The use of qualified panels applying specific evaluation methods for sensory quality control increases the reliability of the results, even more if the method is accredited by official accreditation bodies.

Based on the work developed with young red wine, this paper describes all the steps carried out after having defined the method: assessor selection, basic and specific training, qualification of assessors (individual performance checking) and method validation (panel performance checking). Other procedures necessary to demonstrate technical competence in a permanent way (monitoring of panel and assessors at each session, quality controls and assessor re-qualification) are also described.

Due to the scarce references in sensory method accreditation, many of the tests and criteria proposed are original. They could be helpful for other laboratories dealing with sensory quality control of food products, especially those with quality distinctiveness labels.

1. Introduction

The development of methods to assess in a reliable way the sensory quality of specific foods, mainly products with Protected Designation of Origin (PDO), in order to certificate them is a pressing need (Feria-Morales, 2002). In this sense, the importance of laboratory accreditation will probably increase over the next years (Gacula, 2003).

After method definition and before starting product assessment in a systematic way, several steps have to be carried out: assessor selection, basic and specific training, assessor qualification and method validation. Only when a method provides reliable results (repeatability, reproducibility and discrimination ability) it can be accredited according to ISO 17025 (ISO, 2005a).

To prove that technical competence remains through the time, a continuous monitoring of assessors and panel, assessor re-qualifications, as well as periodical quality controls are necessary.

Regarding assessor selection and training, there are many standards and publications (ASTM, 1981, 2003; Bressan & Behling, 1977; International Olive Oil Council (IOOC), 2007; ISO, 1993, 2005b, 2006, 2008; Issanchou, Lesschaeve, & Köster, 1995; Lyon, 2002; Muñoz, Civille, & Carr, 1992). There are also many reports for panel performance measurement (Brien, May, & Mayo, 1987; Bárceñas, Pérez Elortondo, & Albisu, 2000; Findlay, Castura, Schlich, & Lesschaeve, 2006; King, Hall, & Cliff, 2001; Kwan & Kowalski, 1980; Latreille et al., 2006; Rossi, 2001; Scaman & Dou, 2001), usually referred to numerical scores. However, references for training and checking panels and methods in specific food product evaluation are very scarce (Pérez Elortondo et al., 2007; Torre, 2002), so often internal procedures have to be developed in each laboratory.

Having defined the method to evaluate the sensory quality of Rioja Alavesa (RA) young red wines (Etaio et al., 2010), this work shows the approach and criteria followed for assessor selection, basic training, specific training, assessor qualification and method validation. It also presents the criteria for continuous monitoring of the panel and individual assessors, as well as quality controls carried out throughout the systematic evaluation of wine samples, once the method was accredited in February 2008 (http://www.enac.es).

The innovative approaches and criteria described could be very useful for other laboratories needing to implement sensory methods for the evaluation of specific foods, not only for PDO products, but also for other products with quality distinctiveness labels.

2. Materials and methods

2.1. Assessors

The number of assessors participating in each of the steps explained in this work varied due to three main reasons: (i) some minimum requirements had to be overcome in each step to pass onto the next one; (ii) some assessors left the panel during the...
Selection process was composed of 10 sensorial tests carried out in duplicate through four sessions. A minimum percentage of a 75% success rate of the tests was required to pass this phase. Candidates that did not achieve a 60% success rate would be rejected and candidates with a success rate of between 60% and 75% could retake the non-passed tests once more in order to reach the established 75%.

Nineteen candidates (70.4%) achieved the 75% of the tests, while the other eight candidates (29.6%) stayed between 60% and 75% of the tests. After repeating once non-passed tests all of them reached 75%. The percentage of each test passed in the first attempt is shown in Table 1.

Those who passed the selection phase attended basic training. The aim was to provide the potential assessors with some elementary tools used in sensory analyses and with a basic training on food evaluation. This phase was composed of 12 tests distributed through four sessions, as described by Pérez Elortondo et al. (2007).

