

## Pedigree analysis of the Spanish grapevine cultivar 'Hebén'

L. H. ZINELABIDINE<sup>1)</sup>, J. CUNHA<sup>2), 3)</sup>, J. E. EIRAS-DIAS<sup>2)</sup>, F. CABELLO<sup>4)</sup>, J. M. MARTÍNEZ-ZAPATER<sup>1)</sup> and J. IBÁÑEZ<sup>1)</sup>

<sup>1)</sup> Instituto de Ciencias de la Vid y del Vino (CSIC, Universidad de La Rioja, Gobierno de La Rioja), Spain

<sup>2)</sup> Instituto Nacional de Investigação Agrária e Veterinária (INIAV), Portugal

<sup>3)</sup> Universidade Nova de Lisboa, Instituto de Tecnologia Química e Biológica (UNL, ITQB), Portugal

<sup>4)</sup> Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario (IMIDRA), Spain

### Summary

**The use of Single Nucleotide Polymorphism (SNP) markers allows genetic identification and parentage analysis of grapevine cultivars. Ancient cultivars like 'Hebén' were widely cultivated in the Iberian Peninsula along its history and likely contributed to the origin of varieties which are still cultivated today. The goal of our study was to search for possible first-degree relationships between the female variety 'Hebén' and other Iberian and Mediterranean cultivars. For this purpose, we used a set of 261 SNP markers which allowed identifying 23 trios and 37 parent-offspring relationships supported by high overall likelihood ratios (LOD scores). The results shed light on the relationships among several cultivars from Spain and Portugal, and demonstrated that 'Hebén' is a major founder of current varieties in the Iberian Peninsula viticulture, and contributed to spread the chlorotype A in this region.**

**Key words:** genetic relationships, historical genetics, single nucleotide polymorphism, *Vitis vinifera*.

### Introduction

The Iberian Peninsula has large grapevine diversity: National grapevine catalogues include 222 different varieties in Spain and 511 in Portugal (LACOMBE *et al.* 2011). Nevertheless, in terms of cultivated surface only a few cultivars are important. In Spain, the country with the largest vineyard surface, only two varieties ('Airén' and 'Tempranillo') account for almost half of the total area (about 470,000 ha, CABELLO *et al.* 2011). The trend to cultivate only certain varieties has contributed to the disappearance of many local cultivars, but recently this trend is starting to change, and some wineries, grape growers and consumers are looking for 'new', local products. In this sense, the knowledge of the genetic origin of local varieties, mainly conserved in germplasm banks, may provide an added value to these products. From a historical point of view this knowledge also contributes to understand the origin and development of the viticulture in a given region. In addition, from a scientific point of view, this information may provide a sound basis for the study of the inheritance of certain traits, as well as for selecting or discarding varieties in breeding programs or in association mapping panels.

In this work the old female variety 'Hebén' was selected after several reports indicating its possible important role in the Iberian Peninsula genetic network (LACOMBE *et al.* 2013). 'Hebén' is a winegrape cultivar, already described in the 16<sup>th</sup> century (HERRERA 1513) as a white variety of grapevine producing large and sparse bunches of grapes with big seeds. It was grown in the Andalusian region (Southern Spain) (GARCÍA DE LOS SALMONES 1914), but currently it is hardly cultivated in the provinces of Cordoba, Granada, Badajoz, Guadalajara, Toledo and Cadiz (Spain) (CABELLO *et al.* 2011). In Portugal it is known as 'Mourisco Branco', and it was first cited in the 18<sup>th</sup> century (ALARTE 1711). Another synonym is 'Gibi', which was considered as an Arabic table grape original from Northern Africa that was once grown in southern France and throughout the Iberian Peninsula (GALET 2000). It could have been introduced in Europe sometime during the Al-Andalus period, between the 8<sup>th</sup> and 15<sup>th</sup> centuries. In Spain, 'Hebén' is known as 'Ben', 'Even', 'Edenes', 'Heven', 'Heven Jaen', 'Jeven', 'Laco Blanco', 'Panseras', 'Pansero' or 'Torrantes' (CABELLO *et al.* 2011).

