Ampelographic and Ampelometric Characterization of Berries and Seeds from Traditional Vineyards in Morocco [†]

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Abstract: Morocco, like other Mediterranean countries, is characterized by a great diversity of indigenous varieties of vines, “*Vitis vinifera* ssp. *vinifera*”, due to the climate and the heterogeneity of the landscapes, as well as the know-how and agricultural practices adopted by traditional farmers who have contributed preserving the genetic diversity of these indigenous grape varieties. Within the framework of this study, we seek the identification and characterization of 36 indigenous grape varieties sampled in northern and southern Morocco. The samples studied were taken from traditional vineyards in these regions. For the ampelographic and ampelometric descriptions, 26 characters were used according to a list of descriptors developed by the International Organization of Vine and Wine (OIV). Thus, the ampelographic and ampelometric approaches were refined by a principal component analysis (PCA), which made it possible to group the grape varieties into five distinct groups according to their correlations to the variables linked to the bunch, the berry, and the seed. The results obtained from these different approaches confirmed the presence of great inter-grape and intra-grape variability within the samples studied. This observation encourages us to make more efforts to maintain this variability and to fight against genetic erosion and the threat of environmental changes.

Keywords: vine; *Vitis vinifera* ssp. *vinifera*; traditional grape; ampelographic; ampelometric; OIV

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1. Introduction

The history of vine cultivation is parallel to the history of civilization in the Mediterranean Basin. The oldest perennial and emblematic Mediterranean crops (the olive tree (*Olea europaea* L.), date palm (*Phoenix dactylifera* L.), and the fig tree (*Ficus carica* L.)) and the domestication of the vine (*Vitis vinifera* L.) dates back at least 6000 years [1–3]. Indeed, the first productions of grapes and wine were a source of income and added economic value [4]. In Morocco, like other countries in the Mediterranean Basin, the winemaking tradition dates back to ancient times. To the probable contributions of the Phoenicians and the Romans, the Arab imprint has been added, which, since the Middle Ages, has characterized the winemaking landscapes of the country [5,6]. Subsequently, the historical exchanges between the two Mediterranean shores, French colonialism, and the important diversity of the terroir have for centuries led to the development and evolution of a large number of grape varieties, especially for the production and export of wine [7–9]. Thus, Morocco is characterized by a great diversity of traditional grape varieties thanks to its climate and the heterogeneity of its landscape, but above all, thanks to the local knowledge and the agricultural practices of traditional farmers who have contributed to preserving the genetic diversity of these grape varieties [10–12]. However, in recent decades, the modernization of agriculture and the transformation of agricultural systems have placed genetic resources

of plant origin in a worrying situation. In fact, modern vineyards made from European vines were gaining more space, to the detriment of traditional grape varieties, which have declined or even disappeared from the usual cultivation areas. From this perspective, given that valuation is a first step towards conservation, the present study focuses on the characterization of 36 traditional grape varieties via ampelometric and ampelographic parameters.

2. Materials and Methods

2.1. Prospecting and Sampling

The surveys were carried out at the scale of areas recognized by the persistence of traditional vineyards, using indigenous grape varieties. In this sense, at the scale of Morocco, the study was conducted at 14 sites belonging to two main zones: the Western Rif in the north and the High Atlas in the south (Figure 1). For this, the sampling was carried out in traditional vineyards, at the time of fruiting. From each site, with the help of the farmers, we collected samples of named and recognized fruits for each grape variety. In total, we sampled 27 grape varieties in the Western Rif and 9 grape varieties in the High Atlas (Table 1).

Figure 1. Location of the sampled sites across Morocco.

Table 1. List of grape varieties sampled in different sites.

Region	Grape Variety (Code)
Western Rif	Ainab lebyed (ALB), Ainab leKhal (ALk), Albaydi (ALBY), Elfassi (ALF), Alkouz (ALKO), Babbour Hmara (BABH), Bezzoul Alaouda (BZA), Bezzoul Alaouda Byed (BZAB), Bezoul Alaouda Hmar (BZAH), Boukhanzir (BKH), Boukwaness (BKW), Chwikhi (CHW), Douak (DOU), Eddibani (EDD), Feqqass (FQS), Hmar Bouamar (HBA), Houmrani (HOU), Jenyani (JYN), Lechehab (LCH), Maticha (MTC), Sbyae Lebnat (SBLB), Taferyalet (TFR), Taferyalt Byed (TFRB), Taferyalet Lechehab (TFRL), Taferyalet sfar (TFRS), Taferyalet lekhal (TFRK), Valencia (VAL)
High Atlas	Abouhou (ABH), Bouchouka (BCHK), Guiyyar (GYR), Laadari (LAD), Tiglay n'Timilli (TGHL), Tiniwine (TNW), Aabbou (AAB), Feryali (FRY), Laadari Haouz (LADH)