Achieving satisfactorily a minimum percentage of 75% of the tests was required to overcome this phase. Candidates below this percentage could repeat the non-passed tests in order to reach this 75%, even more than once (always according to the laboratory necessities and considerations, once the results were analyzed).

The 27 candidates started the basic training tests, although three of them did not attend all the sessions for labor or sick leave reasons. Twenty-two candidates (91.7%) reached at the first attempt 75% of the tests and two candidates (8.3%) reached it after repeating some tests. Table 2 shows the percentage of each test passed in the first attempt.

### 3.2. Specific training and assessor qualification

Thirty-one assessors (20 from the described round of tests and 11 coming from a previous round) started the specific training in the methodology and criteria developed to evaluate the sensory quality of young red wines from RA (Etaio et al., 2010). Five assessors left the panel during the specific training for different reasons.

This training extended through 15 sessions (90–120 min each one). References of odour, aroma, taste and mouth-feel were presented throughout these sessions to the assessors. References were prepared in a base wine and are described in Etaio et al. (2010). The number of wines to evaluate in each session increased from one in the first session to nine wines as the training progressed. Initially, all the wines were tasted and commented in the group room. Progressively, some wines were tasted in booths to become the assessors familiar with evaluation procedure by using FIZZ software.

### Table 1

<table>
<thead>
<tr>
<th>Test</th>
<th>Reference</th>
<th>% of passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour vision test</td>
<td>Ishihara test</td>
<td>94.4</td>
</tr>
<tr>
<td>Taste identification test</td>
<td>ISO (1991)</td>
<td>33.3</td>
</tr>
<tr>
<td>Triangle test with sapid substances</td>
<td>ISO (2004a)</td>
<td>96.3</td>
</tr>
<tr>
<td>Duo-trio test with sapid substances</td>
<td>ISO (2004b)</td>
<td>88.9</td>
</tr>
<tr>
<td>Ranking test of colour</td>
<td>ISO (1988)</td>
<td>100.0</td>
</tr>
<tr>
<td>of odour</td>
<td></td>
<td>77.8</td>
</tr>
<tr>
<td>of taste</td>
<td></td>
<td>55.6</td>
</tr>
<tr>
<td>of texture</td>
<td></td>
<td>83.3</td>
</tr>
<tr>
<td>Description test of odour</td>
<td>ISO (1993)</td>
<td>64.8</td>
</tr>
<tr>
<td>of texture</td>
<td></td>
<td>96.3</td>
</tr>
</tbody>
</table>

*a* Each test was done twice by each assessor.

*b* Repetitions of non-passed tests by assessors not reaching the established 75% are not considered in this table.

---

3. Results and discussion

3.1. Assessor selection and basic training

Selection and basic training tests were carried out following a normalized technical procedure described in Pérez Elortondo et al. (2007).

The aim of the selection tests was to detect sensory inabilities in potential assessors, as well as to evaluate their sensory sensibility and capacity to describe their perceptions. Selection tests were attended by 27 candidates.

A preliminary meeting to present the objective and the schedule of the selection process and basic training was held, and each candidate filled in a questionnaire to collect information related to the suitability for sensory analysis (aptitude for foods, health, availability...).
After specific training, the ability of each assessor in reference identification and in wine evaluation was checked by qualification tests.

As no reports of specific tests for assessor qualification were found, tests were designed at the laboratory. They were distributed in three sessions. The first session dealt with identification of the references evaluated in the specific training. Twenty samples of odour attributes and defects, 20 samples of aroma attributes and defects and 10 samples of causes of taste and mouth-feel imbalance were presented to the assessors in the booths. Some repeated references and some base wine samples were also included in order to avoid identification by elimination. References were presented in 10-reference blocks separated by a brief rest to avoid sensory fatigue.

The objective of the second and third sessions was to study the repeatability, reproducibility and discrimination ability in scores, and also to study the attribute (including defects) identification in wines. In the second session eight samples coming from four different wines were evaluated (wines A and B in triplicate and wines C and D once). In the third session the same eight samples were evaluated (samples coming from the same batch were considered as being the same sample). Special attention was given to the selection of samples in order to assure previously that they were quite different regarding some parameters. Otherwise, the selection of very similar samples could lead to interpret that the panel is not discriminative.

