of the Feteasca neagra variety start from 212 g/L in Iasi and a maximum of 239 g/L in Huși, followed by the Cotnari Vineyard where they reach 238 g/L. The Bohotin and Cotești Vineyards stand out for this variety with values of 229 g/L respectively 227 g/L. Muscat Ottonel variety accumulates the most significant amount of sugars, namely 254 g/L in the Bohotin Vineyard followed by Iasi with 247 g/L, Huși with 238 g/L. Slightly lower values are observed in the case of Cotești and Cotnari Vineyards with 222 g/ L and 224 g/L respectively. The Pinot gris variety accumulates considerably more sugars so that it reaches a value of 247 g/L in the Huși Vineyard, 242 g/L in the Bohotin Vineyard and 240 g/L in the Iasi Vineyard. Lower values are found in Cotnari and Cotești where they do not exceed 231 g/L respectively 221 g/L.

Figure 1. The concentration of sugars in the four varieties of musts from Busuioaca de Bohotin, Feteasca neagră, Muscat Ottonel, Pinot gris grapes, harvests of 2016, 2017, 2018, from the Bohotin, Cotești, Cotnari, Huși and Iași vineyards

The total acidity was expressed in sulfuric acid (H_2SO_4) and in the worked musts has values between 5.04 g / L and 7.92 g / L . In figure 2 it is noted that the acids in the must have specific variations of each variety and what is more relevant is that the values decrease slightly in years, which confirms climate change, in the sense that an increase of the average annual temperatures is noticed, namely from 9.1⁰C in 2016 at Cotnari to 9.8⁰C in 2018 in Iași. Busuioaca de Bohotin variety was noted in 2016 with values of organic acids ranging from 5.27 g / L, 5.43 g / L to Bohotin and 7.31 g / L in Huși, 7.23 g / L in Cotești and 6.18 in Iași. The Fetească neagră variety has values that exceed 6 g / L in Cotești and Huși and reach 7.13 g / L, in Cotnari and 7.21 g / L in Bohotin. As for Muscat Ottonel, the values of organic acids are located in quantities ranging from 5.16 g / L in Iasi vineyard and reach 7.92 g / L in Cotnari, while the variety Pinot gris starts from values of 5.07 g / L at Huși and reaches 7.91 g / L at Cotnari vineyard. In 2017, slightly lower values are

observed compared to the previous one, culminating with the year 2018, when organic acids have lower amounts on average by 8% compared to 2016. Thus, the Busuioaca de Bohotin variety oscillates around 7 g / L, for the Bohotin, Huși and Iași vineyards and slightly over 5 g / L for the Cotești and Cotnari vineyards. The black Fetească variety has values ranging from 5.04 g / L in Cotești and 7.20 g / L in Bohotin, with intermediate values for the other three vineyards. The lowest determined values are noted in the case of the Muscat Ottonel variety, these being between 5.08 g / L in Cotnari and 6.29 g / L in Iași, while the variety Pinot gris has amounts of 5.32 g / L in Huși and a maximum of 7.39 g / L in Iași and Cotești. The year 2018 presents lower values of organic acids in grape must, rising temperatures leading to this. The Busuioaca de Bohotin variety has values between 5.11 g / L in Huși, 5.19 g / L in Cotnari, 5.32 g / L in Cotești, 6.15 g / L in Iasi and a maximum to 6.48 g / L from Bohotin.

Figure 2. Concentration of titrable organic acids (total acidity) in the four varieties of musts from Busuioaca de Bohotin, Feteasca neagră, Muscat Ottonel, Pinot gris grapes, harvests of the years 2016, 2017, 2018, from the Bohotin, Cotești, Cotnari, Huși and Iași vineyards expressed in gram sulfuric acid / L

Significantly close to the values of the Feteasca neagră variety, where the organic acids were between 5.07 g / L in Cotești and 6.18 g / L in Cotnari. Intermediate values were determined in Iasi of 5.12 g / L and in Bohotin and Huși of 6.09 g / L. In the same descending line were presented the varieties Muscat Ottonel and Pinot gris, with the exception of the Huși Vineyard, where the variety Pinot gris accumulated 7.27 g / L.