Nowadays, molecular markers allow identifying the putative parents of grapevine varieties. The discovery of the pedigree of 'Cabernet Sauvignon' in 1997 (BOWERS and MEREDITH 1997), based on microsatellite data, opened the way to similar analyses in different regions, including the Iberian Peninsula (LOPES *et al.* 2006, IBÁÑEZ *et al.* 2009). More recently, SNP markers have been shown to be very efficient for parentage analysis (ZINELABIDINE *et al.* 2012, IBÁÑEZ *et al.* 2012).

Recently, LACOMBE *et al.* (2013) published a large list of possible first-degree relationships among grapevine varieties based on the genotype of 20 microsatellite loci. Among all the listed pedigrees, 28 involved 'Hebén' as one of the parents, with LOD values (likelihood ratios) ranging from 19 to 41. Furthermore, 'Hebén' display putative parent-offspring relationships with 45 additional genotypes. In the present work, we have used SNP markers to detect and confirm first degree relationships between 'Hebén' and different cultivars especially from Spain and Portugal.

### Material and Methods

**Plant material:** All Spanish and Portuguese accessions genetically related to the ancient *Vitis vinifera* variety 'Hebén' were collected from the Instituto de Cien-

cias de la Vid y del Vino (ICVV) grapevine collection, at Finca La Grajera (Logroño, Spain), the *Vitis* Germplasm Bank at El Encín (IMIDRA, Madrid, Spain) and from the Coleção Ampelográfica Nacional (CAN) of Instituto Nacional de Investigação Agrária (INIA, Portugal) (Tab. 1). Prime names are proposed mostly according to the *Vitis* International Variety Catalogue (IVVC, www.vivc.de).

**DNA analysis:** DNA was isolated from young frozen leaves using the DNeasy® Plant Mini Kit (Qiagen, Valencia, CA). SNP genotyping services were provided by the Spanish “Centro Nacional de Genotipado” (CEGEN) (www.cegen.org) using previously identified SNPs (CABEZAS *et al.* 2011) and SNPlex or Veracode genotyping platforms, according to ZINELABIDINE *et al.* (2012).

**Parentage analysis:** A search for compatible trios (parents and offspring) and duos (parent-offspring) combinations among the SNPs profiles of grapevines was carried out, using Cervus 3.0 software (KALINOWSKI *et al.* 2007). The analysis was performed with the ICVV database, which includes 1,117 genotypes, mostly corresponding to Iberian cultivars and *sylvestris* plants, but also there are many European and Maghrebian grapevine varieties. In case of doubt, historical data, the number of mismatches and the LOD scores were used for parentage assignment.

## Results and Discussion

The parentage analysis was based on a large set of grapevine genotypes, mostly from Spain and Portugal. Initially, a set of 336 SNPs was used, but after removing failed and non polymorphic SNPs, data for 261 SNPs were obtained. The genotype set included trios previously described using SSRs (BOWERS *et al.* 1999, CABEZAS *et al.* 2003, IBÁÑEZ *et al.* 2009), which were used as control in the parentage analysis (ZINELABIDINE *et al.* 2012). Based on such control data, up to 3 mismatches were allowed for considering a trio, and up to 1 mismatch for a duo.

A number of potential parent-progeny combinations were identified, and those which could be directly related with 'Hebén' were selected: the possible trios (parents and offspring) where one of the varieties involved was 'Hebén' and all the cultivars that share at least one allele per locus with 'Hebén' and, therefore, maintain a putative parent-offspring relationship (duos). 'Hebén' parents could not be found, as no compatible trio with 'Hebén' as offspring was detected. Thus it is possible that one of the compatible duos includes one of 'Hebén' parents. All the other duos must correspond to other 'Hebén' progenies.

A total of 23 trios, and 37 duos were found involving 'Hebén' (Tabs 2 and 3). Some of the trios had been previously described by other authors (Tab. 2), but most of them are reported for the first time, and all were supported by high LOD scores. Given that 'Hebén' carries female flowers, it must be the female parent in all the crosses, and all its descendants (59 or 60 only in this work) will carry the 'Hebén' chlorotype A (GARCÍA-MUÑOZ *et al.* 2011), largely contributing to its spread in the Iberian Peninsula.