Wine samples were evaluated in booths following the criteria and methodology developed for evaluation of young red wines from RA (Etaio et al., 2010).

Calculations and criteria to pass each test are described in Table 3.

Only the assessors who passed all the qualification tests would be included in the expert panel. The assessors who did not pass these tests could retake the non-passed tests up to two more times. If they still did not pass, they would continue training until retaking the qualification tests some months later.

Ten of the 26 assessors (38.5%) passed all the tests in the first round. Eight more assessors (cumulative percentage of 69.2%) passed all the tests after repeating the non-passed tests once, and two more assessors (cumulative percentage of 76.9%) achieved qualification after repeating some tests twice. The consequent panel to evaluate the product in a systematic way was composed of six women and 14 men, with an average age of 43.

Tests for reference identification showed to be the most difficult ones to be passed, since only 13 assessors (50%) passed them at the first attempt.

3.3. Method validation

The objective of the validation is to check the reliability of the method applied with a qualified panel. To this aim, six parameters were considered. The method would be validated when the obtained results for these parameters fulfilled the criteria described in Table 4.

The method validation process was carried out by 13 of the expert assessors. Seven expert assessors attended each session.

In the case of repeatability and reproducibility in scores, two previous sessions were held to determine the uncertainty levels and establish the acceptability limits, according to the previous experience with PDO Idiazabal cheese (Pérez Elortondo et al., 2007). In both sessions eight samples coming from four different wines (A, B, C and D; A and B in triplicate) were tested. Only the data of wines A and B were considered for determining the uncertainties. C and D wine samples were included so as to make it more difficult to notice that some samples were repeated. Standard deviations in repeatability (SDR) and in reproducibility (SDRr) were calculated by applying the formulas shown in Table 3. As there were two wines (A and B) and eight sensory parameters 16 SDR values and 16 SDRr values were obtained. The highest SDR value (0.30) and the highest SDRr (0.48) value correspond to balance and body of wine A. Considering these values the laboratory established the acceptability limits for repeatability and reproducibility shown in Table 4.

Regarding repeatability in attribute identification, reproducibility in attribute identification, reproducibility in discriminative ability in scores and reproducibility in discriminative ability in attribute identification, no literature references have been found, so the acceptability limits were established based on internal technical criteria.

After setting the acceptability limits two validation sessions with the same design explained before were run. When determining SDR and SDRr in validation sessions, all the values were inside the acceptability limits for both wines.

Regarding repeatability in attribute identification, attribute citations for wines A and B through the two validation sessions are shown in Table 5. Twenty-two attributes (including defects and imbalance causes) had a citation frequency (CF) higher than 50% in at least one of the three replications in a session. Except in four cases in session 2 (ripe fruit odour and aroma, and forest berry aroma in wine A, and smoky aroma in wine B) the citation differences among the replications of each attribute were lower than or equal to 2, that being 81.8% of the attributes (18 of 22). Thus, the established criterion was fulfilled.

Regarding reproducibility in attribute identification, 11 attributes had a CF higher than 50% in at least one of the two sessions, considering the wines separately (Table 5). The citation difference between the two sessions for each of these attributes was lower than 6, so criterion was fulfilled.

With regard to reproducibility in discrimination ability in scores, all the sensory parameters except odour intensity resulted discriminative between wine A and wine B in the first session. The same seven parameters resulted discriminative in the second session, so criterion was fulfilled.

Regarding reproducibility in discrimination ability in attribute identification, Table 6 shows the citations for attributes with a CF $\geq$ 50% in at least one of the sessions. Eight attributes resulted discriminative between wines A and B in the first session. In the second session six attributes were discriminative, five of them coincident with attributes that proved to be discriminative in the first session. Thus, 62.5% of the attributes resulting discriminative
in the first session were also discriminative in the second session, so criterion was fulfilled.