The total nitrogen values (Figure 3) were close in the three years of study, being between 0.91 g / L and 1.52 g / L. In the Bohotin Vineyard the total nitrogen was at values between the three years between 1.04 g / L in the case of Muscat Ottonel must in 2017

and 1.54 g / L in 2018 for the same variety. In the Cotești vineyard, the determined values were between 1.04 g / L for the black Feteasca variety in 2017 and 1.39 g / L for the Pinot gris variety the same year.

In the case of Cotnari vineyard, the total nitrogen is at lower values on average by 5% compared to the Cotești Vineyard, these oscillating around zone 1. At Huși the total nitrogen exceeds 1.07 g / L in the case of Pinot gris variety in 2016, reaching value maximum in 2017 of 1.32 g / L.

Figure 3. Concentration of total nitrogen in the four varieties of musts from Busuioaca de Bohotin, Feteasca neagră, Muscat Ottonel, Pinot gris grapes, harvests of the years 2016, 2017, 2018, from the Bohotin, Cotești, Cotnari, Huși and Iași vineyards

3.2. Physico-chemical qualities of wines

As can be seen in figure 4, the wines from the grape varieties under study have slight variations in terms of alcohol concentration, falling within the permissible limits.

Figure 4. Concentration of alcohol in the four varieties of wine from Busuioaca de Bohotin, Feteasca neagră, Muscat Ottonel, Pinot gris grapes, harvests of the years 2016, 2017, 2018, from the Bohotin, Cotești, Cotnari, Huși and Iași vineyards

From the results data it is noted that in 2016 the Busuioaca de Bohotin wine has the lowest concentration of alcohol 11.27% vol in Cotnari and 11.43% vol in Bohotin, followed in the same year by Pinot gris wine in Cotnari (11.91% vol.). In 2017 and 2018 the values of alcohols exceed 12% vol in all cases, ranging from 12.03% vol. in Cotnari (Feteasca neagră) and 12.54% vol. in Bohotin for Muscat Ottonel.

The titrable organic acids (total acidity) are noticeable by slightly lower values than the musts, being in 2016 between 4.46

g / L H_2SO_4 for the Busuioaca de Bohotin wine from Bohotin and 6.83 g / L H_2SO_4 for the same from the vineyard. Cotești. For 2017, the obtained values were between 4.29 g / L H_2SO_4 and 6.33 g / L H_2SO_4 for the Busuioaca variety of Bohotin from Cotnari and Bohotin. Intermediate values were obtained for the Black Feteas assortments of 4.44 g / L H_2SO_4 - 6.20 g / L H_2SO_4 (Cotești / Bohotin), Muscat Ottonel 4.59 g / L H_2SO_4 - 5.24 g / L H_2SO_4 (Cotești / Huși) and Pinot gris 4.92 g / L H_2SO_4 - 6.19 g / L H_2SO_4 (Huși / Iași).

Figure 5. Concentration of the titrable organic acids (total acidity) in the four varieties of wine from Busuioaca de Bohotin, Feteasca neagră, Muscat Ottonel, Pinot gris grapes, harvests of the years 2016, 2017, 2018, from the Bohotin, Cotești, Cotnari, Huși and Iași vineyards expressed in sulfuric acid

Figure 6 shows the concentration of sulfur dioxide identified in the wines selected during the three years of study. It is observed that the values do not show significant variations, the minimum

identified in 2016 being 114.3 g / L in Bohotin the Busuioaca range of Bohotin and a maximum of 141.1 g / L in Cotnari, the Pinot gris assortment.

Figure 6. Concentration of sulfur dioxide in the four varieties of wine from Busuioaca de Bohotin, Feteasca neagră, Muscat Ottonel, Pinot gris grapes, harvests of the years 2016, 2017, 2018, from the Bohotin, Cotești, Cotnari, Huși and Iași vineyards

Regarding the non-reducing dry extract, it gives valuable indications regarding the quality of the wine along with the alcoholic strength and the odorants (Figure 7). For the selected

period, 2016-2018, the wines submitted to the study were noted by generous values of non-reducing dry extract. The hot and dry summers have contributed to the accumulation of elements that lead to this.