'Hebén' is the mother of many Portuguese cultivars. The white cultivar 'Hebén' proved to be a key

genotype for many Portuguese grape varieties since it appears in several trios and duos. In five of these trios 'Alfrocheiro' is the male parent, and gave place to four varieties presently cultivated in Portugal: 'Trincadeira das Pratas', 'Tinta Grossa', 'Castelão Branco' and 'Malvasia Fina', with LOD scores ranged between 70.86 and 79.89 (Tab. 2) (CUNHA *et al.* this issue). 'Alfrocheiro' and 'Hebén' are also the parents of the cultivar 'Allarén', a minor Spanish variety. Other crosses with 'Hebén' gave place to other Portuguese cultivars: 'Rabigato Moreno' and 'Còdega do Larinho' are descents of 'Rabigato' and are planted in Douro region. 'Moscatel Nunes', a cultivar from the Peninsula de Setúbal, arose from a cross between 'Hebén' and 'Muscat of Alexandria'. It could be the same cultivar as 'Nuno Gomes', for which LACOMBE *et al.* (2013) reported the same pedigree, since both have name similarities, have Muscat flavor and match for the four common microsatellite markers used by LACOMBE *et al.* (2013) and VELOSO *et al.* (2010). Other 'Hebén' Portuguese descendants 'Boal Espinho', 'Malvasia', 'Trincadeira Branca', 'Roupeiro Branco', 'Padeiro de Basto', 'Larião', and 'Malvasia Babosa' came from different geographical origins (CUNHA *et al.* 2013), suggesting that the cultivar was widespread in historical times.

Additionally, 'Hebén' exhibited a close relationship with other four Portuguese varieties sharing at least one allele at each of the 261 SNP loci used: 'Almafra', 'Gouveio Real', 'Lourela' and 'Perrum' (Tab. 3).

'Hebén' is the parent of several Spanish cultivars. In the Spanish side many duos and only some trios were detected, the opposite of what happened in the Portuguese case, probably because some of the parent varieties are not available anymore. The genetic origin of eight cultivars could be determined with high LOD scores, ranging between 76.4 and 95.3. Among the trios, and apart from 'Allarén' cited above, only in two cases the second parent was also a Spanish or Iberian variety: 'Mandón' is an offspring of 'Graciano' (and 'Hebén'), and 'Verdejo de Salamanca' is an offspring of 'Listán Prieto'. In the other cases the male parent is a foreign variety, like 'Muscat of Alexandria', which is the parent of 'Moscatel de Angüés'. A cross between 'Hebén' and 'Manseng Noir' ('Ferrón' in Spain) led to the variety 'Señá'. 'Ferrón' was first mentioned in 1914 in the region of Orense as 'Ferrol' (GARCÍA DE LOS SALMONES 1914) and is cultivated in Galicia, Spain. SNP results also confirmed that the cultivars 'Xarello' and 'Viura' arise from crosses between 'Hebén' and 'Brustiano Faux' (LACOMBE *et al.* 2013). In contrast, for variety 'Gorgollasa', reported as the offspring of 'Hebén' and 'Monastrell' based on 20 microsatellites (one mismatch) (GARCÍA-MUÑOZ *et al.* 2011 and LACOMBE *et al.* 2013), the SNP data confirmed 'Hebén' as a compatible parent (Tab. 3), but not 'Monastrell', which was excluded as a parent of this variety. Finally, two additional trios involved 'Hebén': together with the Moroccan cultivar 'Bou Qseb' to give place to the Spanish variety 'Montua' (in Portugal 'Diagalves') and with the Spanish variety 'Monastrell', to give place to the Moroccan variety 'Cot de Cheragas' (Tab. 2). These results, and the genetic origin of the Portuguese 'Larião', are in agreement with the existence of grapevine material exchange between the Iberian Peninsula and the Maghreb region previously pro-