In addition to validate the method according to the cited six parameters, it was also established that each attribute appearing in the score form must be validated. As it was not possible to validate the 36 attributes during the described validation sessions, it was agreed to validate each attribute by studying the reproducibility in attribute identification by the panel. Thus, if the panel identified an attribute in a wine in a session (five or more of the seven expert assessors cited it, according to the criteria explained in Etio et al., 2010) and identified it again in the same wine but in another session, this attribute would be validated.

Based on the experience with young red wines from RA, it was known that some of the attributes (especially some defects) are not so frequent. However, it was agreed to maintain and validate them in order to assure that panel would be ready to identify them when appearing. In this sense, it was accepted to include manipulated samples in wine evaluation sessions to validate the less frequent attributes. These samples would be prepared as the references, with the same compound concentration but with real wine as matrix instead of base wine.

### 3.4. Continuous monitoring of the panel and assessors

Once the method was validated the expert panel started evaluating wines in a systematic way. The present paper considers the data from the first 121 wines evaluated throughout 20 sessions. Apart from the two samples evaluated for harmonization at the beginning of each session (not included among the cited 121 wines), a maximum of eight wines were evaluated by the seven assessors attending the session. Session development and data treatment are explained in Etio et al. (2010). Monitoring of each session was carried out in two ways:

#### 3.4.1. Panel monitoring

It was based on controlling the score dispersion within the panel. It was established that the standard deviation in scores for each sensory parameter in each wine should be lower than 1.
The number of cases that this requirement is not fulfilled (considered a deviation) must be lower than 15% of total cases (product of multiplying the number of samples by eight parameters), as proposed by Pérez Elortondo et al. (2007).

If panel deviation occurred the wines with a higher number of standard deviations equal to or higher than 1 were evaluated again in the next session, and the results checked again.

Regarding the results of panel monitoring, in eight sessions (40%) the standard deviations equal or higher than 1 exceed 15% in the next session, and the results checked again.

The two sessions are considered separately. There are considered only the attributes with a CF ≥ 50% (4 of 7 assessors citing it) in any of the three replications of wine A or B in a session.

The number of discriminative parameters in the second session must not be <50% or >150% of the discriminative parameters in the first session.

The sensory parameters discriminative between A and B wines are determined by the f-Student test.

The discriminative attributes in the second session must be ≥ 50% of the discriminative attributes in the first session and ≤ 150% of the number of discriminative attributes in the first session.

The discriminative attributes between A and B wines are determined considering the three replications of each wine in each session as a whole. An attribute is considered discriminative when its CF is ≥ 50% in one wine and <50% in the other wine.

### Table 4
Parameters studied in method validation and criteria to pass each test.

<table>
<thead>
<tr>
<th>Studied parameter</th>
<th>Criteria to pass the test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeatability in scores: ability to give the same or similar scores when the same wine is evaluated in replicate in the same session</td>
<td>Standard deviation in repeatability (SDR) must be &lt;0.5 (value established after carrying out the sessions to calculate the uncertainties)</td>
</tr>
<tr>
<td>Reproducibility in scores: ability to give the same or similar scores when the same wine is evaluated in replicate in different sessions</td>
<td>Standard deviation in reproducibility (SDR) must be &lt;0.8 (value established after carrying out the sessions to calculate the uncertainties)</td>
</tr>
<tr>
<td>Reproducibility in attribute identification: ability to identify the same attributes (including defects) when the same wine is evaluated in replicate in the same session</td>
<td>Citation difference among the replications of the same wine in the same session must be &lt;2 for at least 80% of the attributes with a citation frequency (CF) ≥ 50%</td>
</tr>
<tr>
<td>Reproducibility in attribute identification: ability to identify the same attributes (including defects) when the same wine is evaluated in replicate in different sessions</td>
<td>Citation difference for an attribute in the same wine between sessions 1 and 2 must be &lt;6 for at least 80% of the attributes with a CF ≥ 50%. Only the attributes with a CF ≥ 50% in at least one of the two sessions are considered (attributes cited at least 11 times in a wine, since the maximum citation times would be: 3 replications × 7 assessors = 21)</td>
</tr>
<tr>
<td>Reproducibility in discrimination ability in scores: ability to establish the same sensory parameters as discriminative between two wines in different sessions</td>
<td>The number of discriminative parameters in the second session must not be &lt;50% or &gt;150% of the discriminative parameters in the first session. The sensory parameters discriminative between A and B wines are determined by the t-Student test.</td>
</tr>
<tr>
<td>Reproducibility in discrimination ability in attribute identification: ability to establish the same attributes (including defects) as discriminative between two wines in different sessions</td>
<td>The discriminative attributes in the second session must be ≥ 50% of the discriminative attributes in the first session and ≤ 150% of the number of discriminative attributes in the first session. The discriminative attributes between A and B wines are determined considering the three replications of each wine in each session as a whole. An attribute is considered discriminative when its CF is ≥ 50% in one wine and &lt;50% in the other wine.</td>
</tr>
</tbody>
</table>