Figure 7. Concentration of non-reducing dry extract in the four varieties of wine from Busuioaca de Bohotin, Feteasca neagră, Muscat Ottonel, Pinot gris grapes, harvests of the years 2016, 2017, 2018, from the Bohotin, Cotești, Cotnari, Huși and Iași vineyards

For 2016, the obtained values were at a minimum of 21.4 g / L and a maximum of 32.1 g / L. For the Busuioaca de Bohotin assortment the values were between 22.7 g / L at Cotnari Vineyard and a maximum of 28.8 g / L at Iași Vineyard. Intermediate values were obtained at Bohotin 23.3 g / L, Cotești 23.6 g / L, Huși 23.1 g / L. For the Fetească neagră assortment, the non-reducing dry extract presented the following values: At Bohotin 22.1 g / L, with 19% more at Cotești, 24.3 g / L at Cotnari, and at Huși and Iași the values were at 25.7 g / L respectively 26.5 g / L. The Muscat Ottonel assortment presents maximum values of 32.1 g / L in Cotești and a minimum of 22.3 g / L in Cotnari, while the Pinot gris assortment goes to extremes starting from 21.4 g / L at Cotnari Vineyard and reaches the value of 32.1 g / L at the Bohotin Vineyard. In 2017 there is an increase of the non-reducing dry extract compared to 2016 on average by 1.2%, so that the minimums were at values of 21.9 g / L and the maximums at 32.4 g / L. Thus, the Busuioaca de Bohotin wine assortment ranges from 23.5 g / L at Bohotin Vineyard and reaches 32.4 g / L at Iași Vineyard. Feteasca neagra presents non-reducing dry extract values from 23.6 g / L in Cotnari and reaches a maximum of 29.7 g / L in Bohotin. For Muscat Ottonel wine this analysis leads to results starting from 24.4 g / L in Bohotin and reaching 29.3 g / L in Iași, while Pinot gris presents a maximum of 29.2 g / L in Iași. The year 2018

brings significantly higher values to the entire range of selected wines, so the minimums start at 22.9 g / L and reach 32.2 g / L. For all the vineyards the values of non-reducing dry extract this year exceed the value of 25.2 g / L in the Busuioaca de Bohotin assortment, for the Feteasca neagra 27.1 g / L, for the Muscat Ottonel 27.3 g / L, and for the Pinot gris more modest 22.9 g / L. This year there is a 1.2% increase in the values determined by non-reducing dry extract compared to the previous year and 1.4% more than in 2016.

4. CONCLUSIONS

As noted in the determinations carried out the concentration of sugars is increasing since 2016, which is explained by the increase of temperatures during the summer, the decrease in volume of precipitation, in conclusion the main factors that contribute to their accumulation in grapes. The grapes selected for the study presented significant values of sugars, these competing for the quality of the wines obtained. The alcoholic strength of the resulting wines is satisfactory, it is within the quality norms established at the level of vineyards and both national and European legislation. The acidity of the must undergoes a slight decrease compared to other years, the pedoclimatic factors and the quality of the variety being decisive in this case, and the acidity of the wine gives freshness and flavor

to them. Must nitrogen is one of the elements that help the yeasts to trigger and lead a balanced alcoholic fermentation, the values determined being optimal in this regard. The amount of sulfur dioxide resulting is not a negative element, the resulting values fall within the norms, so that the wines can be considered biologically stable.

The non-reducing dry extract is a valuable indicator of quality wines, observing an upward accumulation over the years, due to the pedo-climatic conditions, the heating of the climate, the reduction of precipitation but also the increase of the sun during this period. All these substances such as non-volatile acids, glycerol, pectic substances, polyphenols, gums, nitrogenous and mineral substances that define the non-reducing dry extract are concentrated in wine and give them fineness, softness, qualities that are found in Moldova wines.

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