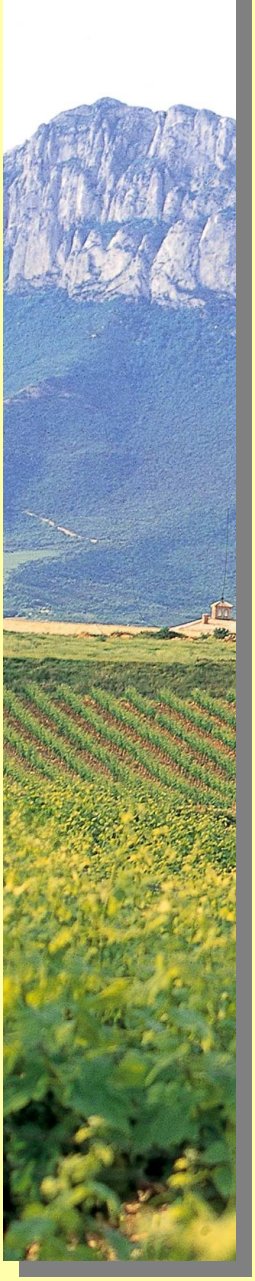
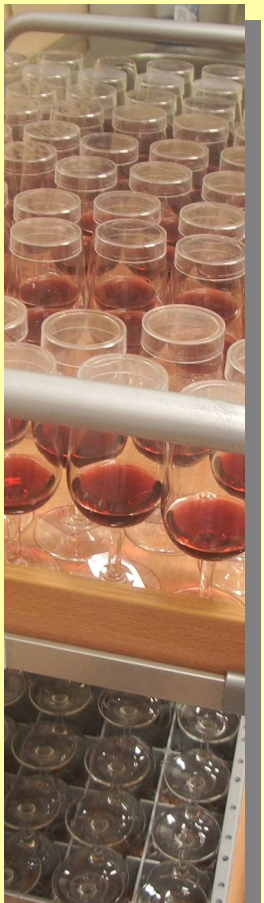


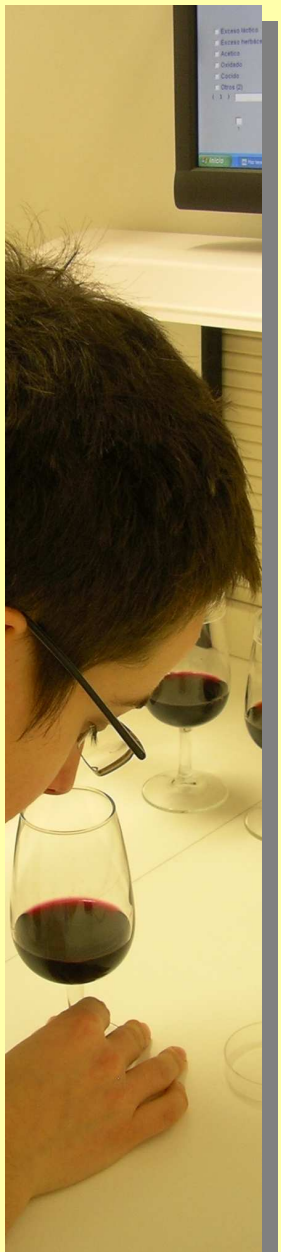
DOKTOREGO-TESIA - TESIS DOCTORAL

Análisis sensorial del vino tinto joven de Rioja Alavesa: descripción y evaluación de la calidad

Iñaki Etaio Alonso

Vitoria-Gasteiz, 2009





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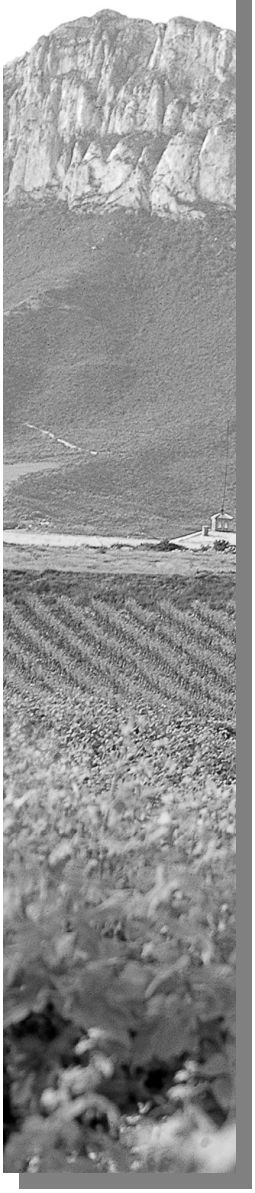

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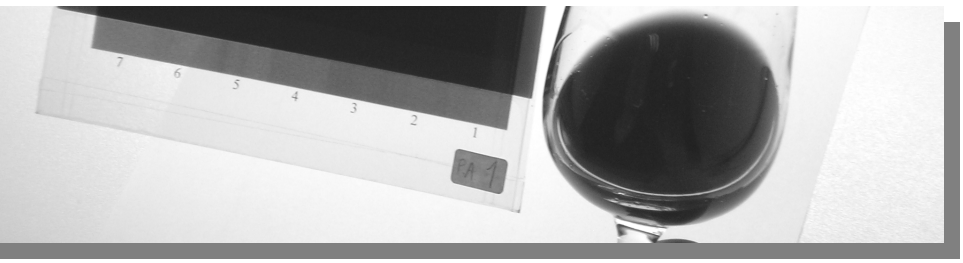

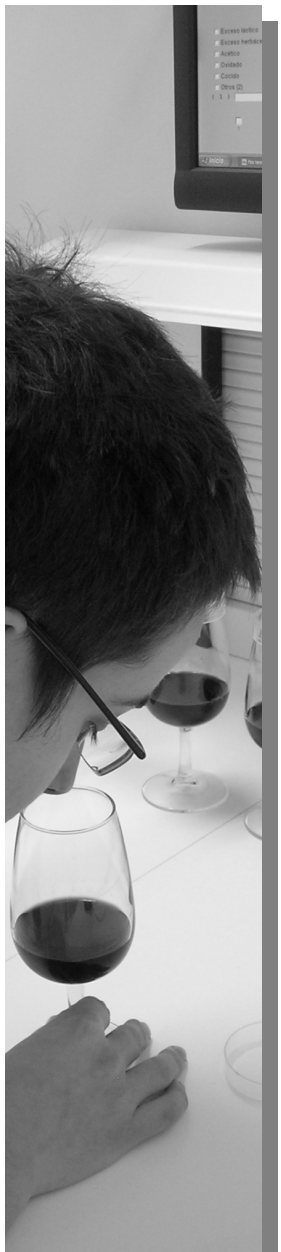

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AUTORIZACION DEL/LA DIRECTOR/A DE TESIS

PARA SU PRESENTACION

El **Dr. Francisco José Pérez Elortondo** y la **Dra. Marta Albisu Aguado** como Directores de la Tesis Doctoral:

Análisis sensorial del vino tinto joven de Rioja Alavesa: descripción y evaluación de la calidad

realizada en el Departamento **Farmazia eta Elikagaien Zientziak - Farmacia y Ciencias de los Alimentos** por el Doctorando **Iñaki Etaio Alonso**, autorizamos la presentación de la citada Tesis Doctoral, dado que reúne las condiciones necesarias para su defensa.

En Vitoria-Gasteiz a 25 de junio de 2009

El DIRECTOR DE LA TESIS LA DIRECTORA DE LA TESIS

Fdo.: Dr. Francisco José Pérez Elortondo Fdo.: Dra. Marta Albisu Aguado

Universidad del País Vasco Euskal Herriko Unibertsitatea

CONFORMIDAD DEL DEPARTAMENTO

El Consejo del Departamento de **Farmazia eta Elikagaien Zientziak – Farmacia y Ciencias de los Alimentos** en reunión celebrada el día 26 de junio de 2008 ha acordado dar la conformidad a la admisión a trámite de presentación de la Tesis Doctoral titulada:

Análisis sensorial del vino tinto joven de Rioja Alavesa: descripción y evaluación de la calidad

dirigida por el **Dr. Francisco José Pérez Elortondo** y la **Dra. Marta Albisu Aguado** y presentada por **Iñaki Etaio Alonso** ante este Departamento.

En Vitoria-Gasteiz a 26 de junio de 2009

Vº Bº DIRECTOR DEL DEPARTAMENTO SECRETARIA DEL DEPARTAMENTO

Fdo.: Dr. Jesús Salmerón Egea Fdo.: Rosa María Hernández Martín

Universidad del País Vasco Euskal Herriko Unibertsitatea

ACTA DE GRADO DE DOCTOR

ACTA DE DEFENSA DE TESIS DOCTORAL

DOCTORANDO: **Iñaki Etaio Alonso**

TITULO DE LA TESIS: **Análisis sensorial del vino tinto joven de Rioja Alavesa: descripción y evaluación de la calidad**

El Tribunal designado por la Subcomisión de Doctorado de la UPV/EHU para calificar la Tesis Doctoral arriba indicada y reunido en el día de la fecha, una vez efectuada la defensa por el doctorando y contestadas las objeciones y/o sugerencias que se le han formulado, ha otorgado por_____la calificación de:

unanimidad ó mayoría

En Vitoria-Gasteiz, a de de 2009

EL/LA PRESIDENTE/A, EL/LA SECRETARIO/A,

Fdo.: Fdo.:

Dr/a: _____ Dr/a: _____

VOCAL 1º, VOCAL 2º, VOCAL 3º,

Fdo.: Fdo.: Fdo.:

Dr/a: _____ Dr/a:_____ Dr/a:_____

EL DOCTORANDO,

Fdo.: Iñaki Etaio Alonso

Esker onak / Agradecimientos

Quiero agradecer a Patxi y Marta los consejos y dirección durante estos años, así como su dedicación en la corrección de esta tesis.

Je veux remercie Pascal Schlich son aide à propos des traitements statistiques des données sensorielles.

Goraipatu behar da ere paneleko kideen “dastaketa tresna” lan ixil hori, bai panel analitikoarena baita kalitate panelarena ere. Sesioak aurrera doazen heinean ez da erraza hasierako motibazioa mantentzea, baina gehienak proiektua bukatu arte (eta askoren kasuan gaur arte ere) han mantendu dira. Lan talde hori gabe ez zen posible izango lan hau gauzatu izana.

También quiero dar las gracias a todos/as los/as expertos/as que han participado en los trabajos desarrollados durante estos años. Gracias a sus orientaciones y al interés mostrado en los proyectos hemos ido definiendo poco a poco el camino.

Es necesario agradecer la colaboración brindada por ABRA para poner en marcha los proyectos descritos en esta tesis. Desde aquí también agradecer a las bodegas que aparecen citadas en los artículos su participación en el proyecto analítico y la paciencia demostrada para seguir las indicaciones dadas. Quiero agradecer especialmente la ayuda prestada por Alberto Majuelo para el sulfitado, embotellado y disposición en cajas de los vinos, y por la bodega García de Olano para el mantenimiento de las botellas en bodega.

Es necesario mencionar la financiación recibida a través de una beca FPU (Formación de Profesorado Universitario) del Ministerio de Educación, así como desde el Departamento de Agricultura y Pesca del Gobierno Vasco – Eusko Jaurlaritza mediante la Convocatoria de ayudas de I+D.

De igual forma, quiero agradecer a la Casa del vino – Ardo Etxea, y en especial a José Baigorri, la colaboración prestada para llevar a cabo el análisis físico-químico de los vinos.

Proiektu analitikoaren fase experimentala bukatu arte gurekin egon zen eta hain lagungarria izan zen Fizz-aren erreginari, Edurneri, jarritako ilusioa eta lana eskertu behar zaio. Tesi honen zatitxo bat berarena da ere.

Urte hauetan hainbeste ordu elkarrekin pasatu dugun laborategiko kide guztiak aipatu behar ere, nahiz ta urtez urte parrandarako gaitasuna serioski galdu…

Kuadrilako Manuk, doktoretza ateratzeko abantaila dexente atera didanak, urte hauetan tesian jarritako interesa eta emandako aholkuak eskertzen ditut ere. Trabatze sentsazioa konpartitzeak ez du ezer konpontzen, baina behintzat konpartitzea ona da.

Eta bukatzeko, ikerketa sofistikatuetan ez dabilen baina urte hauetan apaltasunez bazkari taperrak hornitzen ibili den amari eskerrik beroenak eman behar dizkiot. Lanean eta tesian jarritako interesa eskertzekoa da benetan. Zentzu batean tesia berarena da ere.

Mila esker guztioi eta aurrera! Norbaitek esan zuenez “ardoa dagoen bitartean itxaropena dago!”

Ezina ekinez egina

Herrikoia

No hay empresas imposibles, sino mujeres y hombres incapaces

José Martí

ÍNDICE

LABURPENA / RESUMEN / SUMMARY

LABURPENA

Errioxako ardoak oso ezagunak dira munduan zehar beraien kalitateagatik eta ezaugarri bereziengatik. Hala ere, orain arte ez da panel entrenatuen bidez egindako ikerketa sentsorial deskribatzailerik argitaratu. Ez dago beraz ardo hauen deskribapen sentsorial zientifikorik.

Errioxa Jatorrizko Deitura Kalifikatuak (DOC Rioja) babesten duen eremua hiru zonaldek osatzen dute, horietako bat Arabako Errioxa delarik. Azken zonalde honetako ardorik ohikoena ardo beltz gaztea da. Ardo honek ezaugarri bereizgarri batzuk dauzka, faktore ezberdin batzuen eraginagatik: klima mediterraneoaren eta atlantikoaren eraginpeko klimatologia, lurzoru buztin-karedunak, mahasti askoren hegoaldera begirako kokapena, Tempranillo mahats-barietatearen nagusitasuna eta hainbat familia-upategi txikiren iraupena. Upategi hauetako askok ardoa beratze karbonikoaren bidez egiten jarraitzen dute, Arabako Errioxan tradizionalki erabili den metodoa, hain zuzen ere. Ardoa egiteko erabiltzen den beste metodoa txortena kentzea edo aletzea da, zeinak azken hamarkadetan beratze karbonikoa ordezkatu duen neurri handi batean.

Tesi honek zonalde honetako ardo beltz gazteak ikertzen ditu, bi ildo ezberdinetatik: deskribapen sentsoriala eta kalitate sentsorialaren ebaluazioa.

Lehenengo ikerketa ildoari dagokionez, hiru helburu nagusi definitu ziren. Lehenengo helburua ardoak deskribatzeko eta ardoen artean ezberdintzeko balio duten deskriptoreak zehaztea izan zen. Bigarren helburua, ardoa egiteko metodoak (beratze karbonikoa / txortena kentzea) eta mahats-barietate zuriaren proportzio txikiak gehitzeak ardoaren zentzumen ezaugarrietan duten eragina ikertzea izan zen. Hirugarren helburua ardoaren lehenengo hilabeteetako zentzumen bilakaera ikertzea izan zen.

Ikerketa gauzatzeko, aipatutako faktoreen arabera aukeraturiko 12 upategi ezberdinetako 19 ardo erabili ziren. Hartzidura malolaktikoa amaitu

ostean, ardoak ontzietatik jaso ziren, upategi bakoitzean erabilitako praktika enologikoek ardoen zentzumen ezaugarrietan izan zitzaketen efektuak ekiditeko. Bederatzi hilabetetan zehar ardoak lau garaitan ebaluatu ziren, eta garai bakoitzean ardo bakoitza hiru aldiz dastatua izan zen. Orotara, 40 sesio egin ziren ikerketako ardoak ebaluatzeko. Entrenatutako hamalau dastatzailek osaturiko panel batek ebaluatu zituen ardoak.

Sesio hauek garatu baino lehen, panelak beste 33 sesiotan hartu zuen parte. Sesio hauetan erabili beharreko deskriptoreak aukeratu eta metodoaren gainontzeko aspektuak definitu ziren (ebaluazio prozedura, eskalak, zentzumen erreferentziak…). Sesio hauetan, halaber, panela metodoa jarraituz ardoak ebaluatzeko entrenatua izan zen.

Ikerketako ardoen datuen analisia bariantzaren analisiaren (ANOVA) bidez egin zen. Erabilitako modelu estatistikoak kasuan kasuko helburuaren araberakoak izan ziren.

Kongresutan aurkeztutako komunikazio zientifikoetaz gain, lan deskribatzaile honen emaitzak hiru artikuluetan argitaratuak izan dira, tesi honen “Results and discussion” atalean sartuta daudenak.

Ikerketaren bigarren ildoari dagokionez, ardoen kalitate organoleptikoa ebaluatzeko metodo arautu eta akreditatuen gabezia nabaria da. Produktuak ziurtatzeko erabilgarriak izan daitezkeen metodoak izatea gero eta beharrezkoagoa da, batez ere kalitate handiko produktuetarako (babestutako jatorri-deitura daukaten produktuak, esaterako).

Ikerketaren bigarren ildo honen helburu nagusia Arabako Errioxako ardoen kalitate organoleptikoa ebaluatzeko metodo espezifiko bat garatzea izan zen, ardo hauen ohiko ezaugarriak kontuan hartuta. Metodoa garatu ostean dastatzaile aditu entrenatuen panel bat sortu eta honek ardoen kalitate organoleptikoa era sistematikoan ebaluatuko luke.

Metodoa 15 eztabaida sesiotan zehar garatu zen, Arabako Errioxako ardoen inguruan ezagutza handia zuten 12 adituren parte-hartzearekin (enologoak, upeltegi-jabeak eta gastronomoak). Metodoa ondoko faseen bidez garatu zen: terminoen sorketa, kalitate organoleptikoa definitzen duten parametroen zehaztapena, ebaluazio-eskalaren aukeraketa, parametro bakoitzaren egoera hobezinaren eta kalitate mailaketaren definizioa, ebaluazioa metodologia eta puntuazioak emateko kriterioen definizioa, dastaketa fitxaren garapena, kalitate orokorrean parametro bakoitzak duen kontribuzioaren ezarpena, eta zentzumen-erreferentzien garapena.

Metodoa garatu ondoren, ardoen kalitatea ebaluatuko zuen panela sortzeko prozesua hasi zen. Aukeraketa eta oinarrizko entrenamendua gainditu zituzten hautagaiak metodoa erabiltzeko entrenatuak izan ziren. Entrenamendu espezifikoaren ostean, kualifikazio probak gainditu zituzten dastatzaileek aditu entrenatuen panela osatu zuten. Segidan, metodoa baliozkotua izan zen parametro batzuen ikerketaren bidez (errepikagarritasuna, erreproduzigarritasuna, gaitasun diskriminatzailea…), eta laginak era sistematikoan ebaluatzen hasi zen. Dastatzaile bakoitzaren eta panelaren jardueraren kontrola eta kalitate kontrolak ere ezarri ziren, beharrezkoak baitira.

2008ko otsailean ENAC-ek (Entidad Nacional de Acreditación) akreditatu zuen garatutako metodoa.

Kongresu batzuetan aurkeztutako komunikazioez gain, metodoa liburu formatuan argitaratua izan da (tesi honen CD-bertsioan erantsia). Halaber, tesi hau idatzi den garairako aldizkari zientifiko batean azterketapean dauden bi artikulu ere idatzi dira. Artikulu hauek tesi honen “Results and discussion” atalean daude.

Tesi honetan aurkeztutako emaitzek eta prozedurek informazio interesgarria eta erabilgarria eskaintzen diete, bai upeltegiei, bai produktuak egiaztatzeko lanean diharduten erakundeei eta baita zentzumen-ebaluaziorako metodoak garatu behar dituzten laborategiei ere.

RESUMEN

Los vinos de Rioja son mundialmente conocidos por su calidad y características particulares. Sin embargo, hasta el momento no se han publicado estudios sensoriales descriptivos utilizando paneles entrenados, por lo que no existe una descripción sensorial científica de estos vinos.

Rioja Alavesa (RA) es una de las tres zonas que componen la región amparada por la Denominación de Origen Calificada Rioja (DOC Rioja). El vino tinto joven es el más típico de esta zona y presenta algunas características particulares debidas a varios factores: una climatología con influencia atlántica y mediterránea, unos suelos arcilloso-calcáreos, muchos viñedos orientados hacia el sur, la preponderancia de la variedad de uva Tempranillo y la pervivencia de numerosas bodegas familiares pequeñas. Muchas de ellas continúan elaborando vino mediante maceración carbónica, el método tradicionalmente usado en RA. El otro proceso de vinificación utilizado es el despalillado, el cual ha desplazado parcialmente a la maceración carbónica en las últimas décadas.

Esta tesis se centra en los vinos tintos jóvenes de dicha zona a través de dos líneas de investigación: descripción y evaluación de la calidad sensorial.

En relación a la **primera línea de investigación** se establecieron tres objetivos principales. El primero fue determinar qué descriptores definen los vinos y cuáles diferencian los vinos entre sí. El segundo objetivo fue estudiar el efecto que el proceso de elaboración (maceración carbónica / despalillado) y la adición de pequeñas proporciones de uva blanca tiene sobre las características organolépticas de los vinos. El tercer objetivo fue estudiar la evolución organoléptica de los vinos durante los primeros meses en botella.

El estudio se desarrolló utilizando 19 vinos procedentes de 12 bodegas, las cuales fueron seleccionadas en base a los factores en estudio. Una vez que la fermentación maloláctica había concluido, los vinos fueron recogidos

directamente de los depósitos con la finalidad de evitar la aplicación de diferentes prácticas enológicas en bodega que pudieran afectar a sus características organolépticas. El análisis se realizó por triplicado, en cuatro ocasiones a lo largo de nueve meses. El número total de sesiones fue de 40. La evaluación fue llevada a cabo por un panel formado por 14 jueces entrenados.

Previamente al análisis de los vinos objeto de estudio, el panel participó en 33 sesiones para seleccionar los descriptores a evaluar y definir todos los aspectos relacionados con el desarrollo del método (metodología, escalas, referencias sensoriales…). A lo largo de estas sesiones, el panel fue entrenado en base al método para analizar los vinos.

Los datos de los 19 vinos a estudio fueron tratados mediante análisis de la varianza (ANOVA). Los modelos estadísticos utilizados dependieron del objetivo buscado en cada caso.

Además de varias comunicaciones presentadas en diversos congresos, los resultados de este trabajo descriptivo han sido publicados en tres artículos, incluidos en la sección “Results and discussion” de esta tesis.

La **segunda línea de investigación** responde a la evidente falta de métodos normalizados y acreditados para evaluar la calidad sensorial de los vinos. La necesidad de disponer de métodos sensoriales que puedan ser utilizados para la certificación de producto es cada vez más apremiante, especialmente en el caso de productos de alta calidad (por ejemplo productos con Denominación de Origen Protegida).

El objetivo principal de esta segunda línea fue desarrollar un método específico para evaluar la calidad sensorial de los vinos tintos jóvenes de RA, considerando sus características típicas. Un segundo objetivo, asociado al anterior, fue formar un panel de jueces expertos entrenados para analizar los vinos de forma sistemática.

El método fue desarrollado a lo largo de 15 sesiones de discusión con un grupo de 12 expertos con un profundo conocimiento de los vinos de RA (enólogos, bodegueros y restauradores). Para su desarrollo se llevaron a cabo diversas fases: generación de términos, definición de los parámetros determinantes de la calidad sensorial, definición de la escala de evaluación, definición de la situación óptima y de la categorización de calidades para cada parámetro, definición de la metodología de evaluación y de los criterios de puntuación, desarrollo de la ficha de cata, establecimiento de la contribución de cada parámetro a la calidad global, y desarrollo de referencias sensoriales.

Una vez que el método estuvo establecido, se dio comienzo a la formación de un panel. Las/los candidatas/os que superaron la fase de selección y entrenamiento básico fueron entrenadas/os para aplicar el método. Después de este entrenamiento específico, los jueces que superaron las pruebas de cualificación integraron el panel de expertos entrenados. A continuación, el método fue validado en base al estudio de diversos parámetros (repetibilidad, reproducibilidad, capacidad discriminante…) y se dio inicio a la evaluación de muestras de forma sistemática. El control de la actuación de los jueces y del panel así como los controles de calidad son operaciones necesarias que también fueron implementadas.

El método desarrollado fue acreditado en Febrero de 2008 por la ENAC (Entidad Nacional de Acreditación).

Además de varias comunicaciones en diversos congresos, el método ha sido publicado en forma de libro, el cual se incluye en la versión en CD de la tesis. Asimismo, se han elaborado dos artículos que, a fecha de redacción de esta tesis, se encuentran en fase de revisión en una revista científica. Dichos artículos se incluyen en la sección “Results and discussion”.

Los resultados y los procedimientos descritos en esta tesis proporcionan información interesante y útil a las bodegas, a las entidades que trabajan en la certificación de productos y a los laboratorios que deban desarrollar métodos de evaluación sensorial.

SUMMARY

Rioja wines are famous worldwide because of their quality and particular characteristics. However, sensory descriptive studies made with trained panels have not been published, so there is not a scientific sensory description of these wines.

Rioja Alavesa (RA) is one of the three areas that constitute the region protected by DOC Rioja (Qualified Designation of Origin Rioja). Young red wine is the most typical one from RA and it presents some particular characteristics due to several different factors: climatology with Mediterranean and Atlantic influence, chalky-clayey soils, many of the vineyards oriented to the South, Tempranillo being the predominant grape variety and the existence of a lot of small family-run wineries. Many of them still make wine by carbonic maceration, the traditional method in RA. The other method used is destemming, which has partially displaced winemaking by carbonic maceration over the last decades.

This thesis is focused on young red wines from this area but in two different research lines: sensory description and sensory quality assessment.

Regarding the **first research line**, three main objectives were established for the study. The first one was to find the attributes that describe the wines and that differentiate among them. The second one was to study the influence of the winemaking process (carbonic maceration / destemming) and the addition of small proportions of white grapes on the sensory characteristics of the wines. And the third one was to study the sensory evolution of the wines throughout the first months in bottle.

The study was developed using 19 wines from 12 wineries of RA, which were selected on the basis of the factors under study. Once malolactic fermentation was over, wines were picked up directly from the vats in order to avoid different internal practices that could affect their sensory characteristics. Wines were evaluated in triplicate at four times throughtout nine months. The

total number of sessions was 40. Wines were evaluated by a trained panel of 14 members.

Prior to the evaluation of the wines under study, the panel took part in 33 sessions to select the attributes to be evaluated and to define all the aspects related to the method development (methodology, scales, sensory references…). Through these sessions, the panel was also trained in wine analysis according to the method.

Data from the wines of the study were analyzed by Analysis of variance (ANOVA). The statistical models used varied depending on the cited objectives.

In addition to some communications presented at several conferences, the results of this descriptive work have been published in three articles, which are included in “Results and discussion” section of this thesis.

The **second research line** is related to the evident lack of normalized and accredited methods to evaluate the sensory quality of wines. There is a pressing need for available sensory methods to be used as tools for product certification, especially for high quality products (i.e. products with Protected Designation of Origin).

The main objective of this second line was to develop a specific method to evaluate the sensory quality of young red wines from RA, considering their typical characteristics. After developing the method a trained expert panel would be created to evaluate the wines in a systematic way.

The method was developed through 15 sessions with a discussion group constituted by 12 experts with a great knowledge in RA wines (enologists, winemakers and restaurateurs). Several steps were carried out: term generation, definition of the parameters determining the sensory quality of the product, definition of the scoring scale, definition of the “top situation” and quality grading of each parameter, definition of the tasting methodology and the

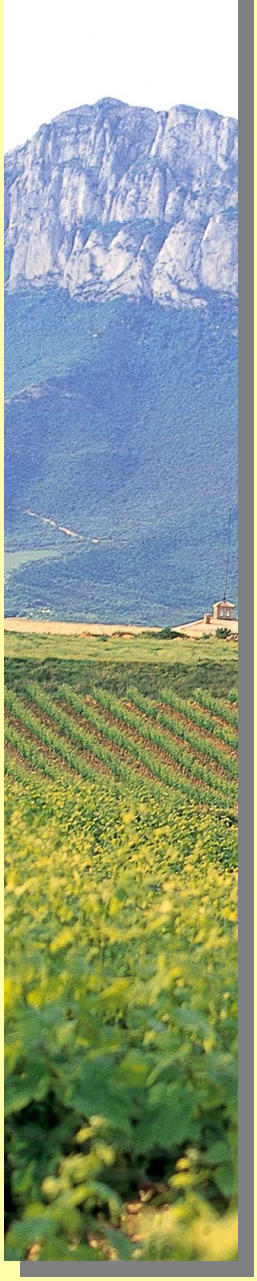
scoring criteria, score card development, definition of the contribution of each parameter to the overall quality, and sensory reference development.

Once the method was defined, the process to create a panel was carried out. The candidates who successfully passed the selection and basic training phases were then trained to apply the method. After the specific training, the judges who passed the qualification tests constituted the trained expert panel. Next, the method was validated by studying several parameters (repeatability, reproducibility, discrimination ability…) and the systematic evaluation of the samples started. Checking of judge and panel performance and quality controls are necessary operations that were also considered.

The method developed for RA young red wines was accredited in February 2008 by an official body (ENAC, Entidad Nacional de Acreditación).

Besides some communications to several conferences, a guide book explaining the method has been published and two articles are under review in a scientific journal. These three works are included in this thesis (the book only in the CD version).

The results and the procedures described in this thesis provide interesting and useful information to winemakers, institutions working in product certification and laboratories dealing with sensory method development.