### Table 5
Attribute citation results for validation in repeatability and reproducibility in attribute identification.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Citations in session 1</th>
<th>Citations in session 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odour complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ripe fruit</td>
<td>6 6 7</td>
<td>19 7 5 3</td>
<td>15</td>
</tr>
<tr>
<td>Licorice</td>
<td>4 3 5</td>
<td>12 3 4 2</td>
<td>9</td>
</tr>
<tr>
<td>Forest berry</td>
<td>4 4 4</td>
<td>12 6 2 1</td>
<td>9</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>4 4 5</td>
<td>12 3 2 2</td>
<td>7</td>
</tr>
<tr>
<td>Aroma complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ripe fruit</td>
<td>6 6 6</td>
<td>18 7 5 4</td>
<td>16</td>
</tr>
<tr>
<td>Licorice</td>
<td>5 4 5</td>
<td>14 4 4 3</td>
<td>11</td>
</tr>
<tr>
<td>Forest berry</td>
<td>3 3 5</td>
<td>11 4 3 3</td>
<td>10</td>
</tr>
<tr>
<td>Balance and body</td>
<td>- -</td>
<td>- -</td>
<td>-</td>
</tr>
<tr>
<td>Global aroma persistence</td>
<td>- -</td>
<td>- -</td>
<td>-</td>
</tr>
<tr>
<td>Acidity excess</td>
<td>2 3 3</td>
<td>8</td>
<td>2 4 2 8</td>
</tr>
</tbody>
</table>

* Only attributes with a citation frequency ≥ 50% in at least one of the repetitions (four or more citations) are included.

### 3.4.2. Individual monitoring of expert assessors

It was based on studying the deviations in scores and deviations in attribute citation. It was established that the score provided by each assessor to each parameter of each sample should be in the range defined by the panel mean rounded to the closest entire range defined by the panel mean rounded to the closest entire number ±1. The number of cases in which this requirement is not fulfilled must be less than 15% of the total cases (number of samples × 8 parameters) for each assessor.

With regard to the results, the requirement was not fulfilled in six cases (4.3% of the total possible cases: 20 sessions × 7 assessors). As occurred with panel, odour complexity, aroma complexity, balance and body, and global aroma persistence were the most problematic parameters (7.4%, 6.5%, 5.9% and 5.8% of individual deviations, respectively; deviations calculated over 121 wines × 7 assessors). Colour intensity (1.5%), colour hue (2.2%), odour intensity (3.1%) and aroma intensity (3.8%) were the parameters with the least number of individual deviations.
For the attribute citation, it was established that each assessor should indicate at least 50% of the attributes considered present in the samples by the panel (noted by five or more assessors). Besides, with the aim of avoiding assessors citing a lot of attributes to fulfill this requirement, it was established that the number of attributes cited only by one assessor should not be higher than 3 multiplied by the number of samples evaluated in the session.