2.2. Ampelographic and Ampelometric Parameters

According to the universal characteristics established by the OIV, the ampelographic and ampelometric descriptions of 36 indigenous Moroccan grape varieties were based on the use of 10 bunches of grapes/grape variety, 30 berries/each bunch of grapes, and 100 seeds [13]. In this context, the study was carried out according to 26 ampelographic and ampelometric characteristics selected from the list of descriptors developed by the International Organization of Vine and Wine (OIV) [13]. Thus, for the description of the grape clusters, 8 OIV descriptors were adopted: 202, 203, 204, 206, 207, 208, 209, and 502. For the description of the berries, 15 OIV descriptors were used: 220, 221, 222, 223, 225, 226, 229, 231, 232, 235, 236, 238, 240, 503, and 505. For the characterization of the seeds, we used 4 OIV descriptors: 241, 242, 243, and 244.

2.3. Statistical Analysis

Using the XLSTAT software, we performed an analysis of variance and correlation.

3. Results

3.1. Ampelographic Parameters

3.1.1. Bunches of Grapes

The ampelographic notations carried out on the bunches of grapes from the different grape varieties showed a fairly high level of variability. From the point of view of the length of the bunches of grapes (OIV 202), we observed that the bunches of the different grape varieties have a length varying from short to very long. Thus, the clusters of the grape varieties AAB, BCHK, and TFRS are very long, while the bunches of the grape varieties BABH, BZAH, and SBLB are short.

Concerning the width of the bunches of grapes (OIV 203), ampelographic analysis revealed a great diversity in width between the different grape varieties. Thus, the widest bunches of grapes belong to the BCHK and LAAH grape varieties, and the very narrow to narrow bunches of grapes belong to the ALK grape variety. The grape clusters of 12 varieties show a narrow to medium width. From the point of view of the compactness of the bunches of grapes (OIV 204), the bunches of grapes of the different grape varieties have a very heterogeneous compactness, ranging from very loose to very compact. Thus, the grape varieties BABH, BKW, and MTC have very compact bunches of grapes, and the grape varieties BZAB, BKH, EDD, and LCH have loose to very loose bunches of grapes. According to the character of the lignification of the peduncle (OIV 207), we note the presence of three categories; one presents the grape varieties with lignification, which are limited to the base only and are the most dominant (19 varieties), and the other are varieties are characterized by lignification at the half of the peduncle (ABH, ALK, BCK, FQS, TFRS, and TNW), and for the third category, the lignification extends beyond half of the peduncle (11 grape varieties).

From the point of view of the shape of the bunches of grapes (OIV 208), and taking into account the shapes proposed in the list of descriptors, we found the existence of three shapes (cylindrical, conical, and funnel-shaped) in the grape varieties studied with the

predominance of the cylindrical shape, and the conical shape being the least common. Regarding the number of wings of the main bunch of grapes (OIV 209), our study revealed that more than half of the grape varieties have one to two wings while 14 grape varieties have no wings. However, in three grape varieties (EDD, TFR, and BCK), the presence of three to four wings was noted.

3.1.2. Berries

Based on our ampelographic analysis of the different grape varieties, we noticed that there is great heterogeneity. Bay length (OIV 220) varies from short to long. Thus, the seeds of most grape varieties are of medium length. Regarding the width of the berry (OIV 221), we have demonstrated a quasi-balanced distribution between two categories (narrow and medium), with a predominance of the first. For the size of the berry (OIV 222), our study confirmed the non-uniformity of the majority of the grape varieties studied (31), as only five grape varieties (ABH, BCK, JYN, ALF, GYR) were listed as having uniform berries. Thus, the ampelographic analysis of the shape of the berry (OIV 223) allowed us to confirm the dominance of the short elliptical shape, followed by the spherical shape.