Table 1  
Grapevine accessions included in this study

| Variety Name <sup>a</sup>   | Accession Name          | Institution <sup>b</sup> | Nº Accesion | Country of origin | Color <sup>c</sup> | Nº Variety /IVC |
|-----------------------------|-------------------------|--------------------------|-------------|-------------------|--------------------|-----------------|
| <b>Ahmeur Bou Ahmeur</b>    | Flame Tokay             | ESP217                   | 5067        | Algeria           | P                  | 140             |
| <b>Airen</b>                | Airén                   | ESP217                   | 5000        | Spain             | W                  | 157             |
| <b>Alarije</b>              | Malvasía                | ESP217                   | 5101        | Spain             | W                  | 213             |
| Albillo Real de Granada     | Borba                   | ESP080                   | BGVCAM0948  | Spain             | W                  | 248             |
| <b>Alfrocheiro</b>          | Albarín Negro           | ESP217                   | 5001        | Portugal          | B                  | 277             |
| Allarén                     | Allarén                 | ESP080                   | BGVCAM0934  | Spain             | W                  | 325             |
| Almafra                     | Almafra                 | PRT051                   | 52313       | Portugal          | W                  | 5191            |
| <b>Amaral</b>               | Amaral                  | PRT051                   | 52908       | Portugal          | B                  | 818             |
| <b>Beba</b>                 | Beba de Jaén            | ESP217                   | 5332        | Spain             | W                  | 22710           |
| Boal Espinho                | Boal Espinho            | PRT051                   | 52017       | Portugal          | W                  | 14154           |
| <b>Bou Qsob</b>             | Bouqseb                 | Sodea Meknes             | -           | Morocco           | W                  | 1593            |
| <b>Brustiano Faux</b>       | Unknown                 | ESP217                   | 6063        |                   | W                  | 41642           |
| Castelao Branco             | Castelão Branco         | PRT051                   | 52615       | Portugal          | W                  | 2321            |
| Castillo de Arcos           | Castillo de Arcos       | ESP080                   | BGVCAM2247  | Spain             | W                  | 2328            |
| <b>Cayetana Blanca</b>      | Blanca Cayetana         | ESP217                   | 5026        | Spain             | W                  | 5648            |
| Cot de Cheragas             | Cheragua                | Sodea Meknes             | -           | Morocco           | B                  | 5169            |
| Côdega do Larinho           | Côdega de Larinho       | PRT051                   | 51317       | Portugal          | W                  | 2743            |
| Corazón de Cabrito          | Corazon de Cabrito      | ESP080                   | BGVCAM2227  | Spain             | W                  | 232             |
| <b>Derechero de Muniesa</b> | Miguel de Arco          | ESP217                   | 5113        | Spain             | B                  | 3525            |
| Eperó de Gall               | Eperó de Gall           | ESP080                   | BGVCAM0893  | Spain             | B                  | 3919            |
| <b>Ferral</b>               | Ferral                  | ESP217                   | 5359        | Spain             | B                  | 4105            |
| <b>Folgasao</b>             | Folgasão                | ESP217                   | 5069        | Portugal          | W                  | 4178            |
| <b>Forcallat Tinta</b>      | Forcallat Negra         | ESP217                   | 5072        | Spain             | B                  | 4192            |
| Fumat                       | Fumat                   | ESP080                   | BGVCAM1880  | France            | R                  | 4289            |
| <b>Gorgollasa</b>           | Gorgollasa              | ESP080                   | BGVCAM1135  | Spain             | B                  | 4904            |
| Gouveio Real                | Gouveio Real            | PRT051                   | 50616       | Portugal          | W                  | 4927            |
| <b>Graciano</b>             | Graciano                | ESP217                   | 5086        | Spain             | B                  | 4935            |
| <b>Hebén</b>                | Hebén                   | ESP080                   | BGVCAM0848  | Spain             | W                  | 5335            |
| <b>Jeronimo</b>             | Jerónimo de Tudela      | ESP217                   | 5370        | Spain             | P                  | 5692            |
| Lario                       | Larião                  | PRT051                   | 51113       | Portugal          | W                  | 6757            |
| <b>Listan Prieto</b>        | Listán Prieto           | ESP080                   | BGVCAM1590  | Spain             | B                  | 6860            |
| Lourela                     | Lourela                 | PRT051                   | 50708       | Portugal          | B                  | 6914            |
| Malvar                      | Malvar                  | ESP080                   | BGVCAM1141  | Spain             | W                  | 7254            |
| Malvasia                    | Malvasia                | PRT051                   | 52714       | Portugal          | W                  | 22968           |
| Malvasia Babosa             | Malvasia Babosa         | PRT051                   | 40603       | Portugal          | W                  | 14139           |
| Malvasia Común              | Malvasia Común          | ESP080                   | BGVCAM0831  | Spain             | W                  | 213             |
| <b>Malvasia Di Sardegna</b> | Malvasia de Sitges      | ESP217                   | 5102        | Spain             | W                  | 7266            |
| <b>Malvasia Fina</b>        | Gual                    | ESP217                   | 5088        | Portugal          | W                  | 715             |
| <b>Mandon</b>               | Mandón                  | ESP080                   | BGVCAM1921  | Spain             | B                  | 7326            |
| <b>Manseng Noir</b>         | Ferrón                  | ESP217                   | 5066        | France            | B                  | 7340            |
| <b>Merseguera</b>           | Messequera              | ESP217                   | 5112        | Spain             | W                  | 7660            |
| Miguel de Arco              | Miguel de Arco          | ESP080                   | BGVCAM2685  | Spain             | B                  | 7710            |
| <b>Molinera</b>             | Castellano Morado       | ESP217                   | 5341        | Spain             | R                  | 7900            |
| Moll                        | Pensal Blanco           | ESP080                   | BGVCAM2682  | Spain             | W                  | 9113            |
| <b>Mollar Cano</b>          | Mollar Cano             | ESP217                   | 5115        | Spain             | B                  | 7901            |
| <b>Monastrell</b>           | Monastrell              | ESP217                   | 5116        | Spain             | B                  | 7915            |
| <b>Montua</b>               | Eva                     | ESP217                   | 5064        | Spain             | W                  | 2520            |
| Moscatel de Angüés          | Moscatel de Angüés      | ESP080                   | BGVCAM2090  | Spain             | W                  | 40885           |
| Moscatel Nunes              | Moscatel Branco         | PRT051                   | 53015       | Portugal          | W                  | 15680           |
| <b>Muscat Of Alexandria</b> | Moscatel de Alejandría  | ESP217                   | 5381        | Greece            | W                  | 8241            |
| <b>Naparo</b>               | Naparo                  | ESP217                   | 5131        | Spain             | B                  | 8345            |
| Padeiro de Basto            | Padeiro de Basto        | PRT051                   | 50806       | Portugal          | B                  | 17360           |
| <b>Pedro Ximenes</b>        | Pedro Ximénez           | ESP217                   | 5143        | Spain             | W                  | 9080            |
| Perrum                      | Perrum                  | ESP217                   | 5146        | Portugal          | W                  |                 |
| <b>Planta Fina</b>          | Planta Fina de Pedralba | ESP217                   | 5155        | Spain             | W                  | 9542            |
| <b>Quigat</b>               | Quigat                  | ESP080                   | BGVCAM0900  | Spain             | W                  | 9854            |