There were three cases where an assessor did not identify 50% of the attributes cited by the panel in a session. There were no cases of an assessor citing an excessive number of attributes. When performance requirements were not fulfilled by the panel or by individual assessors, interviews with the assessors involved were held to discuss the harmonization of their results with the results of the panel. An assessor would be removed from the panel when his/her performance was very bad and/or frequently did not fulfill the requirements. This assessor would continue evaluating the wines and her/his scores would be compared to panel scores, although without considering them. If through two consecutive sessions this assessor fulfilled all the criteria, she/he would be reincorporated to the panel.

In each session, an informative report about personal performance in the previous session was provided to each assessor. This report collects data from the panel (mean scores and attribute citation) and from each assessor (scores, attribute citation and deviations).

When an assessor did not attend any evaluation or training sessions through five consecutive weeks, she/he would be removed temporarily from the panel. To be included again the assessor had to follow the same procedure as an assessor removed because of poor performance. When sessions are not held for two months, training in reference identification and in wine evaluation are carried out with the panel before starting evaluation assays.

3.5. Quality control of the method

As established in the technical procedures of the laboratory a quality control has to be performed each 150 samples at least. Tests to perform and criteria to pass each one were the same as those used for method validation. If requirements were not fulfilled a training session would be held with the panel and quality control test would be carried out again. If requirements were still not fulfilled, wine evaluation assays would be stopped, clients would be informed and measures would be taken.

Quality control also considered attribute citation to check the reproducibility in attribute identification by the panel. Each attribute identified by the panel must be submitted to one quality control at least once a year. For this control, a sample with an identified attribute was presented to the panel in another session. If the panel identified this attribute again it would be considered as passing quality control. If it was not identified, the presence or absence of this attribute in the sample would be discussed and agreed on.

3.6. Assessor re-qualification

Expert assessors have to repeat and pass re-qualification tests at least once a year to demonstrate that they are still capable of evaluating the samples satisfactorily. As tests and criteria for re-qualification are the same as those for qualification, both qualification for new assessors and re-qualification for expert assessors can be performed at the same time. If an expert assessor does not pass one or more of the tests she/he will repeat the non-passed tests up to two times. If tests are not passed, this assessor will be removed from the panel.

Re-qualification tests, in addition to providing information about assessor suitability, helped to keep the assessors alert, avoiding relaxation and undervaluation of training.

4. Conclusions

The procedures described in this paper (assessor selection, training and qualification, method validation, continuous monitoring of individual and panel performance, periodical quality controls) have proved to be valid for the required purposes.

Many of these procedures are innovative and may be very helpful tools for other laboratories dealing with sensory quality control of specific products. This experience can be even more valuable if the accreditation of the method is the objective. Depending on the quality control requirement needed, the sophistication of the procedures and tests can also be increased or decreased.

Availability of the potential assessors has to be considered as one of the most important factors for a candidate to start the procedure to join an expert panel. The training process and the checking steps demand very regular assistance. It has to be expressly considered when planning qualification tests, in order to foresee additional sessions not only for assessors not reaching the requirements at the first attempt but also for assessors missing some sessions.

---

**Table 6**

Attribute citation results for validation in reproducibility in discrimination ability in attribute identification.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Citations in wine A</td>
<td>Citations in wine B</td>
</tr>
<tr>
<td>Ripe fruit</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>Un-ripe fruit</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Licorice</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Forest berries</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>

**Discriminative?**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Citations in wine A</td>
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<tr>
<td>Ripe fruit</td>
<td>18</td>
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<tr>
<td>Un-ripe fruit</td>
<td>3</td>
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</tr>
<tr>
<td>Licorice</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Forest berries</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

**Number of discriminative attributes**

8

---

4 Only attributes with a citation frequency ≥ 50% in at least one of the sessions (11 or more citations) are included.
Regular assistance to training sessions and to evaluation assays is necessary to get progressively the assessor more fitted in the panel, especially when typicity and/or features regarding some complex concepts are considered in the method.

Acknowledgements

The authors thank the wine experts, the qualified assessors and ABRA (Asociación de Bodegas de Rioja Alavesa) for their collaboration, and Eusko Jaurlaritza–Gobierno Vasco for funding this project.

References