1- INTRODUCCIÓN

1.1- El vino tinto joven de Rioja Alavesa

1.1.1- Rioja Alavesa y sus vinos

El espacio geográfico de elaboración de vino amparado bajo la Denominación de Origen Calificada Rioja está conformado por tres áreas: Rioja Alavesa (RA), Rioja Alta y Rioja Baja. RA se encuentra situada al sur del Territorio Histórico de Araba-Álava.

La actividad vitivinícola en esta zona tiene siglos de historia. Tras su introducción por parte de los romanos y su posterior abandono durante varios siglos, la viticultura adquirió una mayor relevancia en la

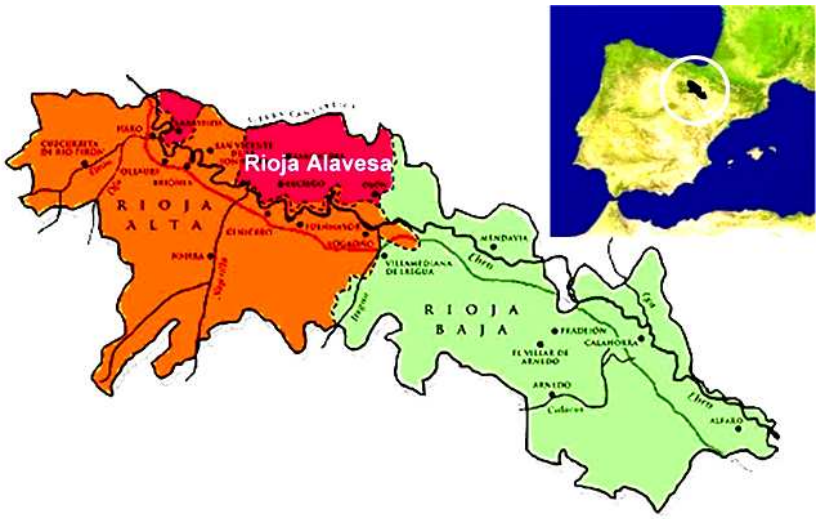


Figura 1.1.1- Mapa de la zona amparada por la DOC Rioja.

Alta Edad Media, cuando la actual RA formaba parte del Reino de Pamplona bajo la denominación de Sonsierra (Larreina y Larreina, 2006). Los fenómenos de superpoblación ligados a la industrialización de determinadas comarcas vascas contribuyeron de manera notable al desarrollo del sector vinícola durante los siglos XIX y XX.

La actividad vitivinícola sigue siendo con diferencia la principal actividad económica de esta zona, constituyendo además el principal sector agrario de la provincia (Larreina y Larreina, 2006), donde en 2007 suponía el 19,6% de superficie agrícola cultivada (Informe de la Cámara de Comercio de Álava: www.camaradealava.com/ecal2008/ecal3.pdf). Según los datos obtenidos de "Estadística industrial" (documento elaborado por el Eustat y el Servicio de Estadística del Departamento de Agricultura, Pesca y Alimentación del Gobierno Vasco – Eusko Jaurlaritza) la producción vinícola de RA supuso en 2006 en torno al 2,68% del PIB en Araba y al 0,45% en la Comunidad Autónoma del País Vasco. Se estima que en los últimos años unos 5.000 puestos de trabajo en RA están directamente ligados al sector del vino, sin incluir temporeros ni propietarios de viñedos con otra actividad económica principal (Larreina y Larreina, 2006).

El volumen de elaboración de vino de RA amparado en la DOC Rioja en la cosecha de 2008 fue de 65.262.993 litros para vinos tintos, 3.094.206 litros para blancos y 2.027.336 litros para rosados (Consejo Regulador DOC Rioja: www.riojawine.com/es/pdfs/ESTADISTICAS_RIOJA_2008.pdf).

La conjunción de diversos factores ha propiciado que los vinos de RA, y especialmente los tintos jóvenes, hayan presentado tradicionalmente una identidad propia y que sean reconocidos por su alta calidad. Entre dichos factores destacan los siguientes:

- Clima: se caracteriza por la confluencia de los climas mediterráneo y atlántico. Precisamente, este último es el que provoca que la humedad en RA (así como en gran parte de Rioja Alta) sea, en términos generales, ligeramente más elevada que en las zonas de la DOC Rioja

situadas más al sureste. La temperatura media anual en RA oscila entre 12,6º y 13,2º y la pluviometría entre 400 y 650 L/m^2 y año (Larreina y Larreina, 2006).

- Orografía: en relación al punto anterior, la cadena montañosa Sierra Toloño – Sierra Cantabria que se extiende en dirección oeste-este protege en gran medida a esta zona del clima atlántico, evitando que su influencia (más frío y mayor pluviometría) sea excesiva (Larreina y Larreina, 2006). Además de ello, su ubicación entre las laderas de dicha cadena montañosa al norte y el río Ebro al sur propicia que dicha zona esté ligeramente inclinada hacia el sur (desde aproximadamente 650 m sobre el nivel del mar hasta unos 400 m). Dicha inclinación conlleva que gran parte de los viñedos estén orientados hacia el sur, con lo que la insolación es mayor y la maduración de la uva se ve favorecida (González, 1993).

- Composición de los suelos: aproximadamente el 95% de los suelos son de naturaleza arcilloso-calcárea (el 5% restante son suelos aluviales y arcilloso-ferrosos), lo cual tiene un efecto beneficioso en la regulación de la hidratación de la vid y, consecuentemente, de la uva. Los suelos arcilloso-calcáreos han sido relacionados tradicionalmente con uvas y vinos de calidad alta (Ruiz, 1986).

- Variedad de uva: de las 4 variedades tintas aceptadas para la elaboración de vino amparado bajo la denominación DOC Rioja (Tempranillo, Garnacha, Mazuelo y Graciano), la variedad Tempranillo (*Vitis vinifera* L.) es la predominante, suponiendo el 96,60% de las 11.915,82 ha cultivadas con dichas variedades (Consejo Regulador DOC Rioja: www.riojawine.com/es/pdfs/ESTADISTICAS_RIOJA_2008.pdf). Tempranillo y Graciano se consideran las variedades tintas autóctonas de Rioja. A pesar de elaborarse algunos vinos monovarietales con algunas de las variedades citadas, los vinos tintos de RA, y especialmente los jóvenes, se asocian necesariamente a la variedad

Tempranillo, aunque también es frecuente una presencia minoritaria de otras variedades tintas y/o blancas autorizadas.

- Mantenimiento de gran número de bodegas pequeñas y medianas y sus prácticas tradicionales: entre otros factores, el accidentado relieve de la zona ha dificultado el establecimiento de extensos viñedos. Este hecho ha posibilitado que la propiedad de los terrenos dedicados al viñedo no esté muy concentrada y que pervivan gran cantidad de pequeñas bodegas familiares. Se calcula que más del 80% de las 275 bodegas de RA registradas en la DOC Rioja son de este tipo (fuente: Asociación de Bodegas de Rioja Alavesa; datos no publicados). Al margen de la implementación de mejoras técnicas en las prácticas vitícolas y enológicas, numerosas bodegas continúan produciendo sus vinos de forma tradicional. En este sentido, muchas de ellas siguen elaborando el vino tinto joven mediante maceración carbónica no estricta, el método tradicionalmente usado en RA (Larreina y Larreina, 2006).

Los vinos amparados por esta Denominación, tanto los tintos como los blancos y los rosados, pueden ser de varios tipos (sin crianza, “crianza”, “reserva” y “gran reserva”), tal y como se describe en el Reglamento del Consejo Regulador (BOE, 2004). El vino tinto joven (frecuentemente denominado también “vino de año” o “vino de cosechero”) es el más tradicional y representativo de RA, aunque en los últimos lustros su porcentaje sobre la producción total de vino tinto haya disminuido frente a aquellos con crianza en barrica, suponiendo en torno al 30% del volumen y menos de la cuarta parte de la facturación (Larreina y Larreina, 2006).

En base a lo recogido en el Reglamento mencionado, los vinos tintos sometidos a crianza en barrica durante un periodo de tiempo inferior a 12 meses no pueden comercializarse como vino “crianza”, por lo que la contraetiqueta expedida por el Consejo Regulador para estos vinos es la misma que la de los no sometidos a crianza en barrica. De hecho, a excepción de aquellos denominados como “de autor”, “de garaje” o “de alta expresión”

(que no disponen de una contraetiqueta específica), los vinos con una crianza muy ligera en barrica son considerados como jóvenes. En este trabajo, cuando se mencione el término "vino joven" se estará haciendo referencia a vinos que no han tenido ningún tipo de crianza en barrica, en concordancia con el concepto tradicional de vino joven.

En el Reglamento del Consejo Regulador se especifica también otra serie de requisitos que deben cumplir los vinos para ser amparados por la DOC Rioja. Éstos hacen referencia a aspectos tales como las zonas de producción, prácticas vitícolas, rendimientos de producción de uva o prácticas de elaboración de cada tipo de vino. Para ser comercializados con la contraetiqueta DOC Rioja dichos productos deben ser previamente calificados. Para ello deben superar diversos controles físico-químicos en los laboratorios oficiales del Consejo Regulador, así como una evaluación sensorial. Según se recoge en el citado Reglamento "*Los vinos calificados deberán mantener las cualidades organolépticas características de los mismos, especialmente en cuanto a color, aroma y sabor. En el caso de que se constate alguna alteración en estas características, en detrimento de la calidad, o que en su elaboración o crianza se hayan incumplido los preceptos de este Reglamento o los señalados en la legislación vigente, será descalificado por el Consejo Regulador, lo que llevará consigo la pérdida del derecho al uso de la denominación en la partida afectada*".

Además de las bases de datos procedentes de los análisis físico-químicos sistemáticos realizados en los laboratorios oficialmente autorizados (DOCE, 1999), existen diversas publicaciones que describen los vinos de Rioja desde un punto de vista físico-químico (Jaime *et al.,* 1974; González, 1988, 1992 y 1993; Elizondo *et al.,* 1994; Martínez *et al.,* 1998 y 2002). Sin embargo, y a pesar de la indudable importancia que tienen sus características organolépticas, llama la atención la falta de publicaciones que describan estos productos mediante la utilización de paneles entrenados, las cuales sí que existen para otros vinos, ya sean varietales o de zonas geográficas determinadas (Noble *et al*., 1984; Guinard y Cliff, 1987; Heymann y Noble, 1987; Noble y Shannon, 1987; De la Presa-Owens y Noble, 1995; Cliff y Dever,

1996; Fischer *et al*., 1999; Vannier *et al*., 1999; Douglas *et al*., 2001; Cliff *et al*., 2002; González *et al*., 2002; Koussissi *et al*., 2002; Mirarefi *et al*., 2004; Kontkanen *et al*., 2005; Schlosser *et al*., 2005; Vilanova y Soto, 2005; Goldner y Zamora, 2007; Culleré *et al*., 2008; Vilanova *et al*., 2008; Tao *et al*., 2009).

1.1.2- Técnicas enológicas en Rioja Alavesa para la elaboración de vinos tintos jóvenes: maceración carbónica y despalillado

Los dos procesos principales de elaboración de vinos tintos jóvenes en RA son la maceración carbónica (MC) y el despalillado (DP). En la Figura 1.1.2 se muestran de forma esquematizada las principales fases en la elaboración de vino, comunes a ambos procesos.

La MC es una técnica muy antigua cuya utilización está fundamentalmente ligada a determinadas zonas de Europa, donde constituye la forma tradicional de elaboración de vino. Dicha técnica fue descrita por primera vez desde un punto de vista científico por M. Flanzy en 1935. Además de en RA, este método sigue teniendo importancia en regiones como Médoc, Bordeaux, Beaujolais, Provence (Ribéreau-Gayon *et al*., 1976; Carnacini y Del Pozzo, 1985), aunque en muchos casos las condiciones de anaerobiosis no son estrictas (Ribéreau-Gayon *et al*., 1976).

La MC estricta consiste en que los racimos con las uvas enteras son ubicados en cubas herméticas en una atmósfera de CO_2. En estas condiciones tienen lugar diversas reacciones enzimáticas (no mediadas por microorganismos) en el interior de la baya, las cuales tienen como resultado la degradación parcial del ácido málico, la producción de etanol hasta aproximadamente un 2% v/v, la formación de sustancias volátiles y fenómenos de disolución de algunos compuestos (como las antocianinas, que aumentan ligeramente la intensidad colorante) a partir de las paredes celulares (Ribéreau-Gayon *et al*., 1976). Posteriormente, la baya se rompe y las levaduras

presentes en la parte exterior de la piel, en el tanque y, en su caso, las levaduras adicionadas, fermentan el mosto.

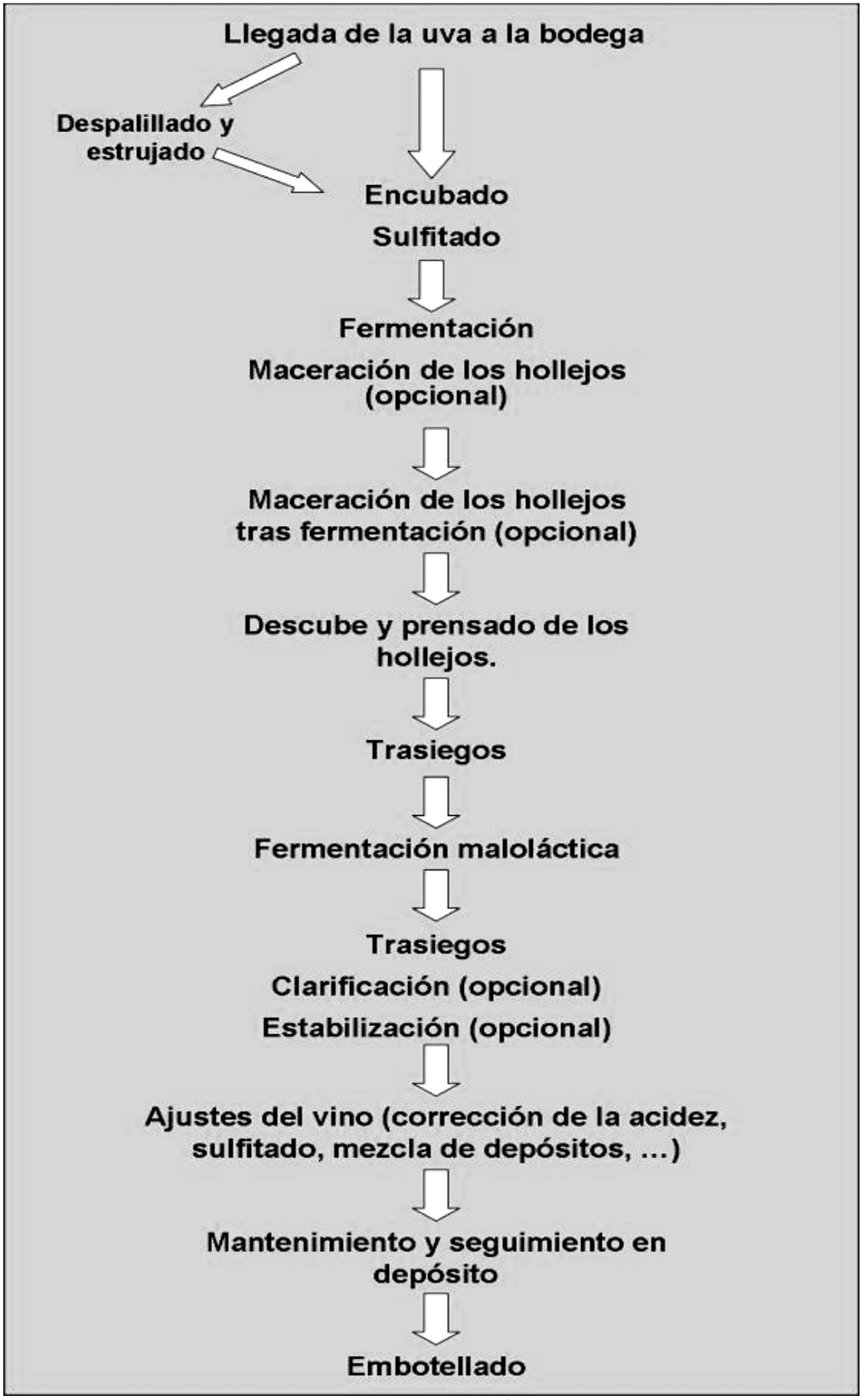


Figura 1.1.2- Principales fases en la elaboración de vino tinto joven en Rioja.

La MC que tiene lugar en las bodegas no suele ser estricta ya que, al ubicar los racimos en el tanque de fermentación, una parte de las bayas se rompe. De esta forma, los procesos químicos diferenciadores de este método sólo tienen lugar en las bayas que permanecen enteras. Es decir, en la práctica tiene lugar de forma simultánea una fermentación anaerobia en el interior de la baya y una fermentación por levaduras en el mosto del fondo del tanque. Cuando esta técnica no es estricta, el CO_2 producido por las levaduras contribuye al mantenimiento de la atmósfera anaerobia. La MC utilizada en RA ha sido y es no estricta, ya que, además de estar parte de las bayas rotas, se utilizan tanques abiertos, se adiciona SO_2 y no se adiciona CO_2 (Jaime *et al*., 1974).

Lo habitual en este tipo de elaboración en esta zona es que, con la fermentación alcohólica sin completar, se obtengan tres fracciones principales de vino ("lágrima", "corazón" y "de prensa"), las cuales, ya sin raspones ni hollejos, completan la fermentación en otro tanque.

El vino "de lágrima" o "escurrido natural" es el que se obtiene a partir del mosto en fermentación del fondo del tanque sin ningún tipo de prensado. Esta fracción tiene un contenido final en etanol de en torno al 10-11% v/v y un menor contenido en polifenoles. Sensorialmente se ha descrito como afrutado, ácido y "muy abierto de color" (González, 1993).

Tras retirar el vino de lágrima los racimos son sometidos a una ligera presión pero sin utilización de una prensa. La técnica tradicional era el pisado de la uva. En la actualidad lo que se suele hacer es dividir el depósito en dos partes y voltear los racimos de una parte encima de la otra con ayuda de un horquillo, en una operación denominada "media vuelta". Posteriormente, se pasan todos los racimos a la otra mitad del depósito en una operación llamada "vuelta entera". Mediante estas operaciones se rompen las bayas que todavía conservaban su integridad y se facilita la extracción de la mayor parte del vino. La fracción obtenida se denomina vino "corazón" o "escurrido de volteo". Esta fracción tiene un contenido final de etanol mayor que el vino de lágrima, así como de polifenoles y de la mayor parte de los demás constituyentes. El vino

"corazón" ha sido definido como vino "de cuerpo" y "mucho color" (González, 1993) y es considerado la fracción de más calidad.

La tercera fracción es el vino "de prensa" o "de escurrido de prensado" que, como su propio nombre indica, se obtiene mediante el prensado mecánico de los hollejos y raspones. El vino obtenido tiene un contenido mayor en polifenoles, presentando una mayor astringencia. Un prensado excesivo, especialmente si se rompen las pepitas, incrementa la astringencia y el amargor debido a la difusión al vino de diversas sustancias tánicas presentes en las partes sólidas (hollejos, raspones y pepitas).

Una vez obtenidas las tres fracciones, lo habitual es mezclarlas y completar la fermentación obteniendo un único vino, aunque hay algunos casos en los que la bodega elabora de forma separada el vino correspondiente a la fracción "corazón", con el fin de comercializar un producto, *a priori*, de calidad superior.

El DP es el método de elaboración más común en todo el mundo. Otras denominaciones son "método bordelés" y "estrujado". Frecuentemente, en la bibliografía se hace referencia a dicha técnica como "vinificación tradicional", aunque en el caso de RA esta denominación no sería correcta e induciría a confusión, ya que el procedimiento tradicional es la MC. El DP se comenzó a utilizar en la región que hoy se conoce como Rioja a finales del siglo XVIII de la mano de Manuel Quintano (Larreina y Larreina, 2006).

Este método consiste en separar el raspón de las uvas mediante una despalilladora según llegan los racimos a la bodega. Esta operación, además de separarlas del pedúnculo, rompe las uvas (de ahí la denominación de "estrujado"). Una vez rotas pasan a un tanque donde tiene lugar la fermentación alcohólica del mosto en contacto con los hollejos. Durante la fermentación los hollejos son sometidos a remontados mediante diversas técnicas para aumentar la extracción de sustancias de los mismos, principalmente materia colorante. El tiempo que los hollejos permanecen en contacto con el mosto en fermentación está en función de las prácticas de cada

bodega, aunque es frecuente mantenerlos en contacto con el vino durante varios días una vez completada la fermentación alcohólica, para así aumentar aún más la extracción de materia colorante.

La producción de vino tinto joven mediante DP ha venido desplazando durante las últimas décadas a la producción mediante MC. A pesar de ello, al menos 113 de las 275 bodegas de RA amparadas por la DOC Rioja declararon en 2008 elaborar vino tinto mediante MC (datos no publicados proporcionados por el Consejo Regulador DOC Rioja). Aunque un número considerable de bodegas pequeñas elabora mediante DP, dicha técnica está fundamentalmente ligada a bodegas medianas y grandes.

Desde un punto de vista físico-químico las principales diferencias entre vinos de MC y de DP serían que los primeros tienen, por lo general, menor acidez (Fuleki, 1974; Ribéreau-Gayon *et al*., 1976; Carnacini y Del Pozo, 1985; Flanzy, 2003), mayor pH (Carroll, 1986; Navarro *et al*., 1988a), menor contenido en polifenoles (Carroll, 1986; Ribéreau-Gayon *et al*., 1976; Carnacini y Del Pozo, 1985; Navarro *et al*., 1988b; Flanzy, 2003), menor contenido en taninos (Fuleki, 1974; Ribéreau-Gayon *et al*., 1976; Carnacini y Del Pozo, 1985; Navarro *et al*., 1988b) y menor contenido en extracto seco (Carnacini y Del Pozo, 1985; Carroll, 1986; Flanzy, 2003). Asimismo, suelen tener también una menor intensidad de color debido a la menor extracción de compuestos colorantes (Fuleki, 1974; Carnacini y Del Pozo, 1985; Carroll, 1986; Navarro *et al*., 1988b), aunque la extracción de dichos compuestos está en gran medida determinada por las temperaturas de fermentación utilizadas (Fuleki, 1974).

En relación a las diferencias de compuestos volátiles, no existen datos suficientemente concluyentes para determinar el origen concreto de las diferencias organolépticas entre ambos tipos de vino, aunque algunos autores han encontrado que diversos compuestos volátiles relacionados con las características frutales están presentes en mayores concentraciones en vinos elaborados por MC. Tal es el caso del cinamato de etilo (Versini y Tomasi, 1983; La Notte *et al*., 1992), benzaldehído y vinilbenceno (Ducruet, 1984; La Notte *et al*., 1992), algunos ésteres de isoamilo (La Notte *et al*., 1992) y

especialmente varios ésteres de etilo (Ducruet, 1984; Carnacini y Del Pozzo, 1985; Etiévant *et al*., 1989; La Notte *et al*., 1992; Álvarez *et al*., 1998; Lõrincz y Vas, 1998; Spranger *et al*., 2004). Las características olorosas y aromáticas particulares de los vinos de MC no se deberían a la presencia de algunos compuestos volátiles exclusivos en este tipo de vinos, sino más bien a que determinados compuestos comunes en vinos de MC y de DP estarían presentes en mayores proporciones en los primeros (Ribéreau-Gayon *et al*., 1976).

Desde un punto de vista sensorial, la bibliografía relacionada con las diferencias entre estos dos tipos de vino es escasa, especialmente los estudios llevados a cabo con paneles entrenados. Algunos autores han comparado sensorialmente ambos tipos de vino mediante evaluaciones sensoriales más o menos informales y/o llevadas a cabo por algunos expertos, pero tan sólo se han encontrado dos estudios en los que se comparan vinos de MC y vinos de DP utilizando paneles entrenados. En el estudio de Fuleki (1974), llevado a cabo con vinos elaborados con uvas Concord (*Vitis lambrusca*), se evaluaron tres parámetros sensoriales: intensidad general de "bouquet", intensidad de "bouquet" Concord e intensidad de "flavor" Concord, por lo que no se describieron las diferencias entre ambos tipos de vino en cuanto a descriptores específicos. El trabajo de Etiévant *et al*. (1989) se centró en el estudio de fenoles volátiles, por lo que no se realizó una descripción sensorial general de los vinos.

Al margen de lo anteriormente citado, sí que existe coincidencia en las referencias bibliográficas en que los vinos de MC tendrían un olor/aroma "particular" (Ribéreau-Gayon *et al*., 1976; Carnacini y Del Pozzo, 1985; Lõrincz y Vas, 1998; Flanzy, 2003).

El término más común para describir estos vinos es "frutal" (Jaime *et al*., 1974; Álvarez *et al*., 1998; Lõrincz y Vas, 1998), con algunas descripciones más precisas como "fresa" y "frambuesa" (Versini y Tomasi, 1983), "cereza" y "kirsch" (Ducruet, 1984), "guindo", "cerezo", "ciruela" y "carozo" (Chauvet, 1971;

Coste, 1971). Algunos otros descriptores de olor/aroma citados son “floral” (Álvarez *et al*., 1998; Lõrincz y Vas, 1998) y "especiado" (Carroll, 1986).

En relación a las características gustativas y trigeminales, los vinos de MC han sido descritos como “suaves” y “aterciopelados” en boca (Fuleki, 1974; Jaime *et al*., 1974; Ribéreau-Gayon *et al*., 1976; Carroll, 1986; Lõrincz y Vas, 1998).

1.1.3- Variedades de uva utilizadas en Rioja Alavesa para la elaboración de vinos tintos jóvenes

Las variedades de uva tinta aceptadas por el Consejo Regulador DOC Rioja son Mazuelo, Graciano, Garnacha y Tempranillo.

Los viñedos de la variedad Mazuelo suponen únicamente 102,75 ha (un 0,88% de la superficie cultivada en 2008 en RA con variedades tintas autorizadas; Consejo Regulador DOC Rioja: www.riojawine.com/es/pdfs/ESTADISTICAS_RIOJA_2008.pdf). Estas uvas se suelen mezclar con uvas de la variedad Tempranillo para elaborar vinos tintos, tanto jóvenes como crianzas.

La variedad Garnacha tinta representa un 1,20% de la superficie cultivada en RA con variedades tintas autorizadas. Estas uvas se mezclan con las de Tempranillo para elaborar vinos tintos, siendo también utilizadas para elaboración de rosados.

La variedad Graciano constituye el 1,32% de la superficie cultivada en RA con variedades tintas autorizadas y es considerada una variedad autóctona. Se suele mezclar con uvas de Tempranillo para elaborar vinos tintos aunque algunas bodegas elaboran tintos jóvenes monovarietales de Graciano.

La variedad Tempranillo es, con diferencia, la mayoritaria en RA (96,60% de la superficie cultivada con las variedades tintas autorizadas) y es considerada autóctona.

Los descriptores de olor/aroma utilizados por diversos autores para describir los vinos elaborados con la variedad Tempranillo son “frutal” (Álvarez *et al*., 1998; Reyero *et al*., 2000), “frutos rojos” (Álvarez *et al*., 1998; Reyero *et al*., 2000), “naranja”, “fresa” y “mermelada de ciruela” (Clarke y Bakker, 2004) y “floral” (Álvarez *et al*., 1998).

En RA, muchos vinos tintos jóvenes se elaboran exclusivamente a partir de uvas de la variedad Tempranillo, aunque también es tradicional la vinificación adicionando pequeñas proporciones (habitualmente menos del 5-10% del peso total) de otras variedades de uva, tanto tintas como blancas. El Reglamento del Consejo Regulador establece un porcentaje máximo en peso para las variedades blancas adicionadas en la elaboración de vinos tintos. Este límite es de un 15% en vinos de MC y de un 5% en vinos de DP (BOE, 2004).

La principal variedad de uva blanca utilizada en la elaboración de vinos tintos jóvenes es la denominada Viura (fuera de Rioja es más conocida como Macabeo). Esta variedad es la mayoritaria tanto en la zona amparada por la DOC Rioja (3.924,57 ha, un 97,75% del total de hectáreas plantadas con variedades blancas autorizadas; datos del Consejo Regulador de la DOC Rioja: www.riojawine.com/es/pdfs/ESTADISTICAS_RIOJA_2008.pdf) como específicamente en RA (948,55 ha, un 98,29% del total de hectáreas plantadas con variedades blancas autorizadas).

No se han encontrado en la bibliografía científica descripciones sensoriales de vinos blancos DOC Rioja elaborados con uva Viura, aunque sí de vinos blancos elaborados con uva Macabeo. Peinado *et al*. (2004) utilizaron para describirlos los términos “frutal”, “balsámico”, “dulce”, “floral” y “disolvente”. De la Presa-Owens y Noble (1995) destacaron los olores a “nueces”, “betún” y “caramelo” en vinos de esta variedad.

La adición de pequeños porcentajes de uva Viura en la elaboración de vino tinto joven es una práctica tradicional en RA. La primera razón podría ser económica o de rendimiento, es decir, que si en la viña existen cepas de uva blanca y no se desea elaborar vino blanco, esa uva se destina a la elaboración de vino tinto. Sin embargo, también está extendida la afirmación de que la adición de uva blanca aportaría "viveza" al vino tinto al aumentar algo su acidez, además de contribuir a los olores/aromas florales y frutales. No se tiene constancia de ningún estudio sensorial descriptivo que aborde dicha cuestión.