Tab. 1, continued

| Variety Name <sup>a</sup>     | Accession Name         | Institution <sup>b</sup> | N° Accesion | Country of origin | Color <sup>c</sup> | N° Variety IIVC |
|-------------------------------|------------------------|--------------------------|-------------|-------------------|--------------------|-----------------|
| <b>Rabigato</b>               | Rabigato               | PRT051                   | 52014       | Portugal          | W                  | 9857            |
| Rabigato Moreno               | Rabigato Moreno        | PRT051                   | 50917       | Portugal          | W                  | 9859            |
| Roupeiro Branco               | Roupeiro               | PRT051                   | 51314       | Portugal          | W                  | 17716           |
| <b>Seña</b>                   | Seña                   | ESP080                   | BGVCAM1688  | Spain             | B                  | 11483           |
| Sabro                         | Sabro                  | ESP080                   | BGVCAM2234  | Portugal          | W                  |                 |
| <b>Sumoll</b>                 | Sumoll                 | ESP217                   | 5180        | Spain             | B                  | 12072           |
| Tarragoní                     | Tarragoní              | ESP080                   | BGVCAM1288  | Spain             | B                  | 12266           |
| Tinta Grossa                  | Tinta Grossa           | PRT051                   | 52906       | Portugal          | B                  | 40711           |
| <b>Torralba</b>               | Torralba               | ESP080                   | BGVCAM1085  | Spain             | B                  | 12580           |
| <b>Trepat</b>                 | Trepat                 | ESP217                   | 5199        | Spain             | B                  | 12633           |
| Trincadeira Branca            | Trincadeira Branca     | PRT051                   | 51012       | Portugal          | W                  | 14130           |
| <b>Trincadeira Das Pratas</b> | Trincadeira Das Pratas | PRT051                   | 52216       | Portugal          | W                  | 15688           |
| <b>Trousseau Noir</b>         | María Ordoña           | ESP217                   | 5105        | France            | B                  | 12668           |
| Turruntés                     | Torrontés              | ESP217                   | 5194        | Spain             | W                  | 12581           |
| <b>Verdejo de Salamanca</b>   | Verdejo                | ESP217                   | 5208        | Spain             | W                  | 40923           |
| <b>Verdil</b>                 | Verdiel                | ESP217                   | 5211        | Spain             | W                  | 12965           |
| <b>Vijiriega Comun</b>        | Vijiriega Común        | ESP217                   | 5213        | Spain             | W                  | 13075           |
| <b>Vinhao</b>                 | Sousón                 | ESP217                   | 5177        | Portugal          | B                  | 13100           |
| <b>Viura</b>                  | Viura                  | ESP217                   | 5216        | Spain             | W                  | 13127           |
| <b>Xarello</b>                | Xarello                | ESP217                   | 5218        | Spain             | W                  | 13270           |

<sup>a</sup> In bold, confirmed names for the corresponding genotypes at the ICVV database.

<sup>b</sup> Institution: ESP080: IMIDRA; ESP217: ICVV; PRT051: INIA.

<sup>c</sup> Color: B: Black; P: Pink; R: Red; W: White.

Table 2

Summary of the trios (parents and offspring) found where 'Hebén' is involved

| Offspring              | Country of origin | Parent 1 | Parent 2             | SNP compared | SNP mismatches | Trio LOD score | Literature <sup>a</sup> |
|------------------------|-------------------|----------|----------------------|--------------|----------------|----------------|-------------------------|
| Cot de Cheragas        | Morocco           | Hebén    | Monastrell           | 241          | 0              | 87.46          | 3                       |
| Boal Espinho           | Portugal          | Hebén    | Malvasia Fina        | 212          | 2              | 83.86          |                         |
| Castelao Branco        | Portugal          | Hebén    | Alfrocheiro          | 220          | 0              | 71.52          |                         |
| Côdega do Larinho      | Portugal          | Hebén    | Rabigato             | 214          | 1              | 70.55          |                         |
| Lario                  | Portugal          | Hebén    | Ahmeur Bou Ahmeur    | 192          | 2              | 70.18          |                         |
| Malvasia               | Portugal          | Hebén    | Amaral               | 221          | 0              | 74.45          | 2,3                     |
| Malvasia Babosa        | Portugal          | Hebén    | Malvasia Di Sardegna | 250          | 0              | 70.46          |                         |
| Malvasia Fina          | Portugal          | Hebén    | Alfrocheiro          | 252          | 3              | 70.86          | 3                       |
| Moscatel Nunes         | Portugal          | Hebén    | Muscat of Alexandria | 215          | 1              | 73.37          | 3                       |
| Padeiro de Basto       | Portugal          | Hebén    | Vinhao               | 216          | 1              | 66.34          | 3                       |
| Rabigato Moreno        | Portugal          | Hebén    | Rabigato             | 213          | 0              | 82.06          |                         |
| Roupeiro Branco        | Portugal          | Hebén    | Folgasao             | 215          | 2              | 53.24          |                         |
| Tinta Grossa           | Portugal          | Hebén    | Alfrocheiro          | 222          | 0              | 74.68          | 3                       |
| Trincadeira Branca     | Portugal          | Hebén    | Trousseau Noir       | 209          | 0              | 64.57          |                         |
| Trincadeira Das Pratas | Portugal          | Hebén    | Alfrocheiro          | 245          | 0              | 79.89          |                         |
| Allarén                | Spain             | Hebén    | Alfrocheiro          | 241          | 0              | 78.63          |                         |
| Mandon                 | Spain             | Hebén    | Graciano             | 240          | 2              | 76.44          | 1,3                     |
| Montua                 | Spain             | Hebén    | Bou Qsob             | 253          | 1              | 94.41          | 3                       |
| Moscatel De Angüés     | Spain             | Hebén    | Muscat of Alexandria | 240          | 0              | 80.77          |                         |
| Seña                   | Spain             | Hebén    | Manseng Noir         | 238          | 0              | 79.93          |                         |
| Verdejo de Salamanca   | Spain             | Hebén    | Listan Prieto        | 238          | 0              | 95.3           |                         |
| Viura                  | Spain             | Hebén    | Brustiano Faux       | 241          | 1              | 78.76          | 1,3                     |
| Xarello                | Spain             | Hebén    | Brustiano Faux       | 239          | 1              | 80.29          | 3                       |

<sup>a</sup> 1 = GARCÍA-MUÑOZ *et al.* 2011; 2 = LACOMBE *et al.* 2007; 3 = LACOMBE *et al.* 2013.

Table 3

Summary of duos (parent-offspring) found where 'Hebén' is involved

| Cultivar 1              | Country of origin | Cultivar 2 | SNP compared | SNP mismatches | Pair LOD score | Literature <sup>a</sup>        |
|-------------------------|-------------------|------------|--------------|----------------|----------------|--------------------------------|
| Fumat                   | France            | Hebén      | 237          | 1              | 28.32          |                                |
| Almafra                 | Portugal          | Hebén      | 215          | 1              | 15.26          |                                |
| Gouveio Real            | Portugal          | Hebén      | 215          | 0              | 21.94          |                                |
| Lourela                 | Portugal          | Hebén      | 214          | 0              | 17.69          |                                |
| Perrum                  | Portugal          | Hebén      | 211          | 1              | 26.12          | 3                              |
| Airen                   | Spain             | Hebén      | 241          | 1              | 34.13          | 3                              |
| Alarije                 | Spain             | Hebén      | 235          | 0              | 30.88          | 2 <sup>b</sup> ,3 <sup>b</sup> |
| Albillo Real de Granada | Spain             | Hebén      | 202          | 0              | 28.75          |                                |
| Beba                    | Spain             | Hebén      | 246          | 0              | 41.74          | 3                              |
| Castillo De Arcos       | Spain             | Hebén      | 241          | 1              | 27.84          |                                |
| Cayetana Blanca         | Spain             | Hebén      | 245          | 0              | 24.49          | 3                              |
| Corazón De Cabrito      | Spain             | Hebén      | 240          | 1              | 30.22          |                                |
| Derechero De Muniesa    | Spain             | Hebén      | 239          | 1              | 23.42          |                                |
| Eperó de Gall           | Spain             | Hebén      | 237          | 1              | 20.32          | 3                              |
| Ferral                  | Spain             | Hebén      | 233          | 1              | 33.44          |                                |
| Forcallat Tinta         | Spain             | Hebén      | 201          | 0              | 30.95          | 3                              |
| Gorgollasa              | Spain             | Hebén      | 240          | 0              | 25.37          | 1 <sup>b</sup> ,3 <sup>b</sup> |
| Jeronimo                | Spain             | Hebén      | 225          | 0              | 32.93          | 3                              |
| Malvar                  | Spain             | Hebén      | 234          | 0              | 37.33          | 3 <sup>b</sup>                 |
| Malvasía Común          | Spain             | Hebén      | 239          | 1              | 20.55          |                                |
| Merseguera              | Spain             | Hebén      | 244          | 1              | 30.62          | 3 <sup>b</sup>                 |
| Miguel De Arco          | Spain             | Hebén      | 235          | 1              | 24.94          | 3                              |
| Molinera                | Spain             | Hebén      | 230          | 0              | 32.89          | 3                              |
| Moll                    | Spain             | Hebén      | 239          | 0              | 29.24          | 3                              |
| Mollar Cano             | Spain             | Hebén      | 250          | 1              | 20.86          | 3                              |
| Naparo                  | Spain             | Hebén      | 221          | 0              | 28.57          |                                |
| Pedro Ximenes           | Spain             | Hebén      | 249          | 0              | 31.87          | 3,4                            |
| Planta Fina             | Spain             | Hebén      | 214          | 0              | 35.44          | 3                              |
| Quigat                  | Spain             | Hebén      | 244          | 0              | 30.73          | 3                              |
| Sabro                   | Spain             | Hebén      | 237          | 1              | 20.37          | 3                              |
| Sumoll                  | Spain             | Hebén      | 237          | 0              | 37.26          | 3                              |
| Tarragoní               | Spain             | Hebén      | 243          | 0              | 33.57          | 3                              |
| Torralba                | Spain             | Hebén      | 223          | 1              | 27.19          |                                |
| Trepát                  | Spain             | Hebén      | 238          | 0              | 31.81          | 3                              |
| Turrutés                | Spain             | Hebén      | 221          | 1              | 26.44          |                                |
| Verdil                  | Spain             | Hebén      | 229          | 0              | 24.96          |                                |
| Vijiriega Comun         | Spain             | Hebén      | 244          | 0              | 26.63          | 3                              |

<sup>a</sup> 1 = GARCÍA-MUÑOZ *et al.* 2011; 2 = LACOMBE *et al.* 2007; 3 = LACOMBE *et al.* 2013; 4 = VARGAS *et al.* 2007.

<sup>b</sup> Full pedigree reported.

posed in several works (ZINELABIDINE *et al.* 2010, GHAFARI *et al.* 2013). A large number of Iberian varieties descent of 'Hebén' has been found in this work (Tabs 2 and 3) what, added to the additional trios and duos reported by LACOMBE *et al.* (2013), reveals its large impact in the Iberian viticulture in terms of its contribution to the varietal patrimony. In the present work, out of a total of 332 Iberian varieties analyzed (data not shown), 'Hebén' showed first order genetic relationships with 60 of them. In addition, some of the Spanish varieties directly related to 'Hebén' are currently very relevant in terms of cultivated surface. 'Airén', 'Cayetana Blanca', 'Viura', 'Xarello' and 'Pedro Ximenes' accounted in 2009 for more than 350,000 ha representing one third of the Spanish vineyard surface (CABELLO *et al.* 2011). In the case of the Portuguese varieties related to 'He-

bén', they are less relevant (less than 1,000 ha), except in the case of 'Malvasia Fina', which is cultivated in 5,500 ha (BÖHM 2011).

## Conclusion

The set of 261 SNP markers is a powerful tool for parentage analysis in grapevine. This study sheds light on the genetic relationships among cultivars from the Iberian Peninsula and demonstrates the close parentage relationships among Spanish and Portuguese varieties. The results allowed to uncover 13 new pedigrees and to confirm 10 previously proposed with higher LOD values. Besides, 23 proposed parent-offspring relationships between 'Hebén' and

other varieties were confirmed and 14 additional relationships were uncovered. Altogether these results demonstrate the very predominant role of the female cultivar 'Hebén' in the Iberian genetic network, which has contributed to the spread of the chlorotype A, the most frequent chlorotype in Western Europe.

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