The presence of the troncovoidal form was also demonstrated in three grape varieties (BZAH, HBA, and SBLB) and flattened spherical was seen in three grape varieties (BKW, MTC and TFRS). The long elliptical shape was revealed in a single grape variety (BCK). The grape varieties studied are distributed according to the color of their berries (OIV 225) into five clearly distinguished groups, each group of which is characterized by a clearly defined skin color: yellow green (17 grape varieties), blue-black (9 grape varieties), pink (5 grape varieties), red (3 grape varieties), and dark red-violet (2 grape varieties).

Regarding the uniformity of the color of the epidermis of berries in different grape varieties (OIV 226), we found that in 30 grape varieties, the color is uniform, and the color of the epidermis was not uniform in only six grape varieties (BABH, EDD, ALF, FRY, HBA, TFR). Concerning the umbilicus (OIV 229), we noted that it is hardly apparent in 25 grape varieties, while it is apparent in 11 grape varieties (BKW, DOU, ALK, EDD, FQS, TFRK, FRY, GYR, LADH, TGH, TNW). Concerning the intensity of the anthocyanin coloration of the pulp (OIV 231), we found that it is varied depending on the grape variety. Thus, it is zero in three grape varieties (ALK, CHW and LCH) and medium to very strong in most grape varieties. In terms of the succulence of the pulp (OIV 232), it is moderately juicy in most grape varieties (25) and not very juicy in only one grape variety (ABH). For the character and firmness of the pulp (OIV 235), it was noted that all the berries of the grape varieties studied are slightly firm, with the exception of the berries of a single grape variety that is very firm, TGH.

From the standpoint of ease of separation of the pedicel (OIV 240), we found that the pedicels of all the grape varieties are difficult to separate, and that it is easy only in three grape varieties (AAB, GYR, LADH). Regarding the weight of the berries, we noticed that most grape varieties have berries with a weight that varies from very low to low, while the berries with an average weight to grow are part of only six grape varieties (ABH, BCHK, GYR, ALB, BZA, and BZAB). For the sugar content of the must (OIV 505), we noticed that 22 grape varieties have a high content, 11 grape varieties have an average content, and very high content was noted in 3 grape varieties (VAL, ALK, TNW).

3.1.3. Seeds

According to the analysis of the ampelographic characters related to the seeds of the different grape varieties, we observed that there are characters that do not discriminate between the different grape varieties, including the formation of seeds (OIV 241), which was found to be complete in all the grape varieties, as well as the transverse groove on the gold-dirty side of the seeds (OIV 244), which is also absent in all of the seeds.

Thus, the difference between the seeds of the various grape varieties was noted in relation to the level of the length of the seeds (OIV 242), which varies from medium to long with a predominance of the average length of the seeds. In addition, the seed weight (OIV

243) shows a variation between the different grape varieties. It varies from low to very high. The weight is medium to very high in most of the seeds, and it is only low in two grape varieties (ALK and ALK).

3.2. Ampelometric Parameters

3.2.1. Analysis of Variance

The analysis of variance for the different ampelometric characteristics measured shows a highly significant difference between the different grape varieties studied ($p < 0.001$), which is the result of significant intra and inter grape variety. This difference is more expressed with very high Fs, particularly for the characteristics relating to the weight of the bunch and the seed (Table 2).

Table 2. Results of the analysis of variance of ampelometric characteristics.

OIV	202	203	206	502	220	221	238	503	242	243
Fisher's F	3104	3104	3428	7114	5695	2646	5406	4083	6760	8320
Pr > F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

The highest grape bunch length (OIV 202) was observed in the LADH grape variety (326 cm) while the lowest average was observed in the BABH grape variety (130 cm). Regarding the bunch width, we noticed that the greatest width was observed in LADH (214 cm), while the lowest is that of the ALK grape variety (86.25 cm). For the length of the peduncle, we found that it varies between 100 cm in the JYN grape variety and 30 cm in SBLB. In addition, the bunch weight showed a strong differentiation in variance, which is much higher than the other parameters measured. In fact, it varies between 1186.5 g in LADH and 112.65 g in FER.

Regarding the berries, we revealed that the berry length varies between 27.75 mm at BCHK and 15 mm at HOU, for which we also noted the smallest berry width (14 mm), while BZA is characterized by the widest width with an average of 21.25 mm. In addition, analyzes of variance revealed that the TFR grape variety has the longest pedicel with an average value of 10.973 mm, while the TFRS variety had the shortest pedicel with an average of 6.25 mm. For the weight of the berry, we marked a strong differentiation; in fact, the highest weight is 6.36 g, which was noted at BZA, while the ALKO grape exhibited the lowest weight with an average of 1.03 g.

From a seed point of view, we found that the seeds have a more or less homogeneous length in most grape varieties, of which we noticed the highest length in LADH (7.858 mm), while the lowest length was noted in DOU (5.65 mm). Conversely to the length, the weight of the seeds showed a great variance between the different grape varieties; the highest weight was noted in ABH with an average of 79.74 mg, while ALKO had the lowest weight with an average of 30.01 mg.

3.2.2. Correlation Matrix of Variables

The analysis of the correlations between the measured parameters highlighted the presence of links between the various quantitative parameters (Table 3). Indeed, it appears that there is a positive and very significant correlation: firstly, between the parameters of the bunch of grapes, particularly the length of the cluster (OIV 202) with the width (OIV 203), and the weight of the bunch (OIV 502) with the length (OIV 202) and the width of the bunch (OIV 203); and secondly, between certain parameters of the berry, including the berry weight (OIV 503), which is strongly and positively correlated with the length (OIV 220) and the width of the berry (OIV 221). In addition, we found that there is a positive and highly significant correlation between the length (OIV 242) and the weight of the seeds (OIV 243). The length of the pedicel (OIV 238) and the sugar content of the must (OIV 505) did not show any correlation with any parameter.

Table 3. Correlation matrix of the different variables analyzed.

OIV	202	203	206	502	220	221	238	503	242	243	505
202	1	0.795	0.543	0.783	0.371	0.230	0.029	0.246	0.397	0.292	−0.055
203		1	0.533	0.835	0.481	0.374	0.003	0.436	0.419	0.250	−0.050
206			1	0.284	0.272	−0.042	0.078	0.265	0.260	0.221	−0.194
502				1	0.472	0.464	−0.138	0.447	0.503	0.371	−0.100
220					1	0.359	−0.057	0.624	0.404	0.388	−0.233
221						1	0.077	0.714	0.459	0.341	0.084
238							1	0.055	0.097	−0.049	0.258
503								1	0.574	0.579	−0.238
242									1	0.847	−0.224
243										1	−0.402
505											1

4. Discussion

Based on the ampelographic approach, the majority of the parameters used demonstrate the existence of fairly significant inter-varietal and intra-varietal variability. In addition, and on the ampelometric level, the statistical approach by the ANOVA test revealed the most discriminating parameters, showing a strong differentiation of variance for two characters: the weight of the bunch and seed.

According to the different ampelometric and ampelographic results obtained, we can confirm the presence of a clear differentiation, not only within the same grape variety, but also between the different grape varieties. This observation is justified by the example of grape varieties characterized by several features at the same time. The HBA variety is a perfect example of this variability, since its bunch is characterized by a short to medium length (202), narrow to medium width (203), loose to medium compactness (204), and a cylindrical and conical shape (208).

The comparison of the ampelographic and ampelometric characteristics of traditional Moroccan grape varieties with other Mediterranean grape varieties has confirmed the existence of a significant diversity but also a resemblance of some ampelographic characteristics, particularly the shape of the berry and the color of the epidermis. For the character of the shape of the berry, we note a dominance of the spherical and short elliptical shape among Moroccan grape varieties; the same results were obtained in varieties from Montenegro [14], Palestine [15], Slovenia [16], and Spain [17]. With regard to the color of the epidermis, it has been observed that almost all Moroccan grape varieties are yellow-green and blue-black in color, a finding which is in line with the results of the work carried out on grape varieties from Spain [17]. However, taking into account the fact that the morphological characteristics vary considerably depending on the region, ecology, care practices, and location, it can be said that these results should also be validated using molecular biology techniques.

5. Conclusions

This work constitutes an opportunity to better understand the Moroccan wine heritage and to compare Moroccan grape varieties to those of other Mediterranean countries. It is, therefore, a study to be completed by molecular characterization approaches. In fact, the importance of the characterization of a rare viticultural genetic resource can be explained through the identification of grape varieties that are tolerant to changing climatic conditions (e.g., drought, increased resistance to pathogenic agents) and could promote sustainable viticulture.

Supplementary Materials: The poster presentation is available online at <https://www.mdpi.com/article/10.3390/BDEE2021-09523/s1>, the video presentation is available online at https://sciforum.net/event/BDEE2021/keynote/321fe49e58b7ee362e0f8201ead1dd6f/presentation_video/Hmimsa%20et%20al.mp4

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