1.1.4- Evolución en botella de vinos tintos jóvenes

Los vinos son bebidas que evolucionan con el tiempo. En el caso de los vinos tintos que no han sido sometidos a crianza en barrica, las características organolépticas van a estar determinadas por los aromas primarios (procedentes de la uva) y secundarios (originados en la fermentación), destacando los olores/aromas frutales. La intensidad de dichos olores/aromas se pierde de forma progresiva, lo cual conlleva que los vinos sin crianza en barrica tengan una vida útil menor, entendiéndose como vida útil el periodo de tiempo durante el cual el vino mantiene unas características organolépticas adecuadas o aceptables (aun considerando el margen de ambigüedad asociado a dichos conceptos).

Gran parte de los estudios publicados sobre la evolución de vinos sin crianza en barrica se centra en la evolución de sustancias volátiles, especialmente en vinos blancos (Rapp y Marais, 1993; Herjavec y Majdak, 2002; Pérez-Coello *et al*., 2003; Oliveira *et al*., 2008) y en menor medida en vinos tintos (Stern *et al*., 1975; Pérez-Prieto *et al*., 2003).

Otros estudios publicados abordan la evolución de los parámetros físico-químicos, otorgando por lo general gran importancia a aquellos relacionados con el color (Castillo-Sánchez *et al*., 2006; Monagas *et al*., 2006; Puech *et al*., 2006; García-Falcón *et al*., 2007; Castillo-Sánchez *et al*., 2008).

Desde un punto de vista sensorial los estudios publicados se centran básicamente en comparar la influencia de diversas condiciones de almacenamiento (principalmente la temperatura) sobre las características organolépticas, tanto en vinos blancos (De la Presa-Owens y Noble, 1997; González-Viñas *et al*., 1998; Pérez-Coello *et al*., 2003) como en vinos tintos (Etiévant *et al*., 1989; Sivertsen *et al*., 2001; Puech *et al*., 2006). Muy pocos trabajos abordan específicamente la evolución sensorial de vinos en condiciones de almacenamiento normales, por ejemplo a temperatura de bodega (Oliveira *et al*., 2008).

Debido a la evolución natural del vino y la consecuente pérdida progresiva de sus propiedades organolépticas características, los vinos tintos jóvenes de RA han sido tradicionalmente consumidos durante su primer año (de ahí la denominación “vinos de año” o “vinos jóvenes”). Dicha afirmación está especialmente extendida en relación al vino elaborado mediante MC, lo cual coincide con lo indicado por otros autores (Carnacini y Del Pozo, 1985). A pesar de ello, no se han encontrado estudios que comparen la evolución de vinos tintos elaborados mediante MC y DP.

1.2- Análisis sensorial descriptivo aplicado a vinos

La evaluación sensorial del vino se basa en la medida, la cuantificación y la interpretación de las características del vino percibidas por los sentidos (el olfato, el gusto, las sensaciones táctiles y la vista) utilizando para ello técnicas científicas (De la Presa-Owens, 2004). En línea con esta definición, en el presente trabajo se entenderá por análisis sensorial de vino los estudios de las características organolépticas de este producto publicados en la literatura científica, para diferenciarlo de la simple cata más o menos informal ("métodos tradicionales de cata" en palabras de De la Presa-Owens [2004]). Ello no es óbice para que en bastantes estudios científicos, en los que el análisis sensorial no es el principal objetivo sino más bien un complemento a otro tipo de análisis, se describan los vinos de forma un tanto informal o utilizando en muchas ocasiones fichas de cata ya existentes (por tanto, sin seleccionar específicamente los descriptores a evaluar).

Dentro del análisis descriptivo existen diferentes métodos, entre los cuales destacan el "Perfil de flavor" (*Flavor Profile*©), el "Análisis Descriptivo de Espectro" (*Spectrum Descriptive Analysis*©), la "Elaboración de Perfil de Libre Elección" (*Free Choice Profiling*) y el "Análisis Descriptivo Cuantitativo" (*Quantitative Descriptive Analysis*©, QDA), los cuales se abordan ampliamente en diversas publicaciones (Meilgaard *et al*., 1991; Lawless y Heymann, 1998; Piggott *et al*., 1998; Stone y Sidel, 2004).

En el análisis sensorial descriptivo se incluyen también ciertos métodos dinámicos. El objetivo de estos métodos es medir la evolución de las sensaciones producidas por el producto a lo largo del tiempo. Dentro de este grupo de técnicas las principales son el "Análisis Descriptivo Tiempo Intensidad" (TI, *Time Intensity Descriptive Analysis*) y el "Dominio Temporal de las Sensaciones" (TDS, *Temporal Dominance of Sensations*). El número de publicaciones sobre la aplicación a vinos del TI (Ross *et al*., 2007) y del TDS

(Pineau *et al*., 2004; Pessina *et al*., 2005) es mucho menor que el de los métodos estáticos.

De entre los diversos métodos descriptivos citados, el QDA constituye la base de gran parte de los estudios sensoriales llevados a cabo en las últimas décadas. Este análisis fue descrito inicialmente por Stone *et al*. (1974), y posteriormente por Stone y Sidel (1998). En este método se cuantifica la intensidad de las sensaciones mediante escalas continuas de 15 cm con una indicación verbal que cruza la línea a 1,5 cm de cada uno de los extremos. En el QDA los jueces toman parte en la definición de los términos y referencias a utilizar, son entrenados y evalúan las muestras de forma independiente (Meilgaard *et al*., 1991; Lawless y Heyman, 1998; Stone y Sidel, 2004).

En el análisis sensorial de vino la mayoría de los estudios se han llevado a cabo mediante lo que Lawless y Heymann (1998) denominan "análisis descriptivo genérico", también denominado "elaboración de perfil convencional" (*conventional profiling*). Este tipo de análisis suele basarse en el QDA o en el *Spectrum Descriptive Analysis,* aunque con diversas modificaciones, las cuales invalidan el uso de estas denominaciones registradas (Lawless y Heymann, 1998).

En los análisis descriptivos de vinos mediante la utilización de escalas comunes para todos los jueces es frecuente la elaboración de gráficos (especialmente "telas de araña") para presentar de forma muy sencilla la descripción sensorial del producto. Estas representaciones permiten además comparar de forma muy visual las diferencias sensoriales entre vinos.

Mediante el análisis descriptivo genérico se han descrito una gran cantidad de vinos de diferentes variedades de uva y procedencias geográficas (Noble *et al*., 1984; Guinard y Cliff, 1987; Heymann y Noble, 1987; Noble y Shannon, 1987; Sivertsen, 1994; De la Presa-Owens y Noble, 1995; Cliff y Dever, 1996; Fischer *et al*., 1999; Vannier *et al*., 1999; Douglas *et al*., 2001; Cliff *et al*., 2002; Koussissi *et al*., 2002; Mirarefi *et al*., 2004; Kontkanen *et al*., 2005; Schlosser *et al*., 2005; Vilanova y Soto, 2005; Goldner y Zamora, 2007;

Culleré *et al*., 2008; Vilanova *et al*., 2008). Este análisis también ha sido utilizado para conocer el efecto de diversas prácticas vitícolas (Cortell *et al*., 2008; Tardaguilla *et al*., 2008), enológicas (McDaniel *et al*., 1987; Etiévant *et al*., 1989; Girard *et al*., 2001; Swiegers *et al*., 2009) y de conservación (Etiévant *et al*., 1989; De la Presa-Owens y Noble, 1997; González-Viñas *et al*., 1998; Sivertsen *et al*., 2001) sobre las características organolépticas de los vinos.

En relación al análisis descriptivo es necesario destacar la importancia de la terminología utilizada, así como de las referencias sensoriales. A pesar de que en gran parte de los estudios el propio panel haya generado y seleccionado los términos para describir los vinos, se han realizado diversos intentos para definir y clasificar la terminología de olores/aromas, ya sea para un grupo de vinos en concreto (Cristovam *et al*., 2000; López *et al*., 2001; Aznar *et al*., 2006) o para un uso general a todo tipo de vinos (Noble *et al*., 1987; Jackson, 2000; Pfister *et al*., 2006). La rueda de los olores/aromas de Noble *et al*. (1987) es la que tiene una mayor difusión a nivel mundial. También se ha publicado una propuesta de terminología para las sensaciones trigeminales en vinos tintos (Gawel *et al*., 2000; Gawel *et al*., 2001).

Las referencias sensoriales se desarrollan para simular las diversas sensaciones que originan los productos a analizar, con el objetivo principal de homogeneizar conceptos y entrenar a los miembros del panel en la identificación de cada descriptor. Gran parte de los estudios descriptivos referidos anteriormente incluyen la composición de las referencias utilizadas. En muchas ocasiones, éstas son preparadas sobre una matriz vínica, intentando reproducir lo mejor posible el contexto en que cada sensación será percibida en el vino.

Algunas de las referencias indicadas en los diferentes artículos están preparadas a partir de sustancias químicas mientras que otras, especialmente aquellas relacionadas con olores/aromas frutales y vegetales, se suelen preparar a partir de productos naturales. Las primeras tienen la ventaja de ser muy reproducibles, mientras que las segundas, si bien son más difíciles de

estandarizar, reproducen de una forma mucho más fiel los olores/aromas más complejos (debidos a varios compuestos químicos).

Las referencias descritas en cada artículo se limitan, evidentemente, a los descriptores utilizados en el estudio. Sin embargo, es posible encontrar la composición de prácticamente todo el abanico de olores/aromas (incluidos defectos) presentes en los vinos en publicaciones tales como Noble *et al*. (1987) y Jackson (2000). La primera publicación sería la más completa, ya que incluye la composición de las referencias de 88 de los 94 descriptores que conforman la rueda de los olores/aromas.

Si bien el número de publicaciones en las que se detalla la composición de referencias de olores/aromas es extenso, las publicaciones que describen la composición de referencias de descriptores gustativos y trigeminales son menos numerosas (Guinard y Cliff, 1987; Noble y Shannon, 1987; Girard *et al*., 2001; Mirarefi *et al*., 2004; Goldner y Zamora, 2007; Cortell *et al*., 2008; Tardaguila *et al*., 2008; Swiegers *et al*., 2009).

En relación a las características de apariencia, aunque en muchos de los estudios no se tienen en cuenta, cuando son evaluadas no se incluyen referencias físicas. En estos casos se suelen utilizar definiciones y términos para orientar la asignación de puntuaciones en la escala (Bakker y Arnold, 1993; Pokorný *et al*., 1998; Girard *et al*., 2001; Sivertsen *et al*., 2001), y en algún caso (Tardaguila *et al*., 2008) se recurre a coordenadas de color estandarizadas como el *Munsell Book of Colour* (Munsell A.E.O., 1998).

El tratamiento estadístico de los datos procedentes del análisis descriptivo genérico, dependerá de los objetivos de cada estudio, aunque el tipo de análisis más frecuente es el análisis de la varianza (ANOVA). Mediante dicho análisis se estudia la significación de los efectos debidos a los productos, jueces y otras variables experimentales (Lundahl y McDaniel, 1988).

El Análisis de Componentes Principales (PCA, Principal Component Analysis) ha sido utilizado también en numerosos estudios sensoriales

descriptivos con vinos. El PCA se usa para reducir la dimensionalidad de los datos descriptivos y así facilitar la interpretación y presentación de los resultados (Piggot y Sharman, 1986). Otros tipos de análisis estadísticos utilizados en estudios sensoriales descriptivos sobre vinos son el Análisis Procrustes Generalizado (Williams y Langron, 1984; Williams *et al*., 1984; Petka et al., 2006), la Regresión Parcial por Mínimos Cuadrados (Francis *et al*., 1998; Frøst y Noble, 2002; Boselli *et al*., 2004; Cozzolino *et al*., 2008) y el Análisis de Variables Canónicas (CVA, *Canonical Variate Analysis*) (Noble *et al*., 1984; Heymann y Noble, 1989). La utilización de dichos métodos es, sin embargo, mucho menos frecuente que el ANOVA. Estas técnicas de análisis multivariante se suelen utilizar para relacionar datos sensoriales descriptivos con otro tipo de datos (Noble y Ebeler, 2002), como los procedentes de análisis instrumentales o ensayos hedónicos, o cuando la descripción del producto se realiza mediante algunos métodos sensoriales específicos (caso del Análisis Procrustes Generalizado para analizar los datos obtenidos mediante el método Desarrollo de Perfil de Libre Elección [Meilgaard *et al*., 1991; Lawless y Heyman, 1998; Stone y Sidel, 2004]).

1.3- Evaluación de la calidad sensorial en vinos

La calidad de un producto alimentario tiene naturaleza multidimensional (Plsek, 1987; Muñoz *et al*., 1992; Lawless, 1995; Molnár, 1995), siendo evidente que, en el caso del vino, la calidad sensorial es uno de los principales determinantes de su calidad global.

El concepto de calidad sensorial de los productos alimenticios es un tema un tanto controvertido. Muy frecuentemente, la calidad sensorial se asocia directamente a las preferencias de los consumidores. Según este planteamiento y de una forma un tanto generalista, un producto cuyas propiedades organolépticas tengan una alta aceptación por parte de los consumidores tendría una alta calidad sensorial. Desde otro enfoque, la evaluación de la calidad sensorial se basaría en la medida rigurosa de cómo el producto se ajusta a unas determinadas características predefinidas que le son propias, utilizando para ello jueces expertos entrenados, sin recabar la opinión de los consumidores. Según el producto de que se trate predominará uno de estos dos enfoques, por lo demás complementarios en muchas ocasiones. Para el sector alimentario es de gran interés utilizar ambas fuentes de información (consumidores y paneles entrenados) para definir la calidad del producto.

En la industria alimentaria el control de la calidad sensorial suele llevarse a cabo en base a especificaciones previamente establecidas (Muñoz *et al*., 1992; York, 1994; King *et al*., 2002), mediante la aplicación de diversos métodos: método descriptivo integral/exhaustivo, método de graduación de la calidad, método “dentro/fuera”, método de diferencia respecto a un control… Habitualmente, el principal objetivo de la aplicación de estándares de calidad es determinar si el producto fabricado cumple unos mínimos exigibles y puede ser comercializado, y no tanto categorizarlo en función de su calidad sensorial (ya que se supone que todos los lotes son iguales o muy similares entre sí).

No obstante, también se han descrito métodos para categorizar la calidad sensorial de diversos alimentos tales como tunas (higos chumbos) peladas en almibar (Cerezal y Duarte, 2004), aguas de consumo (Bernal *et al*., 1999) y diversos productos pesqueros como merluza, pulpo, dorada y salmón mediante el Método del Indice de Calidad (*Quality Index Method*, QIM) (Huidobro *et al*., 2000; Baixas-Nogueras *et al*., 2003; Sveinsdottir *et al*., 2003; Barbosa y Vaz-Pires, 2004).

En los alimentos con distintivos de calidad, como es el caso de los productos tradicionales o típicos con Denominación de Origen Protegida (DOP), la calidad sensorial está íntimamente ligada a diversos factores como su origen, las materias primas utilizadas, los procesos de elaboración o aspectos culturales (Ballester *et al*., 2005; Bertozzi, 1995; Cayot, 2007; Parr *et al*., 2007; Monteleone y Bertuccioli, 2005). En Europa, estos productos están regulados por el Reglamento (CE) 510/2006 (DOUE, 2006). Dicha norma no es de aplicación a vinos, los cuales están regulados por el Reglamento (CE) 479/2008 (DOUE, 2008), si bien la orientación que emana del mismo es que las solicitudes de denominación de origen o de indicación geográfica para vinos se examinen conforme al planteamiento recogido en el Reglamento (CE) 510/2006. La norma específica para vinos mencionada establece expresamente que, en el pliego de condiciones para solicitar la protección para vinos con Denominación de Origen Protegida, deben constar “sus principales características analíticas y organolépticas”, aunque sin especificar nada más en lo que a estas últimas se refiere.

En base a lo anteriormente citado, el pliego de condiciones de cada DOP debería incluir, por mínima que sea, una descripción de las características organolépticas que debe presentar el producto. A pesar de ello, frecuentemente se recurre a la ambigua mención de cualidades “características”, aunque sin especificar suficientemente cuáles son dichas cualidades. Su definición es importante para poder diferenciar estos productos de otros similares que no tienen dichos distintivos de calidad (Bertozzi, 1995; Cayot, 2007).

Al margen de la frecuente ambigüedad acerca de las características organolépticas que deben presentar los productos con DOP, existe un vacío evidente en el desarrollo de métodos para asegurar de forma rigurosa y técnicamente competente que dichos alimentos se ajustan a las características declaradas. A pesar de que en muchas DOPs se utilizan paneles de catadores para certificar el producto, a menudo ni los conceptos sensoriales ni el método de evaluación sensorial están suficientemente definidos. Debido a ello, la evaluación de la calidad está en gran medida a expensas de la valoración que cada experto haga en base a su concepto de calidad.

En los productos con DOP la evaluación sensorial no suele ir más allá de determinar si éstos cumplen unos requisitos mínimos (frecuentemente ausencia de defectos) y pueden ser certificados y comercializados bajo la denominación correspondiente. Se han publicado muy pocos métodos que permitan categorizar su calidad en base a cómo se ajustan a las características óptimas, pudiendo así establecerse diferencias de calidad entre productos certificados. Entre estos casos estarían los métodos descritos para evaluar la calidad sensorial del queso Idiazabal (Pérez Elortondo *et al*., 2007), del aceite de oliva virgen extra (IOOC, 2005) y del espárrago de Navarra (Torre, 2002). En los ejemplos citados, además de señalarse la posible presencia de defectos, se puntúan determinados parámetros y/o la intensidad de determinados descriptores, lo cual aporta información descriptiva y permite también conocer los puntos fuertes y débiles del producto.

En el caso concreto del vino, durante las últimas décadas se han propuesto diversas fichas de cata para evaluar la calidad: escala de 20 puntos de Davis (Ough y Baker, 1961; Amerine y Roessler, 1983), ficha para concursos internacionales de la Organización Internacional de la Viña y el Vino (OIV, 1994); ficha de la Unión Internacional de Enólogos (reproducida en OIV, 1994), ficha de la Unión Española de Catadores (reproducida en Del Castillo, 2005), ficha de la Facultad de Enología de Bordeaux (reproducida en Peynaud y Blouin, 2002), ficha de cata hedónica para la evaluación de la calidad (Jackson, 2000) … Sin embargo, en la mayor parte de los casos los parámetros a evaluar no están suficientemente definidos por lo que diferentes jueces

pueden no entender exactamente lo mismo sobre un determinado concepto. Igualmente, en las fichas no se suelen especificar suficientemente los criterios para puntuar cada uno de los parámetros, por lo que quedan en gran medida en función de la interpretación, experiencia y conocimientos de cada juez. Por otro lado, las fichas de cata publicadas están habitualmente enfocadas hacia un abanico amplio de vinos ("vinos espumosos", "vinos tranquilos"…) por lo que la tipicidad y las características específicas de cada vino (determinadas por el suelo, el clima, la variedad de uva, las prácticas enológicas…) no son consideradas. Dichas propiedades organolépticas que caracterizan a cada vino están indudablemente ligadas a la calidad sensorial, por lo que al utilizar una ficha de cata excesivamente genérica no se consideran estos aspectos.

En el caso de los vinos de Rioja no se tiene conocimiento de métodos de evaluación de la calidad sensorial específicos.

El desarrollo de métodos para evaluar de una forma rigurosa la calidad sensorial de productos específicos (especialmente aquellos con DOP) con vistas a su certificación es una necesidad cada vez más apremiante (Feria-Morales, 2002). Más allá de su desarrollo, la acreditación de dichos métodos por parte de entidades oficiales supone una garantía de competencia técnica del laboratorio (Pérez Elortondo *et al*., 1999). La acreditación de métodos de análisis en base a la norma ISO 17025 (ISO, 2005a) se está realizando desde hace ya varios años, aunque el número de métodos de análisis sensorial acreditados es muy escaso en comparación con otros tipos de análisis. Según Gacula (2003), la importancia de la acreditación de laboratorios se incrementará notablemente los próximos años. La cada vez mayor relevancia de la acreditación de métodos sensoriales en alimentos se debe, en gran medida, a las directrices de la Unión Europea relativas a las exigencias para los productos con distintivos de calidad.

En el momento de redactarse el presente trabajo no se tiene conocimiento de ningún método acreditado de análisis sensorial de la calidad del vino.

Una vez desarrollado el método de evaluación de la calidad sensorial, y antes de su aplicación de una forma sistemática y de su eventual acreditación, es indispensable disponer de un panel cualificado para evaluar las muestras con las suficientes garantías. Para ello es necesario llevar a cabo una serie de pasos, tales como selección de jueces, entrenamiento básico y entrenamiento específico, cualificación de jueces y validación del método. Únicamente cuando el método proporciona resultados fiables (repetibles, reproducibles y discriminantes) puede ser acreditado en base a la norma ISO 17025 (2005a). Para conservar la acreditación a lo largo del tiempo es necesario demostrar que el laboratorio sigue manteniendo la competencia técnica, para lo cual debe llevarse a cabo un control continuado del panel y de los jueces, así como controles de calidad periódicos.

En la bibliografía existen numerosas normas y artículos sobre la selección y entrenamiento de jueces (Bressan y Behling, 1977; ASTM-STP, 1981; Muñoz *et al*., 1992; ISO, 1993; Issanchou *et al*., 1995; Lyon, 2002; ASTM, 2003; ISO, 2005b; ISO, 2006; IOOC, 2007; ISO, 2008), así como sobre el seguimiento y control del panel y los jueces (Kwan y Kowalski, 1980; Brien *et al*., 1987; Bárcenas *et al*., 2000; King *et al.*, 2001; Rossi, 2001; Scaman y Dou, 2001; Findlay *et al*., 2006; Latreille *et al*., 2006). Dichas referencias están enfocadas habitualmente a puntuaciones numéricas; en la mayoría de los casos a la medición de intensidades.

Las referencias sobre entrenamiento, seguimiento y control de paneles y métodos en el caso de productos específicos son muy escasas (Torre, 2002; Pérez Elortondo *et al*., 2007). Además de la falta de referencias de otros laboratorios, las particularidades de los métodos de evaluación de productos específicos hacen casi inevitable el desarrollo de procedimientos nuevos para el entrenamiento y cualificación de jueces, validación de métodos, control de panel y jueces, y control de calidad, o al menos la adaptación de otros procedimientos ya existentes.

2- OBJECTIVES

The objectives of the research work described in **the first part** of this thesis are based on two premises. On the one hand, there is an evident lack of scientific studies describing young red wines from Rioja Alavesa (RA) by descriptive sensory analysis. On the other hand, the work developed with these wines may probe to be very interesting and helpful for wineries.

The cited lack of scientific information is also true for the sensory differentiation of wines made by carbonic maceration (MC) and those wines made by destemming (DP).

Scientific information regarding the effect of the addition of white grapes on the organoleptic characteristics of red wine is also very scarce, although this practice is very common in RA.

Another important aspect in young red wines is the evolution of the organoleptic characteristics throughout the first months in bottle. Unlike barrel aged wines, the lack of information is notable.

On these bases, the research described in this thesis may be very helpful, especially for wineries from this zone, because it provides scientific information for the better understanding of the wines and the effect of the mentioned factors.

The objectives of the first part of this thesis were the following:

1.1- To describe the organoleptic characteristics of young red wines from RA by using descriptive sensory analysis.

1.2- To determine the effect of the winemaking process (MC *vs*. DS) and the addition of Viura white grape on the organoleptic characteristics of these wines.

1.3- To study the evolution of the organoleptic characteristics of these wines in bottle, also identifying the evolution differences due to the winemaking process (MC / DP) and due to the addition of Viura white grapes.

The objectives of **the second part** of this thesis are supported by the need for having available normalized methods to evaluate the sensory quality of wines in general, and RA young red wines in particular. In this thesis, the method developed and applied to evaluate these wines is described.

This method applied by a trained and qualified panel is a very useful tool for the wine sector. It allows categorizing sensory quality of the wines and knowing their weak and strong points.

This work is also an available experience for other laboratories dealing with development of methods to evaluate the sensory quality of food products.

The objectives of the second part of this thesis were the following:

2.1- To establish a specific method for evaluating the sensory quality of young red wines from Rioja Alavesa.

2.2- To develop sensory references for the attributes, defects and imbalance causes more frequent in these wines.

2.3- To develop and to apply protocols for training and qualification of judges, for method validation, for monitoring the performance of the panel and individual judges, and for periodic quality controls of the method.

3- MATERIAL Y MÉTODOS

3.1- Descripción sensorial del vino tinto joven de Rioja Alavesa. Influencia del método de elaboración, variedades de uva y momento del año sobre las características sensoriales.

Antes de describir el desarrollo del método y el análisis llevado a cabo con las muestras es necesario mencionar algunos aspectos comunes a ambas fases en relación a los jueces, la sala de cata y el servicio de las muestras de vino y de las referencias.

Jueces

Tras contactar con diversas personas que pudieran estar interesadas en tomar parte en el estudio y recabar información sobre su interés y disponibilidad, se comenzó la fase de definición del método y entrenamiento con 18 personas, la mayoría de las cuales tenía alguna experiencia en análisis sensorial. Cuatro personas abandonaron el entrenamiento por diversas causas, por lo que fueron 14 los jueces que comenzaron a evaluar los vinos del estudio, aunque únicamente 10 de ellos (siete mujeres y tres hombres, con una edad

media de 38,8 años) evaluaron todos los vinos en los cuatro tiempos en que se dividió el estudio. Los motivos principales de abandono del panel y de falta de regularidad en la asistencia a las sesiones fueron los cambios en la situación laboral, siendo la falta de interés o el embarazo otros motivos más puntuales.

Sala de cata

Las instalaciones del Laboratorio de Análisis Sensorial Euskal Herriko Unibertsitatea (LASEHU) están situadas en la Facultad de Farmacia de Vitoria-Gasteiz. El LASEHU dispone de un laboratorio químico, una cocina / zona de preparación, una sala de limpieza, una sala de grupo con capacidad para unas 15 personas y una sala con siete cabinas normalizadas (ISO, 2007) e informatizadas.

La actividad principal desarrollada en el laboratorio químico fue la preparación de referencias, así como el almacenamiento de muestras en refrigeración.

En la cocina se sirvieron las muestras y las referencias, además de ubicarse en ella el bodeguero.

En la sala de limpieza se lavaron las copas mediante un lavavasos.

Figura 3.1.1- Sala de grupo.

La sala de grupo se utilizó principalmente para las discusiones relativas al desarrollo de referencias y para la puesta en común de las puntuaciones dadas a las muestras (armonización), actividades que tuvieron lugar durante la fase de desarrollo del método y entrenamiento del panel.

La sala con cabinas se utilizó en las últimas fases del entrenamiento del panel y en la fase de evaluación de las muestras del estudio. Esta sala constaba de siete cabinas informatizadas, así como de un climatizador y dos humidificadores. Las evaluaciones se llevaron a cabo bajo condiciones controladas de temperatura (21±2ºC) y humedad relativa (60±20%). Ambas magnitudes fueron registradas mediante un termohigrómetro (Testo 175-H2, Testo AG, Lenzkirch, Germany).

Figura 3.1.2- Cabinas.

En cada sesión, tanto en la sala de grupo como en las cabinas, se dispusieron servilletas de papel, agua y galletas “cracker” sin sal para la eliminación de sabores residuales. Además de ser una práctica habitual en la evaluación de vino, Ross *et al*. (2007) observaron que las galletas “cracker” son más efectivas para reducir la sensación de astringencia residual que otros posibles productos.

Servicio de las muestras de vino y de las referencias

Tanto las botellas de vino a partir de las cuales se sirvieron las muestras como las referencias sensoriales se ubicaban en el bodeguero el día previo a ser evaluadas. La temperatura del bodeguero era de 16±2ºC y se controló de forma continua mediante un registrador de temperatura (Testo 175-T2, Testo AG, Lenzkirch, Germany).

Las botellas de vino se abrían inmediatamente antes de ser analizadas las muestras. Durante la fase de evaluación de los vinos, el panel fue dividido en dos grupos, uno que evaluaba las muestras por la mañana y el otro por la tarde. Una vez dispensadas las muestras para el turno de la mañana, se desplazaba el aire del espacio de cabeza de las botellas mediante un sistema

de bomba de vacío (Screwpull wine pump set WA-101, Le Creuset UK Limited, Andover, Hampshire). Tras esta operación las botellas se ubicaban de nuevo en el bodeguero, para ser evaluadas en el turno de la tarde.

Tanto las muestras de vino como las referencias de olor y aroma fueron servidas en copas estandarizadas (ISO, 1977) y cubiertas con placas de Petri para reducir la pérdida de sustancias volátiles. El volumen dispensado era de 35±4 mL, servido mediante un dosificador volumétrico (Precision pour™ 3 ball liquour pour, Precision Pours, Inc. Minneapolis/St. Paul). En el caso de las muestras para evaluación de la apariencia se dosificaba un volumen de 25±1 mL mediante otro dispensador. Para la evaluación de referencias de sensaciones sápidas y trigeminales se utilizaron vasos de plástico.

Figura 3.1.3- Dosificadores volumétricos.

La temperatura de las muestras al ser dispensadas era de 16±2ºC, aunque en el momento de su evaluación podía ser ligeramente mayor en función del tiempo transcurrido desde su servicio.

3.1.1- Definición del método y puesta a punto del panel

3.1.1.1- Muestras de vino

Durante la fase previa a la evaluación de los vinos objeto de este estudio se analizaron 75 vinos de diversas localidades de RA. Todos ellos estaban acogidos a la DOC Rioja, excepto unos pocos que fueron recogidos directamente de los depósitos de las bodegas antes de ser calificados. La mayor parte de los vinos utilizados en esta fase previa eran de la cosecha de 2004.

Figura 3.1.4- Botellas de vino de RA en el bodeguero.

3.1.1.2- Definición del método

3.1.1.2.a- Generación y selección de descriptores

Antes de iniciar el trabajo con el panel se elaboró un listado de descriptores frecuentemente utilizados en la evaluación sensorial de vino. Para ello se utilizaron dos fuentes de información: referencias bibliográficas y una reunión con un grupo de expertos en vino tinto joven de RA (bodegueros, enólogos y restauradores) en la que se discutió cuáles son los descriptores más frecuentes. Este listado fue utilizado como información de apoyo durante la generación y selección de los descriptores.

La generación de términos descriptivos por parte del panel se llevó a cabo a lo largo de seis sesiones, durante las cuales se evaluaron 14 vinos. Las muestras se presentaron codificadas con un número de tres dígitos. En las dos primeras sesiones se generaron descriptores mediante comparación entre

vinos, anotando los jueces las semejanzas y diferencias entre cada pareja presentada. De la tercera a la sexta sesión se describieron varios vinos considerados individualmente. Durante estas cuatro sesiones los jueces dispusieron de la Rueda de los Aromas (Noble *et al*., 1987) y del listado de descriptores mencionado, para facilitar la generación de términos. En estas primeras sesiones se presentaron diversas referencias potenciales de descriptores de olor, sabor y sensaciones trigeminales, para facilitar la discusión sobre algunos términos y, al mismo tiempo, comenzar el desarrollo de las referencias sensoriales.

Durante estas sesiones los jueces no generaron descriptores de apariencia, ya que, previamente, se decidió evaluar únicamente dos parámetros de apariencia: el matiz y la intensidad de color. Esta decisión estuvo basada en el trabajo llevado a cabo con el grupo de expertos para definir el método de evaluación de la calidad sensorial (trabajo descrito en la segunda parte de esta tesis). La conclusión en relación con la apariencia fue que sólo esos dos parámetros discriminan entre los vinos tintos jóvenes de RA. La consideración de otros parámetros de apariencia hubiera hecho más tediosa la evaluación sin aportar información relevante.

En la séptima sesión se presentó al panel el listado de descriptores citados durante las seis primeras sesiones, así como la frecuencia de citación de cada uno (Tabla 3 del artículo 1). Los descriptores a evaluar (páginas 641 y 642 del artículo 1) fueron elegidos mediante discusión y por consenso, teniendo en cuenta especialmente la frecuencia de citación de los mismos.

3.1.1.2.b- Definición de la metodología de evaluación y puntuación

Durante las sesiones de generación de descriptores se utilizó, de forma provisional, una metodología de evaluación basada en la definida previamente por el grupo de expertos participantes en la definición del método de evaluación de la calidad sensorial. Dicha metodología fue simplificada de forma que, si bien los jueces evaluaban las muestras en un mismo orden y siguiendo un

procedimiento común (cómo oler, cómo evaluar el aroma…), no estuvieran condicionados para señalar específicamente unos u otros descriptores.

La metodología de evaluación definitiva se estableció una vez que los descriptores fueron seleccionados (Figura 2 del artículo 1).

Considerando que el análisis iba a ser cuantitativo, en la sexta sesión los jueces, además de señalar los descriptores percibidos, tuvieron que indicar por primera vez en una escala la intensidad percibida para aquellos con una mayor frecuencia de citación hasta ese momento. Esta escala preliminar era continua, desde "nula" en el extremo izquierdo hasta "muy elevada" en el extremo derecho. En la sesión novena se introdujo la escala definitiva a utilizar, una escala de intervalos estructurada del 1 al 7. Su elección se basó en la experiencia del laboratorio en la evaluación sensorial descriptiva cuantitativa de quesos de pasta dura (Bárcenas *et al*., 1999; Bárcenas *et al*., 2001).

Una vez definidos los descriptores a cuantificar se estableció la ficha de evaluación sensorial, inicialmente en papel y posteriormente en sistema informático (programa FIZZ, Biosystèmes, Couternon, Version 2.10 A).

3.1.1.2.c- Desarrollo de referencias sensoriales

El desarrollo de referencias sensoriales comenzó en la tercera sesión y se prolongó hasta la decimonovena, momento en el cual la composición de todas ellas quedó definitivamente establecida.

Las de olor fueron presentadas en copas estandarizadas mientras que aquellas a evaluar en boca fueron dispuestas en vasos de plástico blancos.

Las referencias fueron preparadas sobre una base vínica con el fin de que su evaluación se aproximara lo máximo posible a la percepción de dichas sensaciones en el vino. Para la preparación de la base vínica se eligió un vino de mesa comercial (vino tinto de mesa Don Simón, Bodegas García-Carrión)

que, debido a su gran producción a nivel industrial, presenta unas características organolépticas homogéneas entre lotes y a lo largo del tiempo. La composición de la base vínica se definió a partir de diversas diluciones de dicho vino mediante discusión y por consenso (Tabla 4 del artículo 1).

En el desarrollo de las referencias se optó por utilizar preferentemente compuestos químicos, con el fin de evitar la falta de homogeneidad asociada a los productos naturales (condicionada frecuentemente por la época del año, el estado de maduración, los diferentes proveedores…). Sin embargo, en algunos casos no fue posible reproducir con compuestos químicos determinados descriptores sensoriales, por lo que se recurrió a diversos alimentos.

Una vez elegida(s) la(s) sustancia(s) a partir de la(s) cual(es) reproducir cada uno de los descriptores, se desarrollaron referencias combinadas por razones de practicidad. En el caso del olor y del aroma, en cada una se combinaron dos descriptores. La elección de cada combinación se hizo de tal manera que ambos se apreciaran de forma similar a como cuando eran evaluados individualmente. Por tal motivo, se evitó combinar descriptores que pudieran estar próximos entre sí (por ejemplo frutas de bosque rojas, frutas del bosque negras y fruta de árbol).

En el caso de los sabores y sensaciones trigeminales, se combinaron en una misma referencia cuatro descriptores (acidez, astringencia, amargor y cuerpo).

Las referencias se presentaban a cada uno de los jueces en las cabinas de forma individual y bajo condiciones controladas de temperatura y humedad. De esta forma se evitaron las posibles diferencias de intensidad de olor que hubieran tenido lugar en caso de suministrar las mismas copas a todos los jueces, así como las variaciones de temperatura en la sala de grupo (donde no existía control de temperatura).

Una vez definidos los descriptores de cada referencia combinada así como las sustancias a partir de las cuales se prepararían, se ajustaron las

intensidades de cada una mediante discusión con el panel. Para las correspondientes a olor y aroma se definió una intensidad alta, claramente perceptible y difícilmente superable por la intensidad de ese mismo descriptor en vinos tintos jóvenes de RA. Se determinó que la intensidad estuviera en el punto 6 de la escala. En el caso de la acidez, amargor, astringencia y cuerpo, se decidió desarrollar dos referencias de intensidades diferentes, una correspondiente al punto 6 de la escala y la otra al punto 2. La composición definitiva de todas las referencias se muestra en la Tabla 4 del artículo 1.

Simultáneamente, para facilitar la asignación de puntuaciones en relación a las intensidades percibidas en las muestras de vino, se complementó cada intervalo de la escala con una breve descripción (Tabla 5 del artículo 1).

Figura 3.1.5- Selección y discusión de referencias sensoriales.

Tal y como se puede observar en la Tabla 4 del artículo 1, las referencias de olor, aroma, sabor y sensaciones trigeminales fueron preparadas a partir de una solución concentrada, la cual era congelada a -26ºC y posteriormente descongelada y llevada a un volumen final con base vínica,

para ser distribuida a los jueces. La congelación de soluciones concentradas permitió agilizar la preparación de referencias durante la fase de evaluación de los vinos.

Figura 3.1.6- Soluciones concentradas en el congelador.

Figura 3.1.7- Soluciones concentradas descongelándose.

Figura 3.1.8- Referencias dispensadas en las copas antes de ser presentadas a los jueces.

Para el matiz y la intensidad de color se desarrollo también una referencia combinada. Para ello se imprimieron diversos matices de color así como diversas intensidades de color en una lámina transparente (Staedtler Lumocolor ink jet transparent film, 100 mm; Nuernberg, Germany) mediante una impresora Lexmark Z605 (Lexington, U.S.A.) utilizando tinta de color InkTek (Galashiels, U.K.) for Lexmark and Samsung Printers (referencia LMI-1026C para color y LMI-1016D black para negro). Los matices y los grados de

intensidad de color se establecieron por discusión con el panel. Las coordenadas de color (en sistema RGB y en % de opacidad con Microsoft Office Word 2003) se muestran en la Tabla 6 del artículo 1. El matiz del vino se evaluaba por comparación con la escala horizontal y la intensidad de color por comparación con la escala vertical, tal y como se puede apreciar en las Figuras 3.1.9 y 3.1.10.

Figura 3.1.9- Referencia de color.

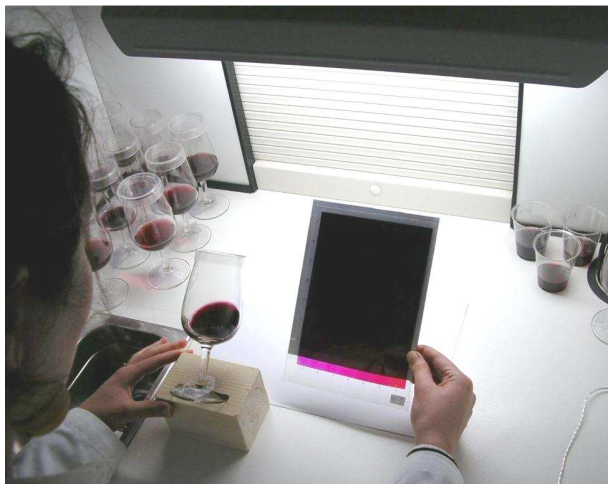


Figura 3.1.10- Evaluación de la apariencia del vino por comparación con la referencia.

3.1.1.3- Entrenamiento del panel

El entrenamiento del panel fue simultáneo en sus primeras fases con la definición del método y el desarrollo de referencias sensoriales, prolongándose a lo largo de 31 sesiones. En cada una de ellas, de 75-90 minutos de duración, además de evaluarse las referencias sensoriales correspondientes (ya definidas o todavía en fase de discusión), se evaluaron varios vinos y se pusieron en común las puntuaciones. El número de muestras de vino evaluadas en cada sesión se incrementó progresivamente, desde 2 hasta un máximo de 6. Si bien el entrenamiento se desarrolló inicialmente en la sala de grupo, en las últimas sesiones los jueces evaluaron los vinos en las cabinas y

fueron entrenados en la asignación de puntuaciones mediante el programa informático FIZZ.

A partir de la sesión 21 se comenzaron a elaborar gráficas donde se representaban las desviaciones de cada juez respecto al panel para cada descriptor. “Desviación” se definió como aquella puntuación que quedara fuera del rango definido por la media del panel ± 2. Tras calcular el porcentaje de desviaciones por encima y por debajo de dicho rango a lo largo de varias sesiones, se mostraba dicha información de forma individual a cada juez con el fin de que fueran conscientes de sus tendencias de puntuación respecto al panel y lograr así una mayor homogeneidad en las puntuaciones.

3.1.2- Evaluación de las muestras

3.1.2.1- Muestras de vino

En el estudio se analizaron 19 vinos de la cosecha de 2005 procedentes de 12 bodegas de diversas localidades de RA (Páganos, Eskuernaga-Villabuena, Guardia-Laguardia, Lapuebla de Labarca, Samaniego y Mañueta-Baños de Ebro). Atendiendo al proceso de elaboración y a la variedad de uva, los vinos se clasificaron en 4 grupos, tal y como se muestra en la Tabla 1 del artículo 2.

La selección y el contacto con las bodegas candidatas a participar en el estudio se llevó a cabo a través de ABRA. Tras informar de los objetivos, se recogió información sobre el proceso de vinificación utilizado en cada bodega y las variedades de uva empleadas. De esta forma se completó el número de cinco bodegas buscado para cada uno de los grupos (a excepción de los vinos elaborados por despalillado y con adición de uva Viura, donde no se consiguió contar con una quinta bodega).

Previamente a la recogida de los vinos se realizaron dos visitas a cada bodega, se ultimaron los detalles de la participación de cada una y se entregó una ficha que debía ser rellenada con diversos datos relativos a los vinos (prácticas vitícolas, datos de la vendimia, datos analíticos del mosto y el vino, datos sobre las condiciones de fermentación alcohólica y maloláctica…). Se hizo especial énfasis en la necesidad de no

Figura 3.1.11- Recogida de los vinos mediante garrafas de vidrio.

llevar a cabo ningún tratamiento que no fuera el trasiego antes de pasar a recogerlo, ya que operaciones como el filtrado o la clarificación, al no llevarse a cabo de la misma forma en todas las bodegas, afectarían de una forma no controlada a las características organolépticas de los vinos, pudiendo interferir con el efecto de los factores a estudiar.

Los vinos fueron elaborados según el procedimiento habitual en cada una de las bodegas y de acuerdo a las prácticas admitidas por el Consejo Regulador de la DOC Rioja (BOE, 2004).

Una vez finalizada la fermentación maloláctica y realizados los trasiegos para retirar los fangos, la última semana de diciembre de 2005 se realizó una visita a cada una de las 12 bodegas para recoger los 19 vinos. Cada uno de ellos se extrajo directamente de los depósitos en dos garrafas de vidrio de 20 L, las cuales se llenaron totalmente con el fin de evitar que quedara un espacio de aire que pudiera oxidar el vino.

Partiendo de los datos de los análisis físico-químicos realizados a los vinos tras la fermentación maloláctica, aquellos con un menor nivel de SO_2 libre fueron sulfitados mediante la adición de metabisulfito potásico (marca comercial Esseco, Trecate, Italia) de forma que todos ellos tuvieran como mínimo 22 mg/L de SO_2 libre.

Las garrafas se mantuvieron dos semanas a una temperatura de 8±2ºC, con el fin de que la mayor parte de las partículas en suspensión decantase. La segunda semana de enero de 2006 los vinos fueron embotellados al vacío en botellas de 750 mL. Los corchos utilizados fueron corchos “técnicos” (corcho técnico Perfect, Juvenal S.A., Santa Maria de Lamas, Portugal). El espacio de cabeza resultante en cada botella fue de aproximadamente 1 cm de altura. Los seis litros de vino del fondo del recipiente fueron desechados para evitar sedimentos. Se embotellaron 36 botellas de 750 mL de cada uno de los 19 vinos.

Figura 3.1.12- Llenado de botellas.

Figura 3.1.13- Encorchado de botellas.

Figura 3.1.14- Botellas encorchadas.

Figura 3.1.15- Ubicación de las botellas en cajas.

Figura 3.1.16- Cajas dispuestas para su transporte a la bodega.

Figura 3.1.17- Botellas en refrigeración en el laboratorio.

A cada botella se le colocó una etiqueta adhesiva donde se indicaba el código del vino (numerados del 1 al 19) así como el tiempo en el que sería recogido y analizado (del 1 al 4). En las botellas sobrantes se indicó el número del vino, por si acaso hubiera sido necesario recurrir a alguna de ellas en caso de ocurrir algún problema con las anteriores.

Las botellas fueron colocadas en cajas de 12 unidades, embaladas y trasladadas a una bodega, en la cual permanecieron tumbadas hasta el momento de su recogida. La temperatura de la bodega era de 12±3ºC (temperaturas más bajas en invierno y primavera y algo más altas en verano) y la humedad relativa de 90±5%.

Las botellas fueron recogidas en 4 ocasiones a lo largo de 2006: a finales de enero, finales de marzo, finales de mayo y primeros de septiembre. Una botella de cada vino fue inmediatamente llevada al laboratorio de la Casa del Vino-Ardo Etxea de Laguardia-Guardia para su análisis físico-químico y otras tres botellas fueron trasladadas al LASEHU para su evaluación sensorial en los días siguientes. En el LASEHU las botellas se mantenían tumbadas en refrigeración a 8±1ºC y el día anterior a ser evaluadas se colocaban en un bodeguero a 16±2ºC.

3.1.2.2- Evaluación sensorial de las muestras

Los 19 vinos fueron evaluados en cuatro series a lo largo de 2006, en cada una de las cuales fueron analizados por triplicado. Cada serie se componía de 10 sesiones, evaluándose 6 muestras por sesión.

En cada una de las series, la distribución a lo largo de las sesiones fue aleatoria, aunque de tal forma que los 19 vinos fueran evaluados una vez, seguidamente una segunda vez y a continuación una tercera vez. De esta forma se pretendían minimizar las posibles diferencias entre ellos en cuanto a su evolución durante su estancia en el laboratorio antes de ser evaluados. En cada serie se utilizó un diseño de bloques completos y equilibrados,

incluyéndose un vino no perteneciente al estudio (“vino 20”) para tener seis muestras en cada una de las 10 sesiones (la distribución en las cuatro series se muestra en el Anexo 2). Para presentarlas de forma aleatoria a los jueces se utilizó un diseño del tipo cuadrado latino extendido.

Cada sesión estuvo a su vez subdividida en dos partes: aproximadamente la mitad de los miembros del panel evaluaba las muestras por la mañana (a las 12:00) y la otra mitad las evaluaba por la tarde (a las 16:30), considerándose conjuntamente todas las puntuaciones. Debido a la influencia que pudiera tener el hecho de evaluar en un momento u otro del día se aconsejó a los jueces venir siempre a la misma hora, lo cual fue cumplido en gran medida a lo largo de las cuatro series.

Figura 3.1.18- Evaluación de vino en cabina.

Para minimizar el posible efecto que la evaluación en una u otra cabina pudiera tener sobre los jueces, se decidió establecer un orden aleatorio de ubicación en las cabinas en función de su orden de llegada.

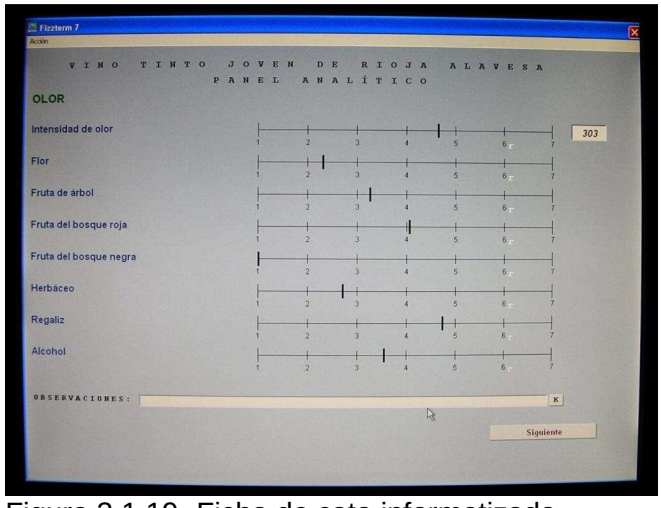


Figura 3.1.19- Ficha de cata informatizada.

Todas las muestras y las referencias sensoriales se disponían en las cabinas inmediatamente antes de que los jueces accediesen a las mismas.

Tal y como se definió en el programa informático, una vez que cada juez señalaba su nombre debía evaluar las referencias de olor, para lo cual se estableció un tiempo mínimo de 2 minutos. A continuación, el juez debía evaluar las referencias de aroma. Pasados dos minutos podía evaluar las referencias de sabores y sensaciones trigeminales. En la pantalla del ordenador se mostraba el listado de referencias a evaluar, así como la intensidad de cada una de ellas sobre la escala.

Transcurridos estos tiempos preestablecidos aparecía el código de la primera muestra que debía ser evaluada por cada juez. Una vez puntuada la intensidad de cada uno de los descriptores olfato-gustativos, el juez debía esperar el minuto preestablecido con el programa informático hasta que apareciera en pantalla el código de la siguiente muestra.

Tras la evaluación olfato-gustativa de las seis muestras se evaluaba el matiz y la intensidad de color de esos mismos vinos bajo la iluminación proporcionada por la lámpara ubicada en cada cabina (Philips Master TL-D 90 De Luxe 18W/965 SLV, Royal Philips Electronics, Amsterdam), muy similar a la luz natural (temperatura de color muy próxima a 6.500ºK e índice de rendimiento cromático mayor de 90%). Para ello se habían dispuesto previamente 2 series de copas adicionales que los jueces llevaban a la cabina para su evaluación.

Al finalizar la evaluación de las muestras aparecía una pantalla donde los jueces podían realizar los comentarios que creyeran oportunos en relación a la sesión.

3.1.2.3- Análisis físico-químico de las muestras

En cada uno de los cuatro tiempos se realizó un análisis físico-químico de los 19 vinos en la Casa del Vino-Ardo Etxea de Laguardia-Guardia, perteneciente a la Diputación Foral de Álava – Arabako Foru Aldundia. Éste es

uno de los tres laboratorios oficiales para analizar los vinos DOC Rioja (DOCE, 1999).

Los parámetros evaluados se muestran en la Tabla 2 del artículo 2. Los análisis fueron realizados siguiendo los mismos protocolos estandarizados utilizados para los vinos DOC Rioja. Cada parámetro fue analizado una vez en cada muestra, utilizándose patrones internos y al menos una muestra repetida para comprobar la exactitud del análisis, tal y como estaba establecido en el protocolo oficial del laboratorio.

3.1.2.4- Tratamiento de datos

Para el análisis estadístico de los datos sensoriales se consideraron las puntuaciones de los 10 jueces que evaluaron los 19 vinos al menos en una ocasión en cada una de las cuatro series.

El tratamiento de los datos se llevó a cabo con el programa SAS (SAS Institute, Cary, NC, USA). El análisis realizado dependió del objetivo perseguido en cada caso.

3.1.2.4.a- Estudio de la actuación del panel

Para conocer la actuación del panel y de cada juez en cada uno de los cuatro tiempos se utilizó el análisis CAP (*Control of Assessor Performances,* desarrollado en el contexto del proyecto Sensobase: https://liris.cesg.cnrs.fr). Para cada juez y cada descriptor se llevó a cabo un análisis de varianza (ANOVA) de una vía, y se consideró que el juez era discriminante para dicho descriptor si el efecto del vino en el test F era significativo (P<0,10). Para cada uno de los descriptores se llevó a cabo un test de concordancia entre cada juez discriminante y el conjunto de jueces discriminantes para ese descriptor calculando el coeficiente de Kendall. Finalmente, se determinó la repetibilidad individual considerando las desviaciones estándar de los replicados de cada

vino y comparándolas con las del panel para determinar si cada juez era significativamente menos repetible que el panel. De esta forma se obtuvo el porcentaje de descriptores para los cuales era discriminante cada juez, el porcentaje de concordancia de cada uno con el panel (referido a los descriptores para los cuales el juez había sido discriminante) y el porcentaje de descriptores para los cuales cada juez no era repetible. Para el cálculo de los descriptores que resultaron discriminantes para el panel se llevó a cabo un ANOVA de dos vías considerando los jueces y la interacción juez x vino como efectos aleatorios. Se consideraron discriminantes los descriptores para los cuales $P<0,05$.

3.1.2.4.b- Descripción sensorial de los vinos tintos jóvenes de Rioja Alavesa y estudio de los descriptores discriminantes entre vinos

Se calculó la intensidad media de cada descriptor a partir de las puntuaciones medias de los replicados de cada vino en cada tiempo y para cada juez, al margen de que el juez hubiera evaluado un solo replicado de ese vino, dos o los tres. En función de la intensidad media con la que, en términos generales, están presentes en los vinos, se ordenaron los 24 descriptores.

Además de su intensidad se determinó cuáles de ellos resultaron discriminantes entre los vinos mediante un ANOVA (procedimiento GLM-General Linear Model de SAS). El modelo utilizado fue el siguiente:

Vino + muestra(vino) + juez

Grados de libertad: 84 = 18 + 57 + 9

En este modelo el error está constituido por la heterogeneidad del panel.

Con el fin de simplificar el modelo estadístico se calculó la media de los replicados de cada vino en cada uno de los cuatro tiempos para cada juez, como si cada vino hubiera sido evaluado una única vez por cada juez en cada

tiempo. Se contrastó el factor vino con el término error (heterogeneidad del panel), para comprobar si la varianza de las puntuaciones entre vinos era significativamente mayor que las varianzas entre jueces. Los descriptores con un $P<0,10$ se consideraron discriminantes (sin considerar el tiempo).

Aunque la evolución de los vinos no era objeto de este análisis, se contrastó el efecto del tiempo (factor muestra(vino)) con el término error (heterogeneidad del panel) para conocer para cada uno de los descriptores si la varianza debida al tiempo era significativamente mayor que las varianzas internas del panel en cada tiempo. De esta forma se determinó qué descriptores evolucionaron significativamente ($P<0,10$) con el tiempo.

Posteriormente se contrastó el factor vino con el factor tiempo (muestra(vino)) para determinar para cada descriptor si la varianza entre vinos era significativamente mayor que la varianza entre tiempos. De este modo, se identificaron los descriptores que eran discriminantes entre vinos a pesar de que hubieran evolucionado de forma significativa con el tiempo.

A partir de los descriptores que habían resultado discriminantes entre vinos se realizó un análisis de componentes principales (PCA) para observar las relaciones de los descriptores entre sí, así como para comprobar visualmente qué vinos fueron los más estrechamente relacionados con cada uno de los descriptores. Dicho análisis se llevó a cabo a partir de las medias del panel en su conjunto para cada descriptor en cada uno de los cuatro tiempos. Los vinos y descriptores se proyectaron en un diagrama bidimensional.

3.1.2.4.c- Determinación de las diferencias entre los vinos en función del proceso de elaboración y la variedad de uva

Se analizaron los datos sensoriales y los datos físico-químicos de forma separada aunque siguiendo un procedimiento similar.

Para simplificar el modelo relativo a los datos sensoriales se calculó la media de las puntuaciones del panel para cada vino y cada tiempo, como si cada vino hubiera sido evaluado cuatro veces por el panel. El análisis se realizó a partir de 76 datos (19 vinos x 4 tiempos). En el caso de haber considerado todos los datos disponibles (19 vinos x 4 tiempos x 10 panelistas x 3 replicados) los grados de libertad hubieran sido mayores y, en consecuencia, la media cuadrática del error menor, la F mayor y la posibilidad de encontrar diferencias significativas mayor. El planteamiento realizado fue, por tanto, muy conservador.

En un primer paso, se llevó a cabo un ANOVA de tres vías (procedimiento GLM-General Linear Model de SAS) en base al siguiente modelo:

Proceso + VariedadUva + Proceso*VariedadUva + vino(Proceso*VariedadUva)

Grados de libertad: 18 = 1+1+1+15

En base a este modelo, tres factores (proceso, variedad de uva y vino) fueron contrastados con el término error (que es la varianza asociada al tiempo).

En un siguiente paso, los factores proceso y variedad de uva fueron contrastados con el vino: vino(Proceso*VariedadUva), que en este caso constituía el error. El modelo utilizado para este ANOVA de dos vías fue el siguiente:

Proceso + VariedadUva + Proceso*VariedadUva

Grados de libertad: 3 = 1+1+1

En este análisis se comparó la varianza entre los dos procesos de elaboración y la varianza entre las elaboraciones con y sin uva Viura con la varianza entre los vinos, para determinar qué descriptores eran dependientes

de cada uno de esos dos factores (proceso de elaboración y variedad de uva). Debido a que el análisis fue muy conservador, se consideró que había diferencias significativas cuando el valor de F era mayor que 2.

Para el análisis de datos físico-químicos se siguió el mismo procedimiento, con la diferencia de que los datos a partir de los cuales se realizaron los ANOVAs no eran una media de varios datos, al disponerse de un único dato para cada vino en cada tiempo.

Los descriptores sensoriales y parámetros físico-químicos para los cuales existían diferencias significativas en función del proceso de elaboración y/o de la variedad de uva fueron analizados mediante análisis de variables canónicas (CVA) para maximizar la separación entre los tipos de vino en base a los factores en estudio. Para ello se utilizaron las medias de los cuatro tiempos para cada descriptor y vino, es decir, se partió de 19 datos por cada descriptor. En el caso de los parámetros físico-químicos se partió de las medias de los datos de los diferentes tiempos para cada vino, es decir, de 19 datos por cada parámetro. Los descriptores sensoriales y tipos de vino, y los parámetros físico-químicos y tipos de vino fueron proyectados, de forma separada, en un diagrama bidimensional.

Finalmente, se construyó un diagrama bidimensional en el que se aprecia visualmente la relación entre los diferentes descriptores sensoriales y los parámetros físico-químicos. Para ello se incorporaron estos últimos al diagrama de descriptores sensoriales y tipos de vino, manteniendo los ejes, contribución de cada descriptor (vectores) y coordenadas de los tipos de vino del diagrama sensorial.

3.1.2.4.d- Estudio de la evolución de los vinos

Para estudiar el efecto del tiempo sobre las intensidades de los descriptores sensoriales se consideraron las medias de las puntuaciones de cada juez para cada descriptor y vino en cada tiempo. El ANOVA de tres vías

llevado a cabo (procedimiento GLM-General Linear Model de SAS) tenía el siguiente modelo simplificado:

Juez + vino + tiempo + juez*vino + juez*tiempo + vino*tiempo

Grados de libertad: 273 = 9+18+3+162+27+54

En este modelo el término residual estaba constituido por la interacción juez*vino*tiempo.

En el análisis, el factor vino estaba compuesto a su vez por otros dos factores, el proceso de elaboración y la variedad de uva, con el fin de considerar ambos factores y sus interacciones:

Vino = Proceso + VariedadUva + Proceso*VariedadUva + Vino (Proceso x VariedadUva)

Grados de libertad: 18 = 1+1+1+15

Por lo tanto, en la fórmula inicial el factor vino debiera ser sustituido por sus componentes. Igualmente, en cada una de las interacciones con otro factor el factor vino debiera ser sustituido por sus componentes, generándose interacciones entre cada uno de los factores del primer modelo con cada uno de los componentes del factor vino. Por lo tanto, el modelo resultante incluía 15 términos (354 grados de libertad) más el término residual o error (403 grados de libertad).

En el análisis, tanto el factor juez como el factor vino (Proceso x VariedadUva) fueron considerados un efecto aleatorio. Por tanto, la heterogeneidad de los jueces y la heterogeneidad de los vinos fueron consideradas en la inferencia estadística llevada a cabo con el factor tiempo y su interacción con los factores proceso de elaboración y variedad de uva.

Mediante el cálculo de las medias cuadráticas se obtuvo el término error para cada factor de interés (Tabla 2 del artículo 3).

En relación al análisis de los datos físico-químicos se aplicó un ANOVA de tres vías con el tiempo, el proceso de elaboración y la variedad de uva como factores y el vino como efecto aleatorio. De esta forma, se contrastó la variación debida al tiempo con vino(proceso*VariedadUva)*tiempo como término error.

Tanto para los datos sensoriales como para los físico-químicos se consideraron las interacciones del tiempo con el proceso de elaboración y con la variedad de uva para determinar si existían diferencias en la evolución del vino en función de estos dos factores.

Debido a que el análisis fue bastante conservador, se consideró que existían diferencias significativas cuando $P<0,10$.

Los descriptores sensoriales y parámetros físico-químicos para los cuales existían diferencias significativas en función del tiempo fueron analizados mediante análisis de variables canónicas (CVA) para maximizar la separación entre los cuatro tiempos. Para ello se utilizaron las medias de los 19 vinos para cada descriptor y tiempo, es decir, se partió de cuatro datos por cada descriptor. En el caso de los parámetros físico-químicos, se consideraron las medias de los vinos para cada parámetro y en cada tiempo, es decir, cuatro datos por cada parámetro. Los descriptores sensoriales y los tiempos, y los parámetros físico-químicos y los tiempos fueron proyectados, de forma separada, en un diagrama bidimensional.

3.2- Desarrollo de un método para la evaluación de la calidad sensorial y puesta a punto de un panel de jueces expertos.

3.2.1- Desarrollo de un método para evaluar la calidad sensorial de los vinos tintos jóvenes de Rioja Alavesa

En la presente sección, además de diversos aspectos tales como las muestras utilizadas o la sala de cata, se describen los pasos llevados a cabo para desarrollar el método de evaluación de la calidad sensorial de los vinos tintos jóvenes de RA. Las fases del trabajo están ordenadas cronológicamente, aunque, en algunos casos, varias de ellas se solaparon en el tiempo.

3.2.1.1- Muestras de vino

Para desarrollar el método se utilizaron 90 muestras de vino tinto joven de RA embotelladas y etiquetadas. La mayor parte de ellas fue proporcionada por ABRA. Dado el número de muestras y considerando que procedían de diferentes localidades de RA (Guardia-Laguardia, Páganos, Mañueta-Baños de Ebro, Lapuebla de Labarca, Navaridas, Oion-Oyón, Eltziego-Elciego, Samaniego, Eskuernaga-Villabuena, Bastida-Labastida, Lantziego-Lanciego), se consideró que eran representativas de los vinos tintos jóvenes de la zona.

3.2.1.2- Preparación y disposición de las muestras

Al recepcionar en el laboratorio las botellas de vino se comprobaba que no presentaban ninguna anomalía y que disponían de etiquetas identificativas. Las botellas eran codificadas con una cifra de tres dígitos y ubicadas en un bodeguero a 17±2ºC hasta el momento de ser analizados los vinos.

Todas las muestras utilizadas fueron dosificadas en copas normalizadas de 200 mL (ISO, 1977) inmediatamente antes de ser evaluadas. En cada copa se dispensaban 35±4 mL de vino mediante un dosificador volumétrico. Seguidamente, se tapaba cada copa con una placa de Petri de plástico para disminuir la pérdida de sustancias volátiles. Las muestras eran servidas a 17±2ºC, pudiendo incrementarse la temperatura de la muestra en 1 ó 2ºC durante la sesión.

3.2.1.3- Sala de cata

Las reuniones técnicas para desarrollar el método se llevaron a cabo en el LASEHU (descrito en el punto 3.1). Tanto en la sala de grupo como en las cabinas, cada experto disponía de servilletas de papel, agua y galletas "cracker" para la eliminación de sabores residuales.

3.2.1.4- Grupo de discusión

Para constituir el grupo de expertos con el que se definió el método, se contactó con diversas personas que podrían aportar su gran conocimiento sobre el vino de RA. El grupo lo integraron 12 personas: cinco enólogos o licenciados/ingenieros con larga experiencia de trabajo en el sector vitivinícola, cinco gastrónomos o personas con gran experiencia en el sector hostelero y otras dos personas que, sin tener una relación directa con el vino en su actividad profesional, contaban con años de experiencia en la cata de vinos. Además de estas 12 personas, también se contó con la participación más puntual de algunos expertos que, sin poder asistir de forma periódica a las reuniones, también aportaron su opinión.

Para definir el método se llevaron a cabo 15 reuniones con una frecuencia mensual. Las reuniones comenzaban a las 18:00 horas y tenían una duración de en torno a dos horas y media.

El contenido específico de cada reunión dependía de la fase del desarrollo del método. Además de la discusión teórica sobre aspectos relacionados con la definición del método y de la evaluación y discusión de referencias sensoriales, en todas las sesiones se evaluaron varias muestras de vino tinto joven de RA.

Tras cada reunión se elaboró un acta que recogía los principales aspectos tratados y las decisiones adoptadas. Dicho documento y el orden del día de la siguiente reunión eran enviados tanto a ABRA como a cada uno de los expertos.

A continuación se describen las etapas llevadas a cabo durante las 15 reuniones. Las fases se presentan en un orden cronológico aproximado, ya que en ciertos momentos varias de ellas se llevaron a cabo de forma simultánea.

3.2.1.5- Generación de descriptores

Esta fase tuvo lugar principalmente durante las tres primeras reuniones, en las cuales los expertos evaluaron un total de 18 vinos, anotando los términos olfato-gustativos y de apariencia percibidos. Al no estar definido todavía el procedimiento de evaluación de las muestras, cada experto las evaluó de forma libre.

Si bien esta parte del trabajo estuvo centrada específicamente en las tres primeras sesiones, se continuó recogiendo los descriptores citados por los expertos en las sesiones posteriores.

3.2.1.6- Selección de los parámetros determinantes de la calidad sensorial

Sobre la base del listado de descriptores recogidos, y considerando asimismo los parámetros que habitualmente se suelen utilizar en la evaluación de los vinos tintos (recopilados mediante búsqueda bibliográfica), se eligieron y

definieron por consenso aquellos parámetros que determinarían la calidad sensorial de los vinos.

Para ello, además de considerar la frecuencia de utilización de cada uno por parte de los expertos en las reuniones previas, se formularon dos preguntas principales para dirigir la discusión:

- *¿Realmente determina este parámetro la calidad de los vinos o apenas tiene importancia?*
- *¿Existen realmente diferencias entre los vinos en relación a este parámetro?*

Mediante la respuesta a estas preguntas se pretendía seleccionar aquellos que verdaderamente determinen la calidad y descartar los que, si bien pudieran ser evaluables, no tendrían apenas influencia sobre la calidad sensorial de los vinos.

Los descriptores concretos de olor, aroma, sabor y sensaciones trigeminales recogidos durante las primeras sesiones fueron considerados dentro de los parámetros correspondientes.

3.2.1.7- Definición de la situación óptima y categorización de la calidad para cada parámetro

Se decidió utilizar una escala discontinua de 7 puntos para puntuar cada parámetro. La elección de esta escala se basó en la utilización durante varios años de una similar en el método acreditado de evaluación de queso Idiazabal (Pérez Elortondo *et al*., 2007), la cual se consideró satisfactoria. La correspondencia de cada puntuación con un grado de calidad se muestra en la Tabla 3.2.1.

Tabla 3.2.1- Correspondencia entre puntuaciones de calidad y grados de calidad.

Grado de calidad	Puntuación de calidad
Máxima	7
Muy alta	6
Alta	5
Media	4
Baja	3
Muy baja	2
Nula	1

El siguiente paso fue formular la descripción sensorial correspondiente a cada grado de calidad, lo cual se llevó a cabo mediante discusión, respondiendo a la siguiente pregunta: "*En relación a este parámetro ¿cuál es la situación que debería presentar un vino tinto joven de Rioja Alavesa para ser considerado ideal?"*. Asimismo, se complementó dicha discusión con la evaluación de varios vinos y respondiendo a la pregunta *"¿Qué es lo que le faltaría a este vino para poder ser considerado ideal?"*.

En la definición de la situación sensorial óptima se tuvo en cuenta expresamente el concepto de tipicidad, especialmente en relación a los descriptores de olor y aroma.

Tras definir la situación correspondiente a la calidad máxima (puntuación 7), se describió la situación sensorial correspondiente a los otros seis puntos de la escala para cada uno de los parámetros. Mediante la asociación de la puntuación a un grado de calidad y a una determinada descripción sensorial, se objetivó la asignación de puntuaciones, de tal modo que cada puntuación está definida por la percepción de determinados descriptores o defectos o, en su caso, por la intensidad percibida de una determinada sensación. De esta manera, los jueces no tienen que realizar interpretaciones ni dar su opinión, al estar ya establecidos los criterios para puntuar en función de lo percibido.

3.2.1.8- Definición del procedimiento de evaluación

El procedimiento detallado de evaluación sensorial del vino, incluido el orden de evaluación de los parámetros, se definió con los expertos mediante discusión a lo largo de las primeras sesiones. Éste quedó reflejado en una guía de evaluación que a partir de ese momento se proporcionó a cada experto en cada sesión. De este modo, todos los expertos evaluaban de la misma forma los vinos.

3.2.1.9- Definición de la ficha de cata

Una vez definidos los parámetros, la escala a utilizar y el orden de evaluación, se procedió a elaborar la ficha de cata. Además de la escala para puntuar cada parámetro, en la ficha se incluyeron los descriptores, defectos y aristas más habituales en los vinos tintos jóvenes de RA. Su elección se basó en una discusión con los expertos, tomando en consideración el listado generado durante las primeras sesiones.

En esta fase se trabajó con fichas en papel. La utilización de fichas en soporte informático se implantó posteriormente, una vez que se dio comienzo a la puesta a punto del panel que evaluaría los vinos de forma sistemática en base al método desarrollado.

3.2.1.10- Ponderación de las calidades parciales para el cálculo de la calidad global

Partiendo de que la importancia de cada parámetro no es la misma, la última fase del desarrollo del método fue la definición de la contribución de cada uno de ellos sobre la calidad global.

Tras una discusión con el grupo de expertos, y teniendo en cuenta las ponderaciones de otras fichas de cata, se definió el porcentaje de importancia

de cada parámetro sobre la calidad sensorial global del vino. Es decir, la calidad global del vino se justificaría a partir de las calidades parciales, correspondientes a cada uno de los parámetros considerados.

Una vez establecidas estas ponderaciones, los analistas sensoriales serían los encargados de aplicarlas a las puntuaciones asignadas por el panel para así calcular la puntuación global de cada muestra.

3.2.1.11- Desarrollo de referencias

Las referencias sensoriales se desarrollaron con dos objetivos principales. Por un lado, homogeneizar el vocabulario utilizado y el concepto asociado a cada término, de forma que cuando los expertos se refirieran a una sensación (por ejemplo, olor a frutas del bosque, aroma a cocido…) todos entendieran lo mismo. Por otro lado, utilizarlas posteriormente para entrenar al panel que evaluaría de forma sistemática la calidad sensorial de los vinos.

Su definición comenzó en la cuarta reunión y se prolongó durante el resto de reuniones dado el alto número de referencias a desarrollar y la dificultad que entrañaba la puesta a punto de algunas de ellas. Las potenciales referencias de cada descriptor fueron presentadas a los expertos y discutidas en grupo. En base a los comentarios eran descartadas (en caso de distar mucho de la sensación buscada) o reformuladas para ser evaluadas en otra sesión.

Previamente a la preparación de las correspondientes a las sensaciones olfato-gustativas se definió, mediante discusión con el grupo de expertos, una base vínica sobre la cual prepararlas. Los requisitos que debía cumplir la base vínica eran presentar un olor genérico a vino en el que no destacase ninguna característica en concreto, y que las sensaciones provocadas por dicha base no fueran muy intensas. Por lo tanto, al preparar las referencias sobre esta matriz, destacaría el descriptor buscado sobre un fondo vínico, simulando la percepción de ese descriptor al evaluar un vino. De este modo, su evaluación

se acerca mucho más a la situación real de análisis del vino que si se prepararan simplemente sobre una base acuosa. Para la elección del vino con el cual preparar la base vínica resultaba imprescindible asegurar que presentara siempre las mismas características organolépticas, más teniendo en cuenta que el método a desarrollar iba a utilizarse durante años. Debido a ello, se eligió un vino de mesa comercial, que por su gran producción a nivel industrial siempre presenta aproximadamente las mismas características.

La elección de las sustancias a utilizar en la preparación de cada referencia se realizó inicialmente mediante revisión bibliográfica. Además, se tuvieron en cuenta las sugerencias de los expertos sobre las sustancias y procedimientos que pudieran utilizarse para lograr reproducir la característica buscada.

Preferentemente, se optó por desarrollarlas a partir de productos químicos evitando, en la medida de lo posible, la utilización de productos naturales o alimentos. Si bien, en muchos casos, aquellas preparadas a partir de estos productos pueden reproducir de una forma más real algunas de las características buscadas, la variabilidad de las características de los productos frescos (dependientes del momento del año, proveedor, estado de maduración…) y los riesgos inherentes a utilizar productos comerciales (desaparición de la marca, reformulación del producto…) aconsejaron recurrir a sustancias químicas, en la medida de lo posible. Aunque éste fue el criterio general, en algunos casos hubo que recurrir a determinados productos alimenticios, especialmente al abordar sensaciones que no se deben a un compuesto químico en particular sino a una mezcla compleja de ellos.

En el caso de las referencias para cuya preparación se necesitaban cantidades mínimas de un determinado compuesto, se optó por elaborar soluciones madre concentradas. En estos casos, las referencias se preparaban adicionando un determinado volumen de la solución madre a la base vínica.

Con el fin de establecer un manejo ágil y cómodo de las referencias, se decidió almacenarlas congeladas a -26ºC. El día anterior a ser evaluadas se

descongelaban y se ubicaban en el bodeguero para que alcanzaran la temperatura de servicio requerida (17±2ºC, la misma que el vino). Durante la fase de desarrollo se utilizó la congelación de referencias sin advertir de ello a los expertos, comprobándose que no afectaba a las características organolépticas.

Según se iban definiendo, las referencias eran presentadas a los expertos en sucesivas sesiones, codificadas con tres dígitos. De esta forma, se corroboró que cada una de ellas era identificada y su formulación adecuada.

Las referencias de apariencia fueron desarrolladas sobre un soporte transparente. Para su definición se presentó a los expertos diversas referencias potenciales, las cuales fueron discutidas y reajustadas durante varias sesiones hasta su definitiva aceptación.

3.2.1.12- Tratamiento de los datos y elaboración de informes

El procedimiento a seguir para el tratamiento de datos para la elaboración del informe de cada vino se definió internamente en el laboratorio. Para ello se tuvo en cuenta la experiencia acumulada con el método acreditado para la evaluación sensorial de queso Idiazabal (Pérez Elortondo *et al*., 2007).

Tal y como se definió en el método, siete jueces cualificados evaluarían cada muestra de vino y a partir de las puntuaciones otorgadas se calcularía la media para cada parámetro.

En relación a los descriptores, defectos y aristas, se determinó considerar que cada uno de ellos estaría presente en el vino cuando cinco o más de los siete jueces lo citase.

Respecto al informe a elaborar sobre cada vino, se decidió que en la primera página, además de la identificación de la sesión y el vino, se incluyera la puntuación media de cada parámetro así como los descriptores, defectos y

aristas citados por al menos cinco jueces. En la segunda página se incluirían unos diagramas en forma de tela de araña donde se recogería la frecuencia de citación de los diferentes descriptores, defectos y aristas, aunque dicha frecuencia no llegara a 5. Se consideró que esta información también podría ser de interés para las bodegas.

3.2.1.13- Revisión del método

Aunque el desarrollo del método se consideró formalmente concluido tras las 15 reuniones mencionadas, no fue nunca concebido como algo totalmente finalizado y estático, sino abierto a posibles mejoras según se fuera aplicando de forma sistemática. En este sentido, ante el surgimiento de algunas situaciones que planteaban ciertas dudas se recurrió de nuevo a algunos expertos, tanto internos como externos al panel, para recoger su opinión y formular de forma consensuada los cambios pertinentes al método.

Los dos ejemplos más relevantes de revisión puntual de algunos aspectos fueron los olores/aromas tropicales y a barrica.

En relación a los olores/aromas tropicales, ante la aparición de estas sensaciones en varias muestras y los comentarios surgidos acerca de la falta de tipicidad de dichos vinos, se abordó una discusión acerca de cómo considerarlos. Tras recoger diversas opiniones y realizar una propuesta por parte del laboratorio, se acordó modificar los criterios de puntuación en el caso específico de detección de este tipo de olores/aromas, de forma que estos vinos no pudieran tener una puntuación alta en los parámetros de olor y aroma.

Una discusión similar tuvo lugar acerca de los vinos con olores/aromas a barrica. La crianza en barrica no es una característica típica de estos vinos, por lo que, tras recoger la opinión de los expertos, se decidió que en caso de detectar de forma evidente olores/aromas a barrica en algún vino no se seguiría adelante con la evaluación.

3.2.2- Puesta a punto de un panel de jueces expertos para evaluar la calidad sensorial de los vinos tintos jóvenes de Rioja Alavesa.

Una vez que el método de evaluación estuvo definido, se puso a punto un panel de jueces expertos. Con vistas a la acreditación de dicho método se elaboraron diversos procedimientos normalizados técnicos (PNTs), donde se detallaron todas las fases a seguir para la puesta a punto del panel y para la aplicación del método.

3.2.2.1- Sala de cata

La sala de grupo fue utilizada, fundamentalmente, para el entrenamiento en identificación de referencias y para la puesta en común de puntuaciones otorgadas a las muestras.

Los vinos utilizados durante la fase de puesta a punto del panel y durante la evaluación sistemática posterior fueron evaluados en las cabinas. Asimismo, otras pruebas en las que no se evaluaron propiamente muestras de vino (pruebas de selección, entrenamiento básico e identificación de referencias en la fase de cualificación) también se llevaron a cabo en las cabinas.

Tal y como establece el PNT correspondiente, cada prueba o sesión realizada en cabinas se efectuó bajo condiciones ambientales controladas (temperatura de 21±2ºC y humedad relativa de 60±20%). Para su control se dispuso de un climatizador y de dos humidificadores. La temperatura y la humedad relativa de la sala fueron registradas en cada sesión con un termohigrómetro (Testo 175-H2, Testo AG, Lenzkirch, Germany).

3.2.2.2- Jueces

La terminología a utilizar de aquí en adelante en relación a los jueces hace referencia al grado de cualificación obtenido:

- Juez: término genérico para designar a cualquier persona que lleva a cabo una prueba sensorial, sin especificar su grado de formación.
- Juez catador: aquella persona que ha superado el entrenamiento básico, por lo que tiene una formación básica y general en evaluación sensorial de alimentos.
- Juez experto: aquella persona que ha realizado un entrenamiento en base a un método y/o producto específico y que ha superado las pruebas de cualificación. El término juez cualificado sería equivalente al de juez experto.

  El término experto, si no va acompañado de la palabra juez, hace referencia a las personas que por su actividad profesional y/o trayectoria tienen un profundo conocimiento de un producto en concreto, al margen de que hayan realizado o superado las diferentes pruebas detalladas en este capítulo. Por lo tanto, un experto sólo será considerado juez experto cuando haya superado las pruebas de cualificación en el método y/o producto específico.

Treinta y un jueces catadores (11 mujeres y 20 hombres) que habían demostrado ser aptos para la evaluación sensorial de alimentos (habían superado las pruebas de selección y entrenamiento básico, explicadas en los apartados 3.2.2.6.b y 3.2.2.6.c) iniciaron el entrenamiento específico. Entre ellos se encontraban 14 expertos en vino, ocho de los cuales habían participado en el desarrollo del método. De las otras 17 personas, nueve tenían experiencia en análisis sensorial. Tras realizar las pruebas de cualificación (explicadas en el apartado 3.2.2.6.e), el panel fue constituido con 20 jueces expertos. Al realizarse anualmente pruebas de recualificación para los integrantes de panel y pruebas de cualificación para nuevos jueces, el número de miembros del panel puede variar ligeramente a largo de las campañas.

3.2.2.3- Muestras de vino

Los vinos utilizados para poner a punto el panel y aquellos analizados por el panel ya cualificado fueron vinos tintos jóvenes de RA, correspondientes, de forma mayoritaria, a la cosecha del año anterior (algunos vinos, aunque sean de la cosecha XX, son embotellados y salen al mercado en verano, otoño e incluso invierno del año XX+1, por lo que pueden ser evaluados a comienzos del año XX+2 como vinos jóvenes).

3.2.2.4- Preparación y disposición de las muestras de vino y las referencias

En base a lo establecido en el PNT correspondiente a la recepción de muestras, las botellas se codificaban al llegar al laboratorio de la siguiente manera:

- J (de “joven”).
- Tres cifras: correlativas, según llegaban las botellas al laboratorio.
- Las dos últimas cifras del año de la cosecha correspondiente.
- Una letra: A, B, C… para identificar cada botella de una misma muestra (mismo lote y misma fecha de recepción).

Las botellas codificadas se mantuvieron en un bodeguero a 17±2ºC hasta el momento del análisis. Su temperatura se controló de forma continua mediante un registrador de temperatura (Testo 175-T2, Testo AG, Lenzkirch, Germany), para comprobar que permanecían dentro de dicho margen.

Las muestras fueron dosificadas en copas normalizadas (ISO, 1977). El volumen dispensado fue de 35±4 mL para la evaluación de los parámetros olfato-gustativos y de 25±1 mL para los de apariencia. Sobre cada copa se colocó una placa de Petri de plástico. La temperatura a la que se sirvieron las muestras fue de 17±2ºC.

Tal y como se ha indicado anteriormente, las referencias utilizadas en las diferentes etapas de puesta a punto del panel así como en la evaluación sistemática de vinos, habían sido previamente congeladas. El día anterior a la sesión se descongelaban y se mantenían en el bodeguero a 17±2ºC hasta el momento de la cata. En el caso de las referencias de descriptores y defectos de olor se dosificaban 25±1mL en copas normalizadas, cubriéndolas con una placa de Petri. En el caso de las referencias correspondientes a descriptores y defectos de aroma, así como a aristas, se dispensaba un volumen aproximado de 15 mL en vasos de plástico.

3.2.2.5- Procedimiento de evaluación de las muestras y las referencias

La evaluación de las muestras de vino y de las referencias se llevó a cabo en las cabinas, bajo la iluminación tenue procedente del fondo gris de la pantalla del ordenador, de forma que no se pudiera apreciar la apariencia de las mismas (la luz roja con la que estaban equipadas las cabinas resultaba incómoda para algunos jueces). Las características de apariencia se evaluaron bajo la iluminación de la lámpara dispuesta en cada cabina (Philips Master TL-D 90 De Luxe 18W/965 SLV, Royal Philips Electronics, Amsterdam), la cual era muy similar a la luz natural, con una temperatura de color muy próxima a 6.500ºK y con un índice de rendimiento cromático mayor de 90%.

El procedimiento de evaluación de las muestras y los criterios para puntuar cada parámetro están descritos con detalle en el artículo 4 (Figuras 1-6).

Como procedimiento sistemático de ensayo se estableció que, al comienzo de cada sesión, al menos dos muestras debían ser evaluadas en las cabinas utilizando la ficha en soporte papel. Seguidamente, los jueces expertos pasaban a la sala de grupo para poner en común las puntuaciones, con el objetivo de armonizar criterios en relación a dichas muestras. A continuación, los jueces volvían a las cabinas donde evaluaban hasta un máximo de ocho vinos, asignando las puntuaciones mediante el sistema informático FIZZ

(Biosystèmes, Couternon, versión 2.10 A). El orden en el que cada juez evaluaba los vinos era establecido de forma aleatoria por el propio programa informático. Se programó un tiempo mínimo de espera de 30 segundos entre muestras consecutivas.

Asimismo, se proporcionó a los jueces agua de baja mineralización para enjuagarse la boca, galletas "cracker" para eliminar sabores residuales, vasos de plástico para escupir las muestras y servilletas.

3.2.2.6- Descripción de las fases desarrolladas para la puesta a punto del panel y para el seguimiento y control de éste una vez cualificado.

3.2.2.6.a- *Reclutamiento de jueces*

Para conformar un panel que evalúe la calidad sensorial de los vinos de una forma sistemática durante años y, considerando que en cada sesión deben tomar parte siete jueces expertos, es necesario disponer de un número suficiente de éstos. De esta forma, la evaluación sistemática de los vinos no estará comprometida por situaciones como falta de disponibilidad, situaciones de enfermedad, vacaciones…

Para el reclutamiento de jueces, tras la difusión mediante diversos medios de la posibilidad de realizar las pruebas de selección para en un futuro poder formar parte de un panel de cata de vino, se llevó a cabo una pequeña entrevista con cada candidata/o. En ella se presentó el objetivo de las pruebas, el calendario de las sesiones y se recogieron las perspectivas de cada persona. Asimismo, cada candidata/o rellenó un formulario (Figura 3.2.1) acerca de diversos aspectos que pueden interferir la percepción sensorial, alergias, disponibilidad…

CUESTIONARIO

La información que se solicita será confidencial.

Fecha:----------

Apellidos:----------; Nombre:----------

Genero: ☐ Mujer ☐ Hombre

Edad: ☐ menos de 35 años ☐ entre 35 y 55 años ☐ más de 55 años

Tlf (1):---------- -Tlf (2): ----------

E-mail:----------D.N.I: ……

Dirección:……

Profesión:……

Formación:……

Datos previos sobre análisis sensorial

1.- Señale su disponibilidad y su frecuencia, tanto semanal como diaria, para participar en ensayos de catas.

☐ Lunes ☐ Martes ☐ Miércoles ☐ Jueves ☐Viernes

☐ Horario de mañana (de 10 a 13 horas) ☐ Horario de tarde (de 16 a 19 horas)

Observaciones----------

2.- ¿Ha participado alguna vez en una cata de análisis sensorial?

☐ NO ☐ SI

a.- ☐ cata de consumidores ☐ cata comentada ☐ panel analítico

b.- ¿Qué alimento/s ha evaluado?----------

3.- Explique porqué desea formar parte de un panel de catadores/jueces expertos (interés y motivación).

……

……

Datos sanitarios

4.- ¿Si Ud. sigue alguna dieta especial, señale de qué tipo:

☐ Diabética ☐ Hiposódica

☐ Hipercalórica ☐ Hipocalórica

☐ Vegetariana ☐ Otras (especificar)----------

5.- ¿Toma regularmente algún tipo de medicamento?.

☐ NO ☐ SI ☐ NS / NC

6.- ¿ Ha tenido o tiene problemas (alergia, intolerancia o aversión) con algún alimento?.

☐ NO ☐ SI ☐ NS / NC

*Especificar----------

7.- ¿Es Ud. fumador?.

☐ NO ☐ SI

8.- ¿Es propenso a tener gripe o catarro?.

9.- ¿Tiene alguna enfermedad crónica?.

10.- ¿Lleva prótesis dental?……

Datos sobre alimentación

11.- ¿Qué alimentos y/o bebidas **no** le gustan?.

……

……

12.- En las comidas, acostumbra a echar: Poca sal ☐ Algo de sal ☐ Mucha sal ☐

Eskerrik asko zure laguntzagatik /Gracias por su colaboración

OBSERVACIONES del analista

……

……

Figura 3.2.1- Formulario para el reclutamiento de jueces potenciales.

3.2.2.6.b- *Selección de jueces*

El objetivo de estas pruebas fue detectar posibles problemas relacionados con la percepción sensorial y determinar si cada participante tenía la suficiente sensibilidad para poder formar parte de un panel de evaluación sensorial de alimentos.

La selección consistió en 10 pruebas realizadas por duplicado a lo largo de cuatro sesiones (dos sesiones por semana). Estas pruebas, basadas en normas ISO, están recogidas en la Tabla 1 del artículo 5.

Se estableció que para superar la fase de selección era necesario llegar a un 75% de pruebas superadas (15 de 20). Aquellas/os candidatas/os que no alcanzasen el 60% no continuarían adelante con el proceso, mientras que quienes llegasen al 60% pero sin lograr el 75% podrían repetir una única vez las pruebas no superadas para intentar alcanzar el porcentaje exigido.

3.2.2.6.c- *Entrenamiento básico*

Las personas que superaron la fase de selección llevaron a cabo las pruebas de entrenamiento básico. El objetivo de estas pruebas fue dotarles de unos conocimientos y destrezas básicas en el análisis sensorial de alimentos antes de llevar a cabo el entrenamiento específico, así como comprobar la adecuada aplicación de dichas destrezas. Para ello, se realizaron las 12 pruebas mostradas en la Tabla 2 del artículo 5, a lo largo de cuatro sesiones distribuidas en dos semanas.

Se exigió un 75% de pruebas realizadas correctamente para superar esta fase. Aquellas/os candidatas/os que no llegasen al 75% podrían repetir las pruebas no superadas. Quienes realizaron satisfactoriamente el entrenamiento básico recibieron la calificación de “juez catador”.

3.2.2.6.d- *Entrenamiento específico*

Los jueces catadores fueron entrenados a lo largo de 15 sesiones en la metodología de evaluación de la calidad sensorial del vino tinto joven de RA. Las sesiones que tuvieron lugar por la mañana comenzaban a las 10:00, mientras que las sesiones desarrolladas por la tarde comenzaban entre las 17:00 y las 18:00, en función de la disponibilidad de los jueces. Cada sesión se prolongó por espacio de, aproximadamente, 90 minutos.

En esta fase los jueces fueron instruidos en la utilización de la metodología y criterios recogidos en la guía de evaluación. Asimismo, evaluaron las referencias de olores, aromas y aristas, así como diversos vinos tintos jóvenes de RA. Durante las primeras sesiones las referencias fueron presentadas identificadas, mientras que en las sesiones posteriores se mostraron codificadas, de forma que cada juez debía identificarla, comprobando a continuación su grado de acierto. El número de muestras de vino evaluadas por sesión se incrementó progresivamente según avanzó el entrenamiento hasta llegar a un máximo de nueve.

En la mayor parte de las sesiones, las puntuaciones, descriptores, defectos y aristas de los vinos se recogieron mediante la ficha en formato papel. En las últimas sesiones los jueces fueron instruidos en la asignación de puntuaciones mediante el sistema informático FIZZ.

3.2.2.6.e- *Cualificación y recualificación de jueces expertos*

Tras el entrenamiento específico los jueces realizaron las pruebas de cualificación. El objetivo de las mismas fue determinar si cada uno ellos estaba preparado para formar parte del panel de jueces expertos que evaluaría los vinos de forma sistemática.

Las pruebas de cualificación se desarrollaron a lo largo de 3 sesiones. La primera de ellas estuvo dedicada a la evaluación de referencias. Se

presentaron 50 referencias en total, 20 correspondientes a descriptores y defectos de olor, 20 a descriptores y defectos de aroma y 10 a aristas. Las referencias de olor y las de aroma fueron evaluadas en dos secuencias de 10 referencias cada una, con un descanso de al menos 5 minutos entre ambas.

Tanto para el olor como para el aroma y las aristas, se presentaron algunas referencias duplicadas y se incluyeron algunas muestras de base vínica (sin descriptor o defecto) con el fin de evitar la identificación de referencias por simple eliminación de las ya identificadas. Las respuestas fueron recogidas en formatos en papel previamente definidos en el PNT correspondiente.

Durante las sesiones 2 y 3 se evaluaron las mismas ocho muestras de vino. De éstas, tres pertenecían a un mismo vino (vino A), otras tres a otro vino (vino B) y las dos restantes eran muestras sin replicado (vinos C y D). Las puntuaciones fueron recogidas mediante el programa informático FIZZ.

Los parámetros estudiados en las pruebas de cualificación fueron la identificación de referencias de olor, aroma y aristas, repetibilidad, reproducibilidad y capacidad de discriminación en puntuaciones, e identificación de descriptores y defectos en muestras de vino. La descripción y los criterios de superación de cada uno de estos parámetros están recogidos en la Tabla 3 del artículo 5.

Aquellos que superaron las pruebas de cualificación pasaron a integrar el panel de jueces expertos. Los que no superaron alguna(s) prueba(s) pudieron repetirla(s) hasta en dos ocasiones. Quienes continuaron sin superarla(s) no fueron incluidos en el panel de jueces expertos, debiendo continuar con el entrenamiento hasta la próxima realización de las pruebas de cualificación.

Por otro lado, se estableció que los jueces expertos deberían realizar de nuevo las pruebas de cualificación (recualificación) en el plazo máximo de un año, para garantizar de este modo que continuaban siendo aptos para formar

parte del panel de jueces expertos. Asimismo, se estableció que la cualificación de nuevos jueces y la recualificación de jueces expertos pudiera realizarse conjuntamente mediante las mismas sesiones.

3.2.2.6.f- *Validación del método*

El objetivo de la validación fue comprobar la fiabilidad del método aplicado por un panel de jueces expertos. Para ello, se siguió un protocolo interno previamente establecido y recogido en el PNT correspondiente. La validación se llevó a cabo estudiando seis parámetros: repetibilidad en puntuaciones, repetibilidad en identificación de descriptores, reproducibilidad en puntuaciones, reproducibilidad en identificación de descriptores, reproducibilidad en capacidad discriminante en puntuaciones y reproducibilidad en capacidad discriminante en identificación de descriptores. La descripción de estos parámetros y los criterios de superación de cada uno están recogidos en la Tabla 5 del artículo 5.

Previamente a las sesiones de validación se realizaron dos sesiones para determinar las incertidumbres de repetibilidad y reproducibilidad en puntuaciones. En cada una de ellas se presentaron los mismos ocho vinos de forma análoga a como se ha descrito para las pruebas de cualificación: dos vinos (A y B) por triplicado, y otros dos vinos (C y D) presentados una única vez. Para la determinación de las incertidumbres sólo fueron considerados los datos de los vinos presentados por triplicado. El incluir dos vinos de los cuales no se iban a considerar las puntuaciones tenía como objetivo dificultar el que los jueces se percataran de que algunas muestras estaban repetidas.

La desviación estándar en repetibilidad y en reproducibilidad se determinaron utilizando las fórmulas indicadas en la Tabla 3 del artículo 5, a partir de los datos del panel en conjunto. Al haber dos vinos (A y B) y ocho parámetros se obtuvieron 16 valores de desviación estándar en repetibilidad y otros 16 para la desviación estándar en reproducibilidad. Considerando el valor más alto para cada uno de los dos parámetros se establecieron los límites de

aceptabilidad, en base, principalmente, a la experiencia previa con el método acreditado para queso Idiazabal (Pérez Elortondo *et al*., 2007). Los criterios de superación para los otros cuatro parámetros considerados en la validación (Tabla 5 del artículo 5) se establecieron teóricamente, ya que no se encontraron referencias bibliográficas sobre situaciones similares.

La validación se llevó a cabo a lo largo de dos sesiones con la misma estructura que las citadas de estimación de incertidumbres. Se tuvo especial cuidado en comprobar previamente que los vinos A y B eran diferentes entre sí, al menos en relación a varios de los parámetros sensoriales evaluados.

En la validación del método también se consideró la validación de cada uno de los descriptores y defectos de olor y aroma, así como las aristas, recogidos en la ficha de cata. Dado que resultaba imposible validarlos todos en un pequeño número de sesiones, se definió una metodología de validación en el contexto de la evaluación sistemática de los vinos. Así, se estableció que un descriptor, defecto o arista estaría validado cuando en una sesión al menos cinco de los siete jueces lo hubieran citado para una determinada muestra y en una sesión posterior al menos cinco jueces lo señalaran para esa misma muestra. De esta forma, comprobando la reproducibilidad en la identificación de cada descriptor, defecto o arista, se aseguraría que el panel no lo había identificado por azar.

Algunos descriptores, y especialmente algunos defectos, no son muy frecuentes en los vinos tintos jóvenes de RA, por lo que resultaría excesivamente tedioso y podría alargarse demasiado en el tiempo el esperar que llegase al laboratorio algún vino con el descriptor o defecto en cuestión. Por ello, y teniendo en cuenta la necesidad de asegurar que el panel estuviera preparado para identificarlo en caso de que apareciese, se consideró la posibilidad de utilizar vinos a los cuales se adicionaran los compuestos correspondientes para que presentasen un determinado descriptor o defecto, utilizando las mismas concentraciones que las usadas para la preparación de referencias. Estas muestras, evidentemente, sólo serían consideradas a efectos de validación de descriptores.

3.2.2.6.g- *Seguimiento y control en la evaluación sistemática de muestras*

Una vez que el método estuvo validado se comenzó la evaluación de muestras de vino de forma sistemática. Para asegurar una adecuada actuación del panel a lo largo del tiempo se estableció una sistemática de seguimiento y control después de cada sesión, tanto para el panel como para cada uno de los jueces expertos. Asimismo, se definieron los controles de calidad del método, a realizar de forma periódica.

3.2.2.6.h- *Gestión de la participación de los jueces expertos*

Con el objetivo de asegurar una participación continuada de todos los jueces en las sesiones de evaluación sistemática y evitar así la pérdida de cualificación, se decidió que, cuando un juez estuviera más de cuatro semanas seguidas sin tomar parte en ninguna sesión, debería participar en al menos dos sesiones de evaluación, aunque sin estar incluido entre los siete jueces expertos a partir de cuyos datos se elaboraría el informe de cada vino. Sus puntuaciones serían comparadas con las del panel y, en caso de cumplir los criterios exigidos (explicados en el apartado 3.2.2.6.j), se reincorporaría al panel de jueces expertos.

Del mismo modo, se estableció que, cuando no tuvieran lugar sesiones en un periodo de 2 meses o superior, se debían realizar reentrenamientos del panel antes de llevar a cabo la siguiente sesión de ensayo con vinos. En estos reentrenamientos se explicaría de nuevo la metodología de evaluación y los criterios de puntuación y se evaluarían las referencias, como mínimo, de olor.

3.2.2.6.i- *Seguimiento y control del panel*

Se basó en el control de la dispersión de las puntuaciones del panel en cada sesión. Se estableció que la desviación estándar para cada parámetro en cada muestra evaluada debía ser menor que 1. El número de veces que la

desviación estándar fuera igual o mayor que 1 (lo cual se considera una "desviación") debía ser menor del 15% del número total de desviaciones posibles (resultado de multiplicar el número de muestras por ocho parámetros).

Cuando en una sesión el número de desviaciones superaba el 15% no se elaboraba informe de los vinos con mayor número de desviaciones y otra botella del mismo lote de estos vinos era incluida en la siguiente sesión. Si, al evaluar de nuevo un parámetro que había tenido en la primera sesión una desviación estándar igual o mayor que 1, la desviación estándar resultaba menor que 1, entonces los datos correspondientes a la segunda sesión y a ese parámetro eran incluidos en la matriz de la primera sesión. Si el porcentaje de desviaciones resultante era menor del 15% se elaboraba el informe de esos vinos. Por otro lado, cuando en una sesión se sobrepasaba el 15% de desviaciones se determinaba quiénes eran los jueces responsables de las mismas, y se les informaba sobre los parámetros y las muestras en que se habían desviado.

3.2.2.6.j- *Seguimiento y control individual de jueces expertos*

Se basó en el control de la homogeneidad de las puntuaciones de cada juez respecto a la puntuación media del panel, así como en el control de la concordancia de identificación de descriptores, defectos y aristas con respecto al panel.

En relación a las puntuaciones, se estableció que cada una de las puntuaciones otorgadas por el juez debía encontrarse en el rango definido por la media del panel (redondeada al número entero más próximo) ±1. Por ejemplo, si la media del panel fuera 3,3 la media redondeada sería 3 y la puntuación que debiera haber asignado cada juez sería 2, 3 o 4. En caso de que este supuesto no se cumpliera, sería considerado una "desviación" del juez. Se estableció que el número máximo de desviaciones para cada juez podría ser el 15% del total de desviaciones posibles (resultantes de multiplicar el número de muestras por ocho parámetros).

En relación a los descriptores, defectos y aristas se establecieron dos criterios. Por un lado, cada juez debía identificar al menos el 50% de los descriptores, defectos y aristas identificados por el panel (señalados por al menos cinco jueces). Por otro lado, y para evitar un excesivo número de citaciones en un posible intento por asegurar el cumplimiento del criterio anterior, se estableció que el número total de descriptores, defectos y aristas señalados por un único juez no podría ser mayor que el producto de multiplicar 3 por el número de muestras evaluadas. Es decir, en caso de evaluar ocho muestras, cada juez podría señalar como máximo 24 descriptores, defectos o aristas, siendo el único que los señala para cada muestra y parámetro en concreto.

Cuando en un ensayo no se cumplía alguno de los criterios descritos se comentaba con el juez en cuestión para que fuera consciente de la desviación. En los casos en los que se considerase necesario (por reiteración o por gravedad de la desviación) se suspendería temporalmente al juez. A partir de ese momento, éste seguiría participando en las sesiones de evaluación aunque sus datos no serían considerados en la elaboración del informe, aunque sí que se compararían con los datos del panel. Cuando en al menos dos sesiones consecutivas el juez descalificado cumpliera los criterios sería reincorporado al panel.

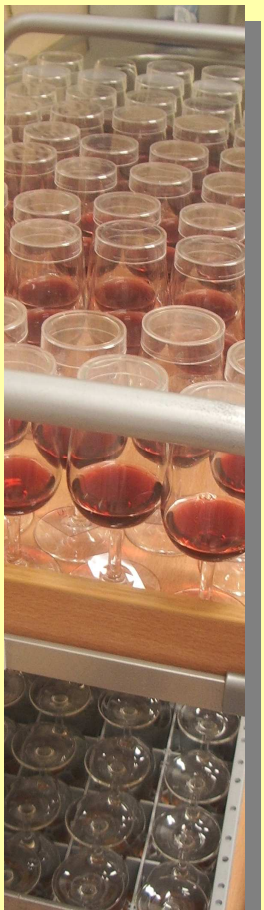
Como parte del seguimiento y control, tras cada sesión se elaboraba un informe personalizado de dos páginas que se facilitaba a cada juez en la siguiente sesión. En la primera página de dicho informe (Figura 1 del artículo 5) se recogían las puntuaciones medias del panel así como las puntuaciones otorgadas por el juez en cuestión, señalándose expresamente sus desviaciones. En la segunda página (Figura 2 del artículo 5) se indicaban los descriptores, defectos y aristas identificados por el panel (señalados por al menos cinco jueces), aquellos descriptores, defectos y aristas señalados asimismo por el juez en cuestión, y aquellos descriptores, defectos y aristas señalados únicamente por él. En esa misma página se incluían los porcentajes del juez en relación a estos dos criterios.

3.2.2.6.k- *Controles de calidad de los ensayos*

Se definieron controles de calidad del método, a realizar de forma periódica durante la evaluación sistemática de vinos. Así, según se estableció en el correspondiente PNT, cada 150 muestras analizadas (o en caso de no llegar a esa cifra en un mismo año, como mínimo una vez al año) se debía llevar a cabo un control de calidad del método. Los parámetros estudiados, el diseño de las pruebas y los criterios de superación eran similares a los de las pruebas de validación del método, tomando en consideración las incertidumbres y los límites de aceptabilidad establecidos en la validación. En caso de que los criterios no se cumplieran habría que realizar un entrenamiento con el panel y repetir el control de calidad del ensayo. Se estableció que, en caso de que en esta repetición tampoco se cumplieran los criterios, se debería suspender la evaluación sistemática de muestras, comunicar al cliente el problema y abordar la nueva situación mediante un análisis de causas y consecuencias y la adopción de acciones correctivas.

Por otro lado, se determinó llevar a cabo un control de calidad relativo a la identificación de descriptores, defectos y aristas a lo largo de cada campaña. Este control consistía en que la muestra en la que un descriptor era citado por al menos cinco jueces era de nuevo presentada en una sesión posterior para ser evaluada y comentada. Si al menos cinco jueces identificaban dicho descriptor se consideraba validado. En caso de no ser señalado por cinco jueces, se discutía expresamente la presencia o no de dicho descriptor en la muestra. Se estableció llevar a cabo dicha operación una vez por campaña para cada descriptor, defecto o arista señalado.

4- RESULTS AND DISCUSSION



4.1- Sensory description of young red wine from Rioja Alavesa. Effect of winemaking process, grape variety and time of stay in bottle on the organoleptic characteristics.

- Article 1. Development of a quantitative sensory method for description of young red wines from Rioja Alavesa.

- Article 2. Effect of winemaking process and addition of white grapes on the sensory and physicochemical characteristics of young red wines.

- Article 3. Sensory attribute evolution in bottled young red wines from Rioja Alavesa.

Article 1

Development of a quantitative sensory method for description of young red wines from Rioja Alavesa.

Etaio, I., Pérez Elortondo, F.J., Albisu, M., Gaston, E., Ojeda, M., Schlich, P.

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DEVELOPMENT OF A QUANTITATIVE SENSORY METHOD FOR THE DESCRIPTION OF YOUNG RED WINES FROM RIOJA ALAVESA

I. ETAIO[1], F.J. PÉREZ ELORTONDO[1,3], M. ALBISU[1], E. GASTON[1], M. OJEDA[1] and P. SCHLICH[2]

[1]*Laboratorio de Análisis Sensorial Euskal Herriko Unibertsitatea (LASEHU)*
Facultad de Farmacia
Universidad del País Vasco/Euskal Herriko Unibertsitatea
Paseo de la Universidad, 7, 01006 Vitoria-Gasteiz, Spain

[2]*Laboratoire d'Interface Industrie-Recherche-Sensométrie (LIRIS)*
Centre Européen des Sciences du Goût (CESG)
15 rue Hugues Picardet, 21000 Dijon, France

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ABSTRACT

A quantitative sensory method was developed to evaluate young red wines from Rioja Alavesa and find the most suitable attributes to describe them. Twenty-four attributes (including appearance, aroma, flavor, taste and mouthfeel attributes) were chosen. Combined quantitative references were developed for these attributes aiming to lower the total number of references to be tasted. Nineteen wines were evaluated at four different times (every 2.5 months after bottling) by a panel trained in the use of this methodology. Attributes were compared in terms of overall intensities, and discriminative power of the attributes was assessed by analysis of variance, considering both sample and time effects. Appearance, taste and mouthfeel attributes revealed to be the most important to describe and discriminate the wines. "Red berry," "floral," "aroma intensity" and "dark berry" were the most important aroma attributes to discriminate among the wines, whereas "alcoholic" and "herbaceous" were the most important in flavor.

PRACTICAL APPLICATIONS

This work provides three main practical applications. First, a list of terms for sensory description of wines from Rioja Alavesa is provided. There are no

[3] Corresponding author. TEL: 34-945013075; FAX: 34-945013014; EMAIL: franciscojose.perez@ehu.es

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scientific reports using sensory panels to describe young red wines from the Rioja region. Attributes that describe and/or discriminate among these wines are also determined. All this information may be useful for a better understanding of these wines and for being used in future studies. Second, a methodology to describe young red wines and to evaluate them is described, which may be useful for further studies concerning wines from this area or other areas. Third, the development of combined references is used as a practical way to present all the references to all the panelists in the booths, although more studies are necessary before recommending this sensory practice.

INTRODUCTION

Rioja wines have a very long history and are famous worldwide. Rioja Designation of Origin was officially recognized in 1925, and since 1991 has held the maximum category of Qualified Designation of Origin (DOC) (Pascual 2003). These wines have to observe many rules and control systems established by the Regulatory Council relating to production zone, viticulture practices, harvest conditions, grape yields, elaboration practices and procedures for the different kinds of wine (BOE 2004). The high quality of wines from Rioja would be because of the combination of three main factors: grape varieties, favorable climate season and soils (Ruiz 1974).

Grape varieties accepted to elaborate wines are Tempranillo (indigenous and preferential for wine elaboration), Garnacha, Graciano (indigenous) and Mazuelo as red varieties, and Viura (preferential for wine elaboration), Malvasía and Garnacha Blanca as white varieties.

DOC Rioja extends over a region situated in the Ebro river valley and is comprised of three subareas (Fig. 1): Rioja Alta (northwest part of Rioja Community), Rioja Baja (eastern part of Rioja Community and some villages in the southwest of Navarre) and Rioja Alavesa (RA) (in Araba-Alava province, Basque Country). These areas differ somewhat because of soil composition and, to a certain extent, because of winemaking practices. RA has a slightly cool and wet climate because of both Atlantic and Mediterranean influence (mean temperature 12.9C and precipitation 500 L/m^2 per year). RA is protected from the northern weather by the Toloño/Cantabria mountain range, extending the vineyards from high up down to the Ebro river (from 650 to 400 m above sea level). Because of this slope, almost all the vineyards are oriented to the south, so sun radiation take-up is higher, and consequently, grape ripening is better (González 1993). This factor is considered to have a positive effect on the quality of the grapes.

Soil composition of RA is approximately 95% chalky-clayey, which has a beneficial effect on the grape hydration regulation and it is associated with high-quality grapes and wines (Ruiz 1986).

FIG. 1. GEOGRAPHIC LOCATION OF RIOJA REGION AND RIOJA ALAVESA

The harsh relief of RA has made it difficult to establish large vineyards and winemaking cooperatives as occurs in other zones of the Rioja region. Nowadays, small family-run wineries still comprise more than 80% of the 275 wineries of RA registered in the DOC Rioja. In spite of adopting technical improvements, many of them produce their wines in the traditional way, as previous generations did.

Although many wineries produce different kinds of wines, young red wine is the most traditional wine and represents approximately half of more than 60 million of wine liters produced in this subarea.

Tempranillo (*Vitis vinifera* L.) represents 96.3% of the 11,903 hectares cultivated with red varieties (data from the Regulatory Council, http://www.riojawine.com). It can be said that Tempranillo is the red variety associated with RA, especially in the case of young red wines. Many wineries add small amounts of the permitted white varieties when elaborating red wines.

Young red wines are made by carbonic maceration (traditional method in RA) or by destemming (crushing the grapes before fermentation). Malolactic fermentation usually occurs before the end of the year, reducing the acidity and making the wines smoother. After clarifying, decanting and filtering (the used operations depend on each winery), red young wines are kept in stainless steel vats (some wineries still use cement vats) until they are bottled and commercialized. The first wines are in the market around December to January, but the

majority of wineries start selling during the following months. Young red wines are intended for consumption during the first year, when their sensory characteristics are optimum.

These wines are commonly described as fruity, as well as having subtle floral and licorice aromas/flavors. In the mouth, they are medium-bodied and balanced, with moderate astringency. During the first months, many wines present a sensation of effervescence because of the CO_2, which disappears in a few months. Color intensity is medium-high, and color hue is typically purple during the first year (Etaio *et al.* 2007).

There is an interest in the Association of Wineries from RA (ABRA) and in the Administration of the Basque Country to know more about the typical characteristics of these wines, in order to describe them and to enhance their sensory quality. This work is a part of several studies on the subject.

Sensory descriptive analysis combined with univariate or multivariate statistical analysis has been used to describe different wines, such as Bordeaux red wines (Noble *et al.* 1984), Zinfandel wines (Noble and Shannon 1987), Cabernet Sauvignon wines (Heymann and Noble 1987), Pinot Noir and Chardonnay wines (Guinard and Cliff 1987; Cliff and Dever 1996), white wines from Penedés (De La Presa-Owens and Noble 1995), Riesling wines (Douglas *et al.* 2001), Canadian ice wines (Cliff *et al.* 2002), Tacoronte-Acentejo red wines (González *et al.* 2002), red wines from Greece (Koussissi *et al.* 2002) and Bordeaux-style red wines (Kontkanen *et al.* 2005). Although wines from DOC Rioja have a long history and many scientific physicochemical studies have been reported (Jaime *et al.* 1974; González 1988, 1992, 1993; Elizondo *et al.* 1994; Martínez *et al.* 1998, 2002), there is no scientific quantitative sensory description of young red wines from RA (neither from DOC Rioja in general) made by a sensory trained panel. The two main aims of this study were to describe a specific sensory method (including chemical reference development) and to establish the most important descriptive and discriminative sensory attributes in these young red wines.

MATERIALS AND METHODS

Wines

Nineteen wines from 12 wineries from RA were analyzed. A brief chemical characterization of these wines is shown in Table 1. These wines were real manufactures and were produced according to the usual process of each winery and to the practices accepted by the Regulatory Council.

All the wines were from the 2005 vintage and came from different villages. During the last week of 2005, the wines were taken directly from the vats (vat capacity around 30,000 L) in 20-L demijohns. The demijohns were filled to the

TABLE 1.
MAIN CHEMICAL CHARACTERISTICS OF WINES (MEAN VALUES AND SD)

Wine	Ethanol (% vol)*	pH†	Total acidity (g tartaric acid/L)‡	Total polyphenol index§
1	13.57 ± 0.10	3.85 ± 0.01	3.90 ± 0.10	73.25 ± 0.96
2	14.19 ± 0.17	4.07 ± 0.07	3.34 ± 0.17	63.00 ± 1.41
3	13.69 ± 0.13	3.75 ± 0.01	4.32 ± 0.13	55.25 ± 0.96
4	14.48 ± 0.17	3.67 ± 0.02	4.45 ± 0.17	62.75 ± 1.26
5	13.54 ± 0.13	3.80 ± 0.01	4.08 ± 0.13	59.25 ± 0.96
6	13.20 ± 0.13	3.95 ± 0.01	3.38 ± 0.13	57.25 ± 0.96
7	14.68 ± 0.10	3.60 ± 0.02	4.20 ± 0.10	64.25 ± 0.96
8	13.96 ± 0.14	3.61 ± 0.01	4.27 ± 0.14	45.75 ± 0.50
9	14.06 ± 0.13	3.70 ± 0.02	4.03 ± 0.13	59.25 ± 0.96
10	14.16 ± 0.18	3.91 ± 0.02	3.52 ± 0.18	63.25 ± 0.96
11	13.24 ± 0.18	3.75 ± 0.01	4.55 ± 0.18	63.50 ± 1.29
12	13.52 ± 0.12	3.70 ± 0.02	4.73 ± 0.12	74.75 ± 1.26
13	14.13 ± 0.15	3.63 ± 0.01	4.67 ± 0.15	64.25 ± 0.96
14	13.74 ± 0.02	3.95 ± 0.01	3.89 ± 0.02	60.25 ± 0.96
15	13.42 ± 0.06	3.89 ± 0.01	4.13 ± 0.06	70.75 ± 1.26
16	13.56 ± 0.13	3.68 ± 0.01	4.78 ± 0.13	71.25 ± 0.96
17	13.24 ± 0.13	3.84 ± 0.01	4.28 ± 0.13	57.50 ± 0.58
18	14.03 ± 0.15	3.58 ± 0.01	4.83 ± 0.15	57.25 ± 0.96
19	13.52 ± 0.06	3.56 ± 0.01	4.97 ± 0.06	57.25 ± 0.96

* Determined by absorbance in near infrared reflectance.
† Determined by potentiometry.
‡ Determined by acid–base titration.
§ Determined by absorbance at 280 nm.

top to avoid air space that could spoil the wine. All the wines had finished malolactic fermentation and had been decanted several times to remove lees.

Wines with low SO_2 levels were sulfited to assure a minimum level of free SO_2 of at least 22 mg/L to avoid wine deterioration. After 2 weeks of decantering at cellar temperature (8 ± 2C), the top volume of each demijohn was bottled in a bottling plant at the second week of January 2006. The bottom volume (approximately 6 L) was discarded to avoid sediments.

The bottles were stored in a cellar, lain down and under the same conditions (relative humidity around 90% and temperature around 12C).

The bottles were collected from the cellar for four times: January, March, June and September 2006. At the laboratory, the wines were maintained at 8C until tasting.

Panelists

Eighteen panelists were selected according to interest and availability and were trained to evaluate the wines. The majority of them had experience in

sensory descriptive analysis. After the training, 14 of them started evaluating the wines of the study, although only 10 of them (three men and seven women with an average age of 38.8) evaluated the 19 wines at the four times. Only data from these 10 panelists were used.

Attribute Generation and Selection

A previous list of attributes to describe these wines was collected from the literature and from a discussion session with a group of experts (winemakers, enologists and restaurateurs) with a wide range of experience in tasting wines from RA. This list was used as additional help during term generation.

Fourteen young red wines were tasted and discussed by the panelists through six sessions to generate terms. The duration of each session was around 1 h and 15 min. In the first two sessions, many terms were generated from differences comparing wine pairs. From the third to the sixth session, Wine Aroma Wheel (Noble *et al.* 1987) and the cited list of collected attributes were provided to facilitate term generation. Aroma, taste and mouthfeel references were provided to facilitate the discussion. From a first long list of attributes, a reduced list was compiled after considering citation frequency and by consensus.

There was no discussion to generate and select appearance attributes. According to the previous experience in the evaluation of young red wines from RA (Etaio *et al.* 2007), "color hue" (color shade or tone observed through the thin layer near the rim of the glass) and "color intensity" (how easily the light goes through the bulk of the sample in the glass; color "deepness") were the two appearance attributes that could be discriminative among wines, and considering other appearance attributes would not provide relevant information. These two attributes have been reported in the sensory evaluation of Cabernet Sauvignon wines (Sivertsen *et al.* 2001) and Tacoronte-Acentejo red wines (González *et al.* 2002), although sensory evaluation of appearance is not so commonly reported in wine sensory characterization.

Development of References

The development of quantitative references started in the third session when the panel was presented with possible references to clarify the terms and to define the references. Identical glasses as used for wine evaluation were used for aroma reference presentation, to make reference evaluation as close as possible to wine-tasting conditions. So as to make reference management simpler and more uniform, reference concentrates were prepared and frozen, and then defrosted and made up to the final volume of reference the day before evaluation. The definition of the references for attributes of aroma, flavor, taste and mouthfeel was definitively finished in the 19th session. The physical

TABLE 2.
COLOR COORDINATES OF THE COMBINED REFERENCE TO EVALUATE COLOR HUE AND COLOR INTENSITY*

	Point in the scale						
	7	6	5	4	3	2	1
Color hue (RGB coordinates; horizontal scale)							
Red	204	204	210	211	211	211	211
Green	0	0	0	0	0	50	60
Blue	215	190	165	125	96	75	60
Color intensity (% of shading; vertical scale)	90	75	65	55	45	35	25

* Standard was developed with Microsoft Office Word 2003 and printed in Staedtler (Nuernberg, Germany), Lumocolor, ink jet transparent film (100 μm). Used printer: Lexmark Z605 (Lexington, U.S.A.). Used inks: InkTek (Galashiels, U.K.) for Lexmark and Samsung Printers (Jászfényszaru, Hungary) (LMI-1026C color) for color, and InkTek for Lexmark and Samsung Printers (LMI-1016D black) for black color.

reference material included in Etaio *et al.* (2007) for practical use by wine-makers and interested people was used as reference for "color hue" and "color intensity" attributes. Color coordinates of this reference are shown in Table 2.

Training of the Panel

During the reference defining sessions, two wines were evaluated and discussed at the end of each session to make the panelists more familiar with the wines. After all the references were developed, 12 training sessions were carried out according to the methodology that would be used to evaluate the wines. In the last two sessions, the panelists were instructed in the use of the FIZZ software (version 2.10 A, Biosystèmes, Couternon, France).

Wine Tasting

Nineteen wines were tested in four tasting series throughout year 2006 (every 2.5 months approximately), to take into account the sensory evolution of the wine over time. The first tasting series started 3 weeks after bottling the wines.

All the wines were evaluated in triplicate in each series, which were composed of 10 sessions. Six wines were evaluated in each session. The wines were randomly distributed throughout the sessions of each series in a way that the three replications were consecutive: all the samples were assessed once, then a second time and then a third time. A balanced complete block design was used in each series. In order to minimize any bias as a result of order of presentation, an extended Latin square-type design was used.

Two sessions were carried out per week, and the panelists were divided into two groups in each session, one at 12:00 p.m. and at one 4:30 p.m., according to panelist availability.

The day before the tasting, reference concentrates were defrosted, brought to the final volume with a base wine and put in the cellar (16 ± 2C).

Sessions were carried out under controlled conditions of temperature (21 ± 2C) and relative humidity (60 ± 20%). Aroma references were served in standardized 200-mL wine-tasting glasses (ISO 3591 1977) to get reference evaluation as close as possible to wine evaluation. Wine bottles were opened immediately before morning tasting, and 35 mL samples of each wine were served in standardized glasses. Reference and wine glasses were covered with Petri dishes and were immediately brought to the tasting booths at 16 ± 2C 5 min before the panelists entered. Bottles with the remaining wine were immediately returned to the cellar after displacing the air with inert gas (N_2, Ar and CO_2; Private Preserve, Napa Valley, CA). Bottles were then used in the afternoon session.

References and wines were evaluated in isolated booths according to a previously defined methodology (Etaio *et al.* 2007) shown in Fig. 2. References of aroma, flavor, taste and mouthfeel were evaluated, in this order, before wine evaluation. Consecutive 2-min times for aroma, flavor and taste and mouthfeel were established as the minimum time to evaluate the references, so it was not possible to start evaluating the wines until this time was over. Minimum waiting time of 1 min was established between sample evaluation. Attribute intensities were scored in continuous 7-point scales (ranging from 1 [lowest intensity] to 7 [highest intensity]) by comparison with the intensity of the references. The panelists were instructed to give scores to the attributes in the order they perceived them, despite the attribute order displayed on the screen.

References and samples were expectorated. The panelists were instructed to rinse with water between references and between wines, and to use unsalted crackers to decrease astringency carryover (Ross *et al.* 2007). Some panelists found an insipid jelly liquid solution helpful in recovering from this carryover effect so it was also provided. Appearance attributes were evaluated by using six additional glasses containing 25 mL sample. The panelists were told to have a rest and to leave the tasting room if necessary, which was carried out by many of them. The duration of the sessions was around 1 h.

Data Analysis

All statistical analysis was performed using SAS (SAS Institute, Cary, NC). The analysis of panel performances was run by the Control of Assessor Performances (CAP) system (reference available through the SensoBase

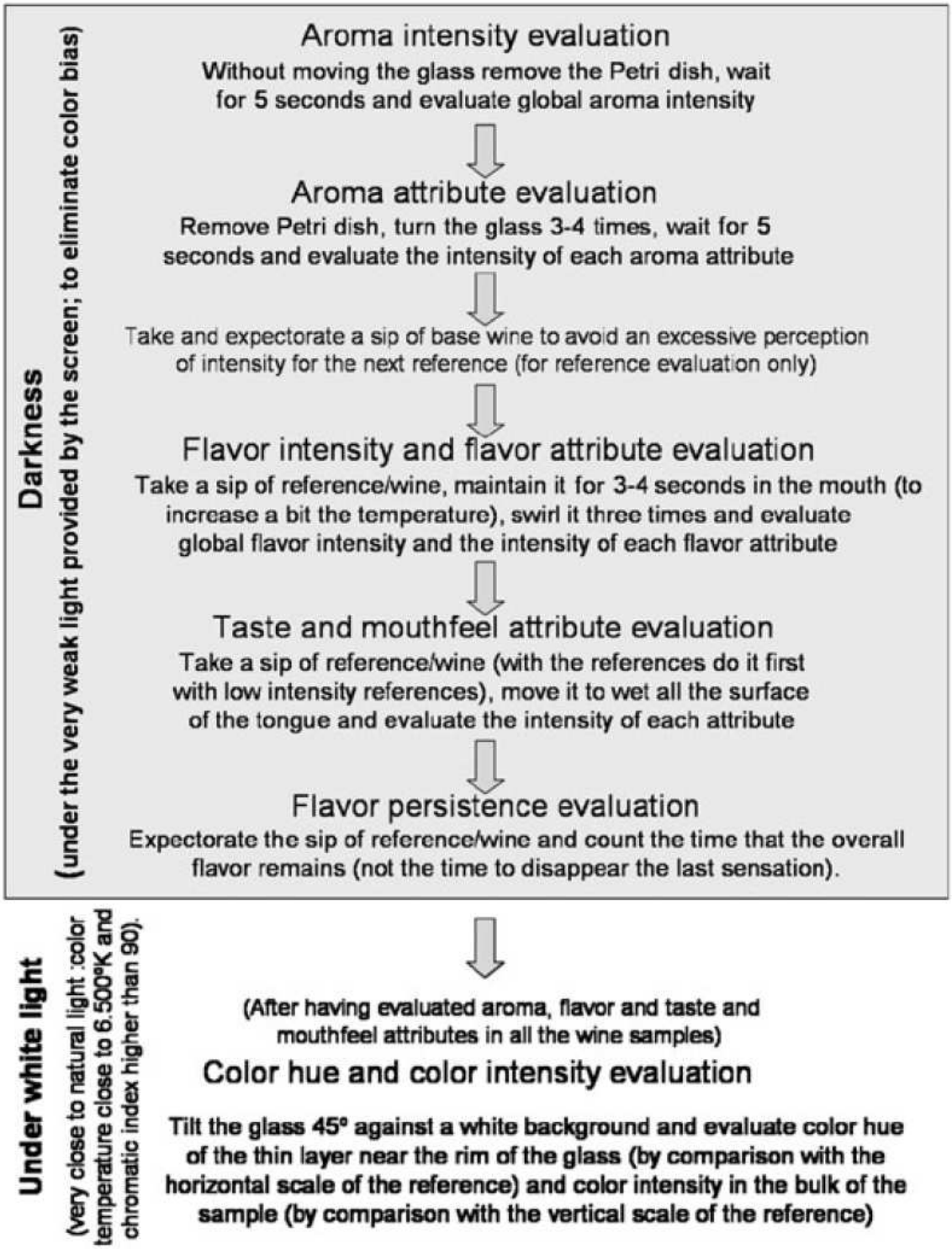

FIG. 2. METHODOLOGY FOR REFERENCE AND WINE EVALUATION

project, https://liris.cesg.cnrs.fr) at each time of profiling. This system examines performance at individual and group levels. One-way analysis of variance (ANOVA) is performed for each pair of panelist and attribute, and the panelist is considered as discriminative if the *F*-test of the product effect is significant at $P < 0.10$. Then, a test of agreement with the other discriminative panelists is carried out by means of the Kendall coefficient. Finally, individual repeatability is assessed considering the SDs of replicates by product and compared with the group level in order to state whether each subject is significantly less repeatable than the group. The paper will report the percentage of individual discrimination, agreement with the group and lack of repeatability. These percentages were computed over all cases (panelists × attributes over time). At group level, the CAP system ran a two-way ANOVA considering subject and subject by panelist as random effects. The average number of significant ($P < 0.05$) attributes for the wine effect is reported by time and globally.

F-test was carried out to find what attributes presented significantly different scores ($P < 0.10$) on the evaluated wines. The three replicates of each wine within each time were averaged by panelist, so each wine was considered to have been evaluated in quadruplicate (four times). The wines were both tested against the error term (heterogeneity of the panel) and against the time effect (sample [wine] effect). *F*-test was previously run to analyze the time effect (sample [wine] effect) over the differences in the attributes scoring.

Correlation principal component analysis (PCA) was carried out to produce a two-dimensional plot of wines and attributes. PCA was conducted on the mean scores of the four testing times for all the attributes featuring significant differences among wines in the ANOVA.

RESULTS AND DISCUSSION

Attribute Generation and Selection

A long list of terms was compiled during the first six sessions. After removing the hedonic and inappropriate terms, the list shown in Table 3 was obtained. This list was discussed by the group in the seventh session to reach a consensus about which attributes to use. Some terms of this list were rejected because of very low citation frequency.

Attributes related to generic fruit were the most problematic (they were grouped under the "tree fruit" term, to differentiate from other fruit subfamilies: "berry," "tropical fruit," "citric fruit," "dried fruits" . . .), as well as those related to "green-vegetal-herbaceous" (use of the term "herbaceous" was decided upon). Although hesitating over the convenience of maintaining "alcoholic" aroma ("alcoholic" is not common in wine description, although

TABLE 3.
LIST OF TERMS CITED AFTER THE FIRST SIX SESSIONS

Aroma terms	Citation frequency	Flavor terms	Citation frequency	Taste and mouthfeel terms	Citation frequency
Floral	54	Tree fruit	50	Astringency	69
Tree fruit	52	Licorice	32	Acidity	42
Aroma intensity	35	Floral	21	Bitterness	17
Alcoholic	31	Alcoholic	18	Balance	17
Dark berry	27	Red berry	14	Prickly	12
Red berry	18	Flavor intensity	6	Alcoholic	8
Herbaceous	14	Dark berry	5	Sweetness	7
Licorice	12	Herbaceous	4	Persistence	4
Pine/fresh wood	7	Dried fruit	4	Body	3
Wood	6	Pungent	4	Others (Citation < 2)	3
Caramel	5	Wood	3		
Pungent	5	Other fruits (Citation < 2)	2		
Tropical fruit	4	Others (Citation < 3)	9		
Citrus fruit	4				
Other fruits (Citation < 4)	7				
Others (Citation < 3)	14				

Noble *et al.* [1987] found "ethanol aroma" as a suitable attribute to differentiate among Zinfandel wines), it was maintained because the majority of the panelists assured to perceive it. "Licorice" has been reported to describe wines in few cases (Fischer *et al.* 1999; Vilanova and Soto 2005), but it is considered characteristic in RA young red wines (Etaio *et al.* 2007).

Eight attributes were finally selected for aroma: "floral," "tree fruit," "aroma intensity," "alcoholic," "dark berry," "red berry," "herbaceous" and "licorice."

It was decided by consensus to maintain all these attributes for flavor evaluation in the mouth, although the citation frequency was notably lower for some of them ("flavor intensity," "dark berry" and "herbaceous").

The chosen list for taste and mouthfeel attributes included "astringency," "acidity," "bitterness," "balance," "prickly," "persistence" and "body." In spite of their low citation frequency, "body" and "persistence" were maintained because of the experience and the citation in the bibliography. The inclusion of "persistence" (which is a flavor-related attribute) in this group is because of methodological aspects as it is evaluated in the mouth after evaluating taste and mouthfeel sensations. After several sessions "prickly" sensation was

removed because of lack of consensus by the panel. The definitive list of attributes of aroma, flavor and taste and mouthfeel (with their references) is shown in Table 4. "Aroma intensity," "flavor intensity," "licorice," "alcoholic," "balance" and "persistence" are not very frequently cited in the literature. These attributes are considered in the quality evaluation of RA wines (Etaio *et al.* 2007). The remaining attributes are quite common in the sensory description of other types of wine, although most studies also reported some terms ("vanilla," "oak," "spicy," "toasted" . . .) related to aging in the barrel, which is not used for Rioja young red wine production.

Development of References

References were developed on a base wine prepared from a very neutral commercial red table wine that, because of its very large and controlled production from a lot of grape batches, is very homogeneous throughout the year. Used references were quantitative, so many sessions were necessary to develop them. As the study would extend through many months, chemical references were developed to assure that their quality and intensity remained always the same. Several chemical compounds added to the base wine for each attribute were presented to the panel for discussion of their appropriateness. It was not possible to find a suitable chemical reference for "tree fruit" aroma and flavor, so a market product (commercial grape juice) was used. It was decided by consensus to use the same aroma references as references for flavor too (by evaluating them in the mouth).

After choosing the chemical compound for each attribute, combined references that include more than one attribute (two in the case of the aroma/flavor references and four in the case of taste and mouthfeel references) were developed. This was explained in terms of accuracy and convenience. If all the panelists evaluated a reference by using the same glass, the intensity of the reference would not be the same for all of them, as removing the Petri dish several times would cause the intensity to change. If all the references are presented in each booth, each panelist would evaluate them presenting the same or very similar intensity, in each and every session. In addition, conditions to evaluate the references in each booth will be more appropriate than evaluating them in the group room. Combined references allowed to serve all the attribute references but serving a lower number of glasses than the number of attributes.

Some works reported the extremely limited human capacity to identify several aroma components in aroma mixtures. Laing and Francis (1989) and Livermore and Laing (1996) indicated that humans may not be able to identify more than three or four components of aroma mixtures, and that the accuracy to correctly identify the components in a mixture decreases as the number of

TABLE 4.
ATTRIBUTES AND REFERENCES FOR THE EVALUATION OF AROMA, FLAVOR, TASTE AND MOUTHFEEL SENSATIONS IN YOUNG RED WINES FROM RIOJA ALAVESA

Attribute	Sensory definition	Combined attributes	Reference concentrate composition (to freeze)	Final processing of the reference	Position on the scale
Aroma intensity	Global intensity of aroma (by orthonasal way)	Aroma intensity/flavor intensity/persistence	200 μL solution of linalool and geraniol (1% v/v)* 6 mL licorice solution† 0.25 mL raspberry flavoring‡ 25 mL ethanol absolute 20 mL table red wine	Defrost and carry to a total volume of 500 mL with table red wine	6 (for each attribute)§
Flavor intensity	Global intensity of flavor (by retronasal way)				
Persistence	Duration of overall flavor that reminds the wine, after spitting it				
Red berry	Aroma/flavor associated to berries as raspberry and strawberry	Red berry/herbaceous	0.4 mL raspberry flavoring 20 μL solution of hexenol-3-cis (1% v/v)¶ 2.5 g tannic acid powder** 45 mL of base wine††	Defrost and carry to a total volume of 400 mL with base wine	6 (for each attribute)
Herbaceous	Aroma/flavor associated to vegetative material (stems . . .)				

TABLE 4.
CONTINUED

Attribute	Sensory definition	Combined attributes	Reference concentrate composition (to freeze)	Final processing of the reference	Position on the scale
Floral	Aroma/flavor associated to flower	Floral/dark berry	0.16 mL berry flavoring‡‡	Defrost and carry to a total volume of 400 mL with base wine	6 (for each attribute)
Dark berry	Aroma/flavor associated to berries as blackberries and blackcurrant		160 μL solution of linalool and geraniol (1% v/v) 50 mL base wine		
Licorice	Aroma/flavor associated to licorice	Licorice/alcoholic	14 mL licorice solution 32 mL ethanol absolute	Defrost and carry to a total volume of 400 mL with base wine	6 (for each attribute)
Alcoholic	Aroma/flavor associated to ethanol				
Tree fruit	Generic aroma/flavor associated to fruits as apple, pear, plum . . .	Tree fruit		240 mL of commercial grape juice + 160 mL of table red wine + 16 mL ethanol	6
Acidity	Sensation produced by aqueous solutions of acid substances, as citric acid or tartaric acid	Taste and mouthfeel sensations (low intensities)	15 mL ethanol 0.3 g tannic powder§§ 40 mL water	Defrost and add 205 mL of water and 245 mL of table red wine	2 for astringency, bitterness and body, and 3 for acidity
Astringency	A combination of puckery, drying and roughening sensations in the mouth				

Bitterness	Sensation produced by aqueous solutions of several substances, as quinine or caffeine	Taste and mouthfeel sensations (high intensities)	15 mL ethanol 14 mL glycerol 2.75 g tannic powder 0.95 g tartaric acid 0.0150 quinine sulfate 17 mL table red wine	Defrost and carry to a total volume of 500 mL with table red wine	6 (for each attribute)
Body	Consistency or density in the mouth				
Balance	Situation where acidity, astringency and, if present, bitterness are compensated by sweetness, so there is no a sensation that stands out by excess	No standard			

* Solution prepared in ethanol absolute: 1% linalool and 1% geraniol.
† Licorice solution: dissolve 10 g of licorice paste in 100 mL of warm water by stirring and maintained frozen until use.
‡ Raspberry flavor10703-36 (laboratory sample), Givaudan Ibérica S.A., Pla d'en Batlle s/n, 08470 Sant Celoni, Barcelona, Spain.
§ Moreover, having a persistence reference, each point in the scale was defined as this number multiplied by 2 s, so point 1 in the scale means a persistence of 2 s, point 6 (the reference) corresponds to a persistence of 12 seconds, . . .
¶ Solution prepared in ethanol absolute.
** Tannic acid J-624, Givaudan Deutschland GmbH Giselherstr, 11, D-44319 Dortmund, Germany.
†† Base wine elaborated with table red wine diluted with water (3:1) and added 2 mL ethanol absolute for each 100 mL.
‡‡ Flavor 15.63.5411, International Flavors & Fragances España, Po. de La Castellana 149 28046 Madrid, Spain.
§§ Oenotannin perfect. Chevallier-Appert, Groupe Oeno France – ZA Alfred Daney, Rue La Motte Picquet 33300 Bordeaux, France.

odors in the mixture increases. So, it was decided to reduce the number of aroma and flavor attributes to two to be combined in the same reference.

The possible attribute combinations were chosen by discussion after presenting different combinations to the panel without identifying them. Attributes that could be close to or included in the same aroma family ("tree fruit," "red berry" and "dark berry") were not put together, to avoid confusion. The combined references chosen were "red berry"–"herbaceous," "dark berry"–"floral" and "licorice"–"alcoholic." "Tree fruit" remained as a single reference. The panelists agreed that both attributes were perceived in each reference, and that perceived aroma/flavor "quality" was the same or very close to the "quality" of the previously tested single references. A combined reference for "acidity," "astringency," "bitterness" and "body" was also developed.

After choosing attribute combinations, aroma and flavor reference intensities were adjusted to locate them in point 6 of a 7-point scale in order to be clearly perceived and to avoid one attribute masking the other, so the panelists could identify each one.

To face the difficulty of scoring when the perceived intensity for an attribute of aroma or flavor was lower than the reference, a complementary nominal scale (Table 5) was also developed.

As taste and mouthfeel sensations are supposed to be almost always perceived, two intensity references were developed for these attributes (one in the lower part of the scale and the other one in the upper part). The opinion of experts and panelists was considered in defining the intensities.

For each reference, a concentrate was prepared, frozen at −26C and, the day prior to the discussion session, defrosted and brought up to a predefined volume with a base wine. The fact of having used frozen-defrosted possible references during the discussion stage made it possible to develop references that would be processed in this manner in the wine evaluation phase. Reference characteristics and preparation are shown in Table 4.

TABLE 5.
NOMINAL SCALE FOR AROMA AND FLAVOR ATTRIBUTE INTENSITY SCORING

Description of the perceived intensity		Score
The attribute is not perceived at all	→	1
Doubts about the presence of the attribute	→	From 1 to 2
The attribute is perceived but very slightly	→	From 2 to 3
The attribute is clearly perceived, although it is slight	→	From 3 to 4
The attribute is clearly perceived, but the intensity is lower than the reference	→	From 4 to 5
The attribute is clearly perceived and the intensity is very close to the reference	→	From 5 to 6
The intensity of the attribute is similar to the reference	→	6
The intensity of the attribute is higher than the reference	→	From 6 to 7

Panel Performance

Panel performance is displayed in Table 6. Averaging the results over tasting time for all the attributes, only 28.5% of the 24 attributes would be discriminative for an average panelist. Among these discriminative attributes, an average panelist would agree with the panel in 60.6% of the cases. An average panelist would be less repeatable than the group in 22.1% of the attributes.

Individual results regarding the discriminative ability were not good. It could be because of the fact that wines were quite similar (all from the same area, from the same vintage and all elaborated mainly with Tempranillo variety), so discriminating among them could be difficult. In spite of this, the average percentage of discriminative attributes for the panel as a whole for the four tasting times was notably higher (44.8%).

Descriptive and Discriminative Attributes

The mean, SD and variation coefficient for each attribute over all the sessions are shown in Table 7. The two attributes that scored the highest were the appearance attributes: "color hue" (5.05) and "color intensity" (4.85). "Color hue" reference ranges from very purple tonality (upper part of the scale) to red tonalities with no purple tonality (lower part of the scale), and "color intensity" reference ranges from very high color deepness or opacity (upper part of the scale) to a color deepness where light can easily go through (lower part of the scale), so high scores could be expected for these two attributes in these young wines that presented the typical purple color, and, in general, high color intensities.

TABLE 6.
PERFORMANCE OF THE PANEL THROUGH THE TASTING SERIES

	First series	Second series	Third series	Fourth series	Overall
Panel discrimination*	58.3	41.7	37.5	41.7	44.8 ± 9.2
Individual discrimination†	26.7	27.5	29.6	30.1	28.5 ± 1.6
Panelist agreement with the panel‡	57.8	65.1	59.4	60.0	60.6 ± 3.2
Panelist lack of repeatability§	21.3	25.8	17.6	23.6	22.1 ± 3.5

* Percent of attributes with a significant ($P < 0.05$) wine effect in two-way analyses of variance (ANOVAs).

† Percent of attributes by panelist with a significant ($P < 0.10$) wine effect in individual one-way ANOVA.

‡ Percent of agreement with the panel (Kendall coefficient) among the attributes by panelists significant in †.

§ Percent of panelists by attribute with a lack of repeatability.

TABLE 7.
F STATISTICS AND *P* VALUES FROM THE MODEL: WINE + SAMPLE (WINE) + SUBJECT

	Mean	SD	Variation coefficient*	*F* statistics			*P* value		
				Wine†	Wine/sample‡	Sample (wine)§	Wine†	Wine/sample‡	Sample (wine)§
Appearance attributes									
Color intensity	4.85	0.94	19.36	64.22	20.59	3.12	0.0000	0.0000	0.0000
Color hue	5.05	1.00	19.70	15.54	3.20	4.85	0.0000	0.0004	0.0000
Aroma attributes									
Red berry	2.77	0.95	34.52	4.29	2.52	1.70	0.0000	0.0043	0.0014
Floral	2.53	1.03	40.75	3.74	5.92	0.63	0.0000	0.0000	0.9843
Aroma intensity	4.22	0.69	16.33	2.80	3.28	0.85	0.0001	0.0003	0.7725
Dark berry	2.55	0.96	37.53	2.68	2.27	1.18	0.0002	0.0098	0.1790
Tree fruit	2.84	1.01	35.59	2.09	2.34	0.89	0.0051	0.0078	0.6955
Herbaceous	2.48	0.90	36.37	1.98	2.36	0.84	0.0091	0.0073	0.7946
Alcoholic¶	3.67	0.78	21.25	1.14	0.49	2.31	0.3066	0.9501	0.0000
Licorice¶	2.40	0.90	37.63	0.79	0.58	1.36	0.7094	0.8964	0.0455
Flavor attributes									
Red berry	2.59	0.83	32.15	3.44	1.54	2.23	0.0000	0.1108	0.0000
Alcoholic	3.83	0.72	18.73	2.77	1.57	1.76	0.0001	0.0987	0.0007
Herbaceous	2.63	0.84	32.07	2.75	3.22	0.85	0.0001	0.0004	0.7726
Floral	2.31	0.89	38.46	2.00	3.33	0.60	0.0081	0.0003	0.9913
Dark berry	2.55	0.91	35.72	1.87	1.84	1.02	0.0158	0.0425	0.4448
Tree fruit	2.61	1.01	38.53	1.62	3.12	0.52	0.0491	0.0006	0.9987
Flavor intensity	4.10	0.64	15.70	1.47	1.36	1.08	0.0938	0.1877	0.3241
Licorice¶	2.62	0.89	33.86	0.58	0.55	1.05	0.9134	0.9174	0.3751
Taste/mouthfeel attributes									
Astringency	4.30	0.70	16.17	17.69	9.87	1.79	0.0000	0.0000	0.0005
Balance	4.27	0.96	22.40	7.02	3.34	2.10	0.0000	0.0003	0.0000
Bitterness	3.70	0.75	20.24	3.92	4.55	0.86	0.0000	0.0000	0.7568
Acidity	4.37	0.63	14.36	3.11	2.88	1.08	0.0000	0.0012	0.3283
Persistence	4.42	0.92	20.75	2.10	2.15	0.98	0.0049	0.0151	0.5220
Body	4.22	0.76	18.10	1.65	0.75	2.19	0.0436	0.7430	0.0000

* Variation coefficient = (SD/mean) × 100.
† Wine is the *F*-test of the wine effect against the error term (heterogeneity of panel).
‡ Wine/sample is the *F*-test of the wine effect against the sample (wine) effect.
§ The sample (wine) effect measures to what extent time induces differences in wines.
¶ No significant attributes ($P > 0.10$) in the *F*-test of the wine against heterogeneity of the panel.

The mean score for the other seven attributes was also higher than the middle point in the scale: "persistence," "acidity," "astringency," "balance," "aroma intensity," "body" and "flavor intensity." Except for "bitterness," all the taste and mouthfeel attributes are included. This could be explained by the fact that these sensations are always present in the wines and they are usually quite easily perceived, whereas "bitterness" is not always present. The mean score of 4.42 for "persistence" means that the overall time that the global flavor sensation in the mouth remained after spitting out the sample was around 8–9 s. "Aroma intensity" and "flavor intensity" presented a mean score higher than 4. Both attributes are always present and well perceived. "Alcoholic aroma" (3.67) and "alcoholic flavor" (3.83) are quite close to the middle point of the scale, and according to the mentioned nominal scale, they were clearly perceived, although with slight intensity.

Variation coefficients for the mentioned attributes were, in all the cases, lower than 23% (SD lower than 1.0).

The mean scores for all the rest of the aroma and flavor attributes were in a narrow range between 2.84 ("tree fruit" aroma) and 2.31 ("floral" flavor), corresponding in the nominal scale to "It is perceived but very slightly." The meaning of these results could be that the identification of these attributes in wine was quite more difficult and that they were not so well appreciated as the mentioned taste, mouthfeel and appearance attributes, despite that these attributes probably are not always present. This difference between aroma scores and taste and mouthfeel scores is in agreement with the data reported by Fischer *et al.* (1999) in Riesling wines, Noble *et al.* (1984) in Bordeaux wines, Noble *et al.* (1987) in Zinfandel wines and González *et al.* (2002) in Tacoronte-Acentejo red wines, where average scores for aroma attributes were in the lower part of the scale.

Results of the *F*-test testing wine effect against heterogeneity of the panel showed that, with a $P < 0.10$, there were significant differences for all the attributes except for "alcohol" aroma and "licorice" aroma and flavor, that resulted not useful attributes to distinguish among the wines. Results for "licorice" were unexpected because it is one of the characteristics commonly associated to young red wines from RA, and it has been defined as one of the key attributes determining sensory quality of these wines (Etaio *et al.* 2007). In addition to having low mean scores, it would not be valid to discriminate among wines. "Licorice" references were said to be understood, well perceived and adequate by the panelists, so it could be considered that "licorice" aroma and flavor were not overall well expressed in the wines studied.

Attributes with the highest significant values ($P < 0.0001$) were those related to appearance, taste and mouthfeel (except "body"), and some aroma and flavor attributes as "red berry" aroma and flavor and "floral" aroma. "Color

intensity" was the attribute that best differentiated among wines, the F value being approximately four times higher than "color hue" and "astringency," nine times higher than "balance" and many more times higher than the rest of the attributes.

"Red berry," "floral," "aroma intensity" and "dark berry" were, respectively, the best aroma attributes to discriminate among wines, whereas "red berry," "alcoholic" and "herbaceous," respectively, were the best discriminative attributes for flavor. Although mean scores for most aroma and flavor attributes are low, the existence of significant differences would indicate that they can be useful to describe and differentiate among wines.

Despite that evolution of the sensory characteristics is not one of the main aims of this paper, a simple F-test was carried out testing the time ("sample [wine]" factor) with the error term (heterogeneity of the panel) to know if there was an influence of the time on the attribute scoring. As shown in Table 7, there are significant differences ($P < 0.10$) for many attributes, whose scores would vary depending on the time ("color intensity," "astringency," "color hue," "balance," "red berry" aroma and flavor, "alcoholic" flavor, "body," "alcoholic" aroma and "licorice" aroma). Despite this variation, when variation among wines ("wine" factor) was tested with variation throughout the time ("sample [wine]") "color intensity," "astringency," "color hue," "balance," "red berry" aroma and "alcoholic" flavor remained discriminative ("wine/sample" column), so they were valid to differentiate among wines although their intensities varied with the time.

"Red berry" flavor and "body" could be valid to differentiate among wines depending on the time of the year when the wine was tasted, so they could not be considered as solid discriminative attributes.

The plot of the PCA applied to the attributes scores for the wines in the study is shown in Fig. 3. The three attributes that were not discriminative ($P > 0.10$) even not considering the time effect were removed before running PCA. The first two principal components accounted for 58.44% (40.55 and 17.89%) of the total variance.

The first component refers mainly to aroma and flavor. It contrasts "herbaceous" character with "fruity" character ("tree fruit," "red berry" and "dark berry"), "floral" character, "persistence" and also "aroma intensity" and "flavor intensity." It seems to be logical. "Herbaceous" character in Rioja wines is usually associated, among other factors, to greater grape yields and not optimally ripened grapes. It would lead to a wine with less aromatic complexity, less aroma/flavor intensity and, because of this, with probable shorter persistence. Also, herbaceous notes coming from the stems of well-matured clusters could hide other aromas and flavors. Negative correlation between "berry"/"fruit" attributes and "herbaceous"/"vegetative" attributes has often been reported in studies with different wines. Guinard

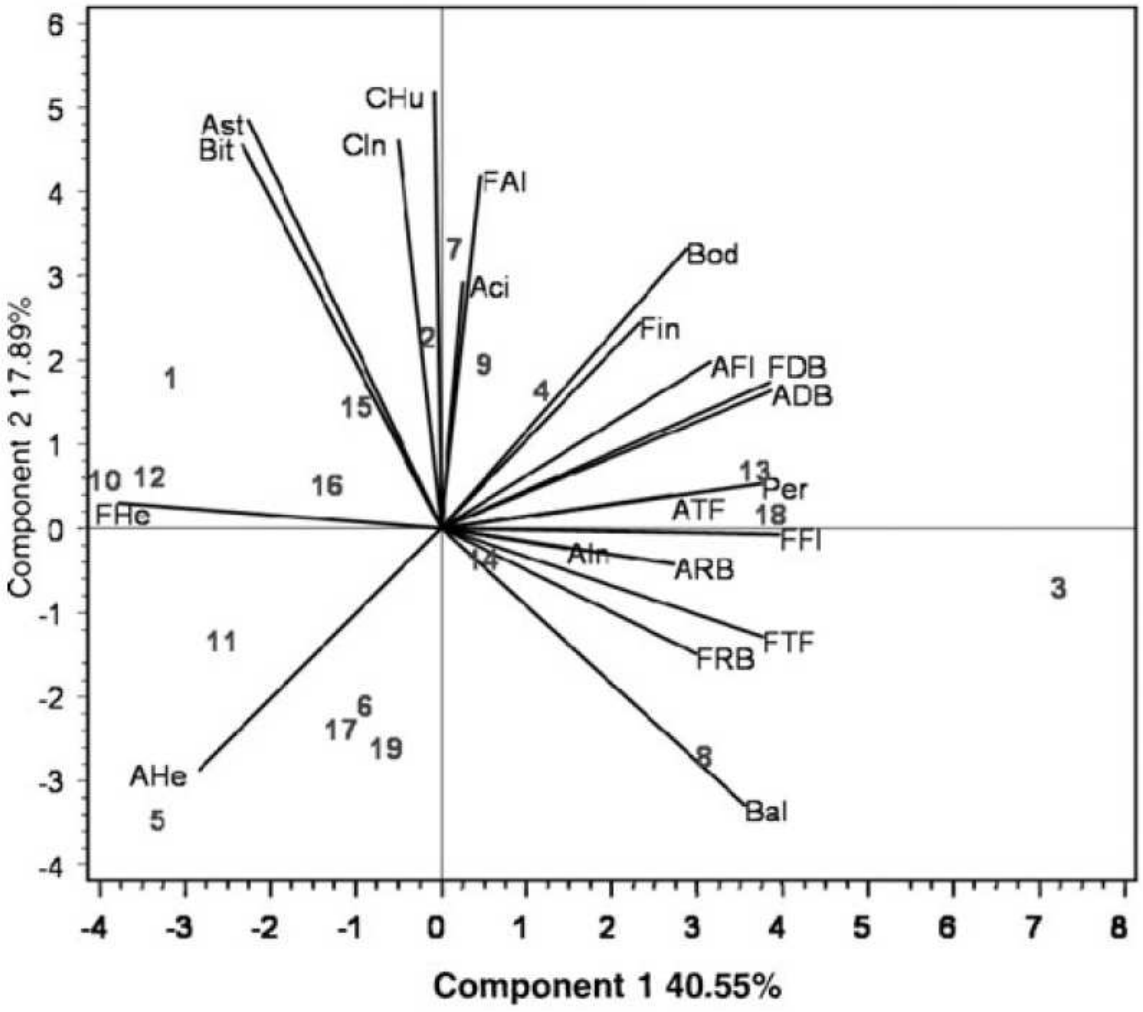

FIG. 3. PROJECTION OF ATTRIBUTE LOADINGS AND WINE FACTOR SCORES (WINES NUMBERED FROM 1 TO 19 ACCORDING TO TABLE 1) ON PRINCIPAL COMPONENTS 1 AND 2

AIn, aroma intensity; AFl, floral aroma; ATF, tree fruit aroma; ARB, red berry aroma; ADB, dark berry aroma; AHe, herbaceous aroma; Fin, flavor intensity; FFl, floral flavor; FTF, tree fruit flavor; FRB, red berry flavor; FDB, dark berry flavor; FHe, herbaceous flavor; FAl, alcoholic flavor; Aci, acidity; Ast, astringency; Bit, bitterness; Bod, body; Bal, balance; Per, persistence; Cln, color intensity; CHu, color hue.

and Cliff (1987) found in Pinot Noir wines that "fresh berry" (strawberry, raspberry, black currant) and "berry jam" (strawberry, raspberry, blackberry) were contrasted with "vegetal," making it possible to separate the wines across the first principal component (PC). Cliff and Dever (1996) found "fruit" contrasted with "herbaceous" in Pinot Noir wines. Kontkanen *et al.* (2005) reported "red fruit" and "black fruit" aromas and flavors contrasted with "fresh vegetables" and "cooked vegetables" aroma and flavors in red wines from Niagara Peninsula. In a study in Zinfandel wines, Noble and Shannon (1987) found "berry" contrasted with "vegetal" attributes across the

first PC. Also, Heymann and Noble 1987) in Cabernet Sauvignon wines found "berry" aroma and "fruit" flavor contrasted with "green bean" aroma and "vegetative" flavor across the first PC.

The second component of the PCA plot is mainly related to appearance and taste and mouthfeel attributes. It contrasts "balance" with "astringency" and "bitterness." It can be considered that when the panel scored high "astringency" and/or "bitterness," they gave low scores to "balance." Color attributes are correlated with "astringency" and "bitterness," which could be explained by the fact that a higher color compound extraction from the skins could be associated to a higher extraction of some compounds that provide bitterness and astringency. These results are in agreement with the data reported by Guinard and Cliff (1987), where the intensity of "red color" and "astringency" separated the wines across the second PC.

CONCLUSIONS

The developed method has made it possible to find the main attributes to describe young red wines from RA and to differentiate among them. This method will make other studies about these wines or also other wines possible. The approach to the development and use of combined references for sensory attributes may be a way of simplifying the running of sessions when there are a lot of quantitative references to evaluate in booths, but always selecting very carefully the attributes to combine, to avoid aroma overlapping. Nevertheless, more studies about the suitability of this sensory practice are necessary.

Appearance attributes ("color intensity" and "color hue") were the best attributes to describe and differentiate the wines during their first year, with high scores and very high discrimination ability. Some taste and mouthfeel attributes ("astringency," "balance," "bitterness" and "acidity") were appropriate too, with medium scores and good discrimination ability.

Although the average scores for aroma and flavor attributes were quite low, many of them were suitable for differentiating among wines. Aroma was slightly more discriminative than flavor. The most discriminative attributes were "red berry," "floral," "aroma intensity" and "dark berry" for aroma and "alcoholic" and "herbaceous" for flavor.

Unexpectedly, "licorice" aroma and flavor did not differentiate among wines.

Many of the attributes that are suitable to describe and differentiate among wines through the first year are influenced by time, which demands a deeper study about the sensory evolution of these wines.

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Article 2

Effect of winemaking process and addition of white grapes on the sensory and physicochemical characteristics of young red wines.

Etaio, I., Pérez Elortondo, F.J., Albisu, M., Gaston, E., Ojeda, M., Schlich, P.

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Effect of winemaking process and addition of white grapes on the sensory and physicochemical characteristics of young red wines

I. ETAIO[1], F.J.P. ELORTONDO[1], M. ALBISU[1], E. GASTON[1], M. OJEDA[1] and P. SCHLICH[2,3,4]

[1] Laboratorio de Análisis Sensorial Euskal Herriko Unibertsitatea (LASEHU), Facultad de Farmacia, Universidad del País Vasco / Euskal Herriko Unibertsitatea, Paseo de la Universidad, 7, 01006 Vitoria-Gasteiz, Spain

[2] Institut National de la Recherche Agronomique (INRA), Dijon, France

[3] Centre National de la Recherche Scientifique (CNRS), Dijon, France

[4] Université de Bourgogne, Dijon, France

Corresponding author: Dr Francisco J. Perez Elortondo, fax + 34 945013014, email franciscojose.perez@ehu.es

Abstract

Background and Aims: This work studies the effect of winemaking process (carbonic maceration (CM) vs destemming) and the effect of grape variety (100% Tempranillo red grapes vs Tempranillo grapes and Viura white grapes) on sensory and physicochemical characteristics of young red wines from Rioja Alavesa.

Methods and Results: Nineteen wines distributed in four groups (the four combinations from the two factors) were collected from 12 wineries. Twenty-four sensory attributes and 15 physicochemical parameters were analysed at four time points through 9 months. Data were analysed by analysis of variance and by canonical variate analysis. CM wines were higher in red berry aroma and flavour, alcoholic flavour and acidity, and lower in licorice and tree fruit aroma. CM wines were higher in ethanol, and lower in glycerol, reducing sugars, total acidity, relative density, total dry extract and colour intensity.

Wines with Viura addition were scored higher in acidity and lower in colour intensity and purple hue. Wines with Viura also had lower values for anthocyanins, total polyphenol index, colour intensity, total dry extract, tannins and pH.

Conclusions: Making red wine by CM compared with destemming introduced some sensory and physicochemical differences in the wines. Viura grape addition influenced a smaller number of sensory attributes and physicochemical parameters.

Significance of the Study: This study increases the information on the sensory description of CM wines and the effect of adding white grapes in making red wine. This work provides winemakers information to be considered when choosing winemaking process and/or adding Viura grapes in making red wine.

Keywords: carbonic maceration, red wine, Rioja, sensory attribute, Tempranillo

Introduction

Rioja wines have a very long history and are famous worldwide for their quality. Since 1925, a Regulatory Council assures that wines under DOC (Qualified Designation of Origin) Rioja abide by rules relating to permitted varieties, viticulture practices, harvest conditions, grape yields and winemaking practices (Boletín Oficial del Estado 2004). Rioja Alavesa (RA) is one of the three sub-areas in DOC Rioja and has some particular characteristics such as soil composition (95% chalky-clayey), climate (Mediterranean/Atlantic climate protected from north winds by a mountain range) and many little wineries that still make wine by the traditional method of non-strict carbonic maceration (CM). CM was the only method used in Rioja until the introduction in the late 18th century of destemming (DS) or the Bordeaux method, the method most extensively used worldwide to make wine by removing the stems and crushing the grapes. Although DS has replaced CM in most of the Rioja region, the majority of the wineries in RA continue producing young red wine by CM.

CM is also used in other European regions such as Médoc, Bordeaux, Beaujolais and Provence (France) to make traditional wines (Ribéreau-Gayon et al. 1976, Carnacini and Del Pozzo 1985), although in many cases, anaerobic conditions are not strict (Ribéreau-Gayon et al. 1976). CM was described for the first time by Flanzy (1935) and involves placing the entire grapes in an atmosphere of CO_2, where several enzymatic reactions occur inside the grape (partial degradation of malic acid, limited

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alcohol production) and some compounds (polyphenols) pass from the skin to the pulp. Usually, some of the grapes get crushed when being put into the tank and other grapes split during anaerobic fermentation, so alcoholic fermentation by yeast occurs simultaneously in the must at the bottom of the tank, with the production of ethanol and CO_2. After obtaining a free run must, clusters are pressed to obtain the must (in RA, an intermediate turning over of the clusters is carried out to obtain the highest quality fraction, the 'heart' must). The resulting musts continue alcoholic fermentation, separately or mixed, in other tanks without stems and skins. In contrast, wines made by DS ferment with skins and are usually maintained for several days with skin maceration after alcoholic fermentation is completed.

In winemaking of CM wines from RA, open tanks are used, SO_2 is added, CO_2 is not added and it is not essential that all grapes are entire. Thus, CM used in RA cannot be considered a strict CM (Jaime et al. 1974).

After alcoholic fermentation, young red wines from RA (both CM and DS wines) undergo malolactic fermentation and are not aged in barrel.

CM wines have been described as having a 'distinctive' and 'rich' aroma (Carnacini and Del Pozzo 1985, Lõrincz and Vas 1998, Flanzy 2003), and to be soft and velvety in the mouth (Fuleki 1974; Jaime et al. 1974; Ribéreau-Gayon et al. 1976, Carroll 1986, Lõrincz and Vas 1998). Because of their early microbiological stabilisation (Flanzy 2003), faster maturation and progressive loss of their 'fresh' and fruity aromas through the first months, CM wines are recommended for early consumption (Carnacini and Del Pozzo 1985). Although floral aromas (Alvarez et al. 1998, Lõrincz and Vas 1998) and also spicy aromas (Carroll 1986) have been reported, aroma attributes used to describe CM wines are mainly fruity (Jaime et al. 1974, Alvarez et al. 1998, Lõrincz and Vas 1998), with more specific reference to strawberry and raspberry (Versini and Tomasi 1983) and cherry or kirsch (Ducruet 1984). It seems that the particular aroma of CM wines compared with DS wines is not due to unique compounds but to the proportion of some volatile compounds common to both being higher in CM wines (Ribéreau-Gayon et al. 1976).

Although there are no conclusive criteria by which to differentiate between CM and DS wines, several volatile compounds related mainly to fruity characters have been reported to be higher in CM wines than in DS wines: ethyl cinnamate (Versini and Tomasi 1983, La Notte et al. 1992), benzaldehyde and vinylbenzene (Ducruet 1984, La Notte et al. 1992), several isoamyl esters (La Notte et al. 1992) and mainly various ethyl esters (Ducruet 1984, Carnacini and Del Pozzo 1985, Etiévant et al. 1989, Alvarez et al. 1998, Lõrincz and Vas 1998, La Notte et al. 1992, Spranger et al. 2004).

Many studies comparing physicochemical characteristics of CM and DS wines have been reported (Fuleki 1974, Carnacini and Del Pozzo 1985, Carroll 1986, Navarro et al. 1988, Alvarez et al. 1998). However, sensory reports comparing these two types of wine are few and quite general, and report the use of sensory panels in very few cases (Fuleki 1974, Etiévant et al. 1989). For CM wines from Rioja, there are no sensory descriptions derived by using trained panels.

Tempranillo (*Vitis vinifera* L.) is the indigenous and preferred variety in RA and represents 96.3% of the 11 903 ha cultivated with red varieties (Rioja Regulatory Council, http://www.riojawine.com). Young red wine from RA is synonymous with Tempranillo wine, which has been described as fruity (Alvarez et al. 1998, Reyero et al. 2000), red berry (Alvarez et al. 1998, Reyero et al. 2000, Etaio et al. 2007), orange, strawberry and plum jam (Clarke and Bakker 2004), licorice (Etaio et al. 2007) and floral (Alvarez et al. 1998, Etaio et al. 2007).

Many wineries frequently add small amounts (less than 15% in total grape weight) of accepted white varieties, mainly Viura (*Vitis vinifera* L.), to make red wine, which is authorised by the Regulatory Council. It is said that Viura grape addition increases perceived acidity in a desirable way and enhances floral and fruity notes (Etaio et al. 2007). In fact, Viura varietal white wines have been described as floral and fruity (Peinado et al. 2004). However, as far as we know, no studies have been reported that describe the sensory influence of adding small amounts of white grape varieties in red wine production, and no sensory evaluations have been carried out with trained panels to confirm the suggested sensory effect of Viura addition in RA red wines.

In sensory descriptive analysis, a trained panel characterises the wine by quantifying perceived sensory attributes. This technique combined with univariate or multivariate statistic analysis has been used to describe different wines (Heymann and Noble 1987, Noble and Shannon 1987, Cliff et al. 2002).

In the present study, descriptive sensory analysis was applied and physicochemical parameters were analysed to provide information about the differences of making wine by CM or by DS in RA young red wines. The aim was also to emphasise the characteristics enhanced by CM that represent the traditional characteristics of young red wine from RA. This information may be considered by winemakers who do not make young red wine by CM when deciding whether to experiment with this technique in order to enhance the indicated characteristics. This study also provides information to winemakers about the suggested effects of the addition of Viura grapes to Tempranillo fermentations.

Materials and methods

Wines

Nineteen wines from the 2005 vintage and from 12 wineries in different villages of RA were studied (Table 1). Before harvesting, instructions were given to the wineries to assure no practices would be performed that could affect the objectives of the study. Wines were made according to the usual winemaking process of each winery and to the practices accepted by the DOC Rioja Regulatory Council (Boletín Oficial del Estado 2004), as wine from these vats would be later commercialised as DOC Rioja wine. As the different methods to

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Table 1. Grape varieties and winemaking practices used in the production of the 19 wines examined in this study.

	Carbonic Maceration	Destemming
Tempranillo 100%	1* (A)†	11 (C)
	2 (B)	12 (I)
	3 (C)	13 (J)
	4 (D)	14 (K)
	5 (E)	15 (E)
Tempranillo + Viura‡	6 (B)	16 (I)
	7 (F)	17 (K)
	8 (D)	18 (J)
	9 (G)	19 (L)
	10 (H)	

*Numbers indicate wine codes
†Letters indicate winery codes
‡Viura percentages ranged from 8% to 15% of total grape weight, except for wine 17, which had only 5% of Viura grapes.

clarify, filter and stabilise the wines used by winemakers could influence sensory characteristics, wineries were asked only to decant the wine to remove lees, which was carried out by them and checked in each winery at the time of wine collection. After undergoing malolactic fermentation and decanting, wines were collected into 20-L demijohns from the vats (vat capacity around 30 000 L) on the same date. Demijohns were completely filled to avoid air space that could deteriorate the wine. Wines with low SO_2 levels were sulphited to assure a minimum level of free SO_2 of at least 22 mg/L to avoid wine deterioration. After 2 weeks at 8 ± 2°C, the top volume of each demijohn was bottled in a bottling plant during the second week of January 2006. Wines were bottled under vacuum in 750-mL bottles using agglomerate cork stoppers. The bottom volume (approximately 6 L) of each demijohn was discarded to avoid sediments.

All bottles were stored in a cellar, laid down under the same conditions (relative humidity of 90 ± 5% and a temperature of 12 ± 3°C). The bottles were collected from the cellar on four occasions (January, March, June and September 2006). In the laboratory, the wines were maintained at 8 ± 1°C until tasting.

Physicochemical analysis

Fifteen parameters were analysed at the stated four time points at the Official Laboratory of Araba County Council, one of the three official laboratories authorised to analyse wines protected by DOC Rioja (Official Journal of the European Communities (1999), C46/10 of 1999). Each parameter was analysed once in each wine and time point. Internal standards and at least one repeated sample were used in the analysis of each parameter to check accuracy, according to the standardised laboratory protocol. Analysed parameters and procedures are shown in Table 2.

Panellists

Eighteen panellists were selected on the basis of interest and availability. The majority of them had experience in sensory descriptive analysis, although not necessarily in wines. During the training (which extended over 8 months), work commitments forced four panellists to discontinue. After the training, the remaining 14 panellists started evaluating the wines, although only 10 (three men and seven women with an average age of 38.8 years) evaluated all 19 wines over the four time points and were therefore considered in the subsequent data treatment. Changes in labour situation, lack of interest and pregnancy were the reasons for four panellists not attending the sessions regularly.

Attribute selection and reference development

Fourteen young red wines from RA were tasted and discussed by the panellists through six sessions to generate terms to describe them. These wines were from the 2005 vintage and included CM and DS wines, wines made only with Tempranillo and wines made with Tempranillo and Viura.

Term generation was carried out by wine pair comparison and also by using the Wine Aroma Wheel (Noble et al. 1987) and a list of attributes collected from the literature and from a discussion session with a group of RA wine experts. Aroma, taste and mouthfeel references were provided to the panellists to facilitate the discussion and the definition of the references. In the seventh session, a reduced list of attributes was defined based on citation frequency and by consensus. Eight attributes were selected for aroma: aroma intensity, floral, tree fruit (related to a generic aroma that could be associated to apple, pear or apricot), red berry, dark berry, herbaceous, licorice and alcoholic. It was decided by consensus to keep all these attributes for flavour evaluation in mouth. The list for taste and mouthfeel attributes included prickly, acidity, astringency, bitterness, body, balance and aromatic persistence (included in this group because of the tasting procedure). Prickly sensation was later removed because of lack of agreement by the panel. There was no discussion about appearance attributes. Colour hue and colour intensity were the chosen attributes according to previous experience with young red wines from RA (Etaio et al. 2007).

Through sessions 8 to 19, the panel was trained in the use of selected attributes. Reference intensities for selected attributes (except for balance, colour intensity and colour hue) were discussed and adjusted to be located in defined points on the scale in use. References were prepared by adding pure compounds (preferentially) to a base wine. Reference composition and the colour reference are described in Etaio et al. (2008) and the colour reference is published in Etaio et al. (2007). Once all the references were defined, the training continued through 12 sessions. In these sessions, panellists evaluated the references and wines according to the methodology that would be used for the evaluation of the wines of the study. The number of wines to be tasted in each session was increased progressively up to six wines. In the 30th and 31st sessions, the

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Table 2. Physicochemical parameters and analytical procedures used to characterise the wines examined in this study.

Parameter	Procedure
Total acidity (as tartaric acid)*	Potentiometric titration up to pH 7 (Official Journal of the European Communities (1990), Commission regulation 2676/90)
Volatile acetic acidity*	Spectrophotometry (colour measurement at 410 nm after reaction with iodine) with segmented flow analyzer Traacs 2000 (Bran + Luebbe, Norderstedt, Schleswig-Holstein, Germany)
Free SO_2*	Spectrophotometry (colour measurement at 560 nm after reaction with pararosaniline) with segmented flow analyzer Traacs 2000 (Bran + Luebbe)
Total SO_2*	Spectrophotometry (colour measurement at 405 nm after reaction with Ellman's reagent (5,5'-Dithio-bis(2-nitrobenzoic acid)) as described by Sadegh and Schreck (2003).
Reducing sugars*	Spectrophotometry (colour measurement at 420 nm after reaction with potassium ferrocyanide) with segmented flow analyzer Traacs 2000 (Bran + Luebbe)
Glycerol	Enzymatic method (Official Journal of the European Communities (1990), Commission regulation 2676/90)
Ethanol % (v/v)*	Spectrophotometry of near infrared reflectance with Technicon InfraAnalyzer 400 (Technicon Instruments Corporation, Tarrytown, NY, USA) as described by Dumolin et al. (1987).
Relative density (20°C)*	By electronic density meter Anton Paar (Graz, Steiermark, Austria) DMA48 according to Density Meter Manual (Anton Paar DMA48 User Manual, German Weber (1990)).
Total dry extract*	Calculation from the specific gravity of the alcohol-free wine (Official Journal of the European Communities (1990), Commission regulation 2676/90)
pH*	By potentiometry with H-plus equipment (Technicon), after calibration with pH standards.
Tannins	By UV/Vis spectrophotometry, as described by Ribéreau-Gayon et al. (1982).
Anthocyanins	Spectrophotometry, after discoloration with sodium bisulphite, as described by Ribéreau-Gayon et al. (1982).
Total polyphenol index (abs_{280})*	Spectrophotometry (Official Journal of the European Communities (1990), Commission regulation 2676/90)
Tonality (abs_{420}/abs_{520})*	Spectrophotometry (Official Journal of the European Communities (1990), Commission regulation 2676/90)
Colour intensity ($abs_{420} + abs_{520} + abs_{620}$)*	Spectrophotometry (Official Journal of the European Communities (1990), Commission regulation 2676/90)

*These methods are accredited in the Laboratory of Araba County Council.

panellists were instructed in the use of FIZZ software (Version 2.10 A; Biosystemes, Couternon, France). The duration of each of these 31 preliminary sessions, which ran over 6 months was about 1 h and 15 min.

Sensory evaluation

Wines were evaluated in four tasting series through 2006 (separated by intervals of approximately 2.5 months). The first series started 3 weeks after bottling of the wines. In each series, a balanced complete block design was used. The 19 wines were evaluated in triplicate by all the panellists through 10 sessions, at a rate of six samples per session, in a way that the three replications were consecutive: all the samples were assessed once, then a second time and then a third time. An extended Latin square type design was used to minimise any bias due to the order of presentation. Wines were randomly coded with three digits. Two sessions per week were carried out, with panellists distributed into two groups according to panellist availability (one group at 12:00 h and the other at 16:30 h).

The day before each tasting session, references and wines were put in the cellar at 16 ± 2°C. Sessions were carried out at controlled temperature (21 ± 2°C) and relative humidity (60 ± 20%). Aroma references were served in standard 200-mL wine glasses (ISO 3591 1977) to get reference evaluation as close as possible to wine evaluation. Wine bottles were opened immediately before morning tasting, and a 35-mL sample of each wine was served in standardised glasses. Reference and wine glasses were covered with Petri dishes and were simultaneously presented at 16 ± 2°C, 5 min before the panellists entered (temperature could increase 2 to 3°C during the session). Bottles with the remaining wine were returned to the cellar after displacing air with inert gas (N_2, Ar and CO_2; Private Preserve™, Napa Valley, California, USA), to be used in the afternoon session. Panellists were randomly placed in the booths according to the order of arrival. References and wines were evaluated in isolated booths according to a previously defined tasting procedure (Etaio et al. 2008) and under weak light to avoid colour bias. A minimum time was established to evaluate the references in the booth prior to wine evaluation. Intensities of aroma, flavour, taste and mouthfeel attributes were scored in a continuous linear scale from 1 to 7 points, according to reference intensities. References

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and samples were expectorated. Panellists were instructed to rinse with water between mouth references and between wines, and were provided with crackers and an insipid liquid jelly solution to recover from astringency effects. The liquid jelly solution was prepared by dissolving commercial jelly used for dessert making (commercialised as powder or as very thin films) in warm water. The liquid jelly solution was considered appropriate by the panellists during the training phase so it was presented in the evaluation sessions.

A minimum waiting time of 1 min was established between sample evaluations. Panellists were told to rest and to leave the tasting room if necessary. Appearance attributes were evaluated last by using six additional glasses with a 25-mL sample under lighting similar to daylight (colour temperature close to 6 500°K, chromatic index higher than 90). The duration of the sessions was around 1 h. Results of panel performance are published in Etaio et al. (2008).

Data analysis

All statistical analysis was performed using SAS® (SAS Institute, Cary, North Carolina, USA). Physicochemical data analysis was run using the value for each wine and time. For sensory data, mean scores of the panel and mean scores of the three replications at each time point were used to simplify the model; thus, it was considered that each wine was evaluated in quadruplicate by a panel. After running a three-way analysis pf variance (ANOVA) with process, grape variety and wine (process × grape variety) as factors and time effect included in the error, data were submitted to a two-way ANOVA to test process and grape variety against wine effect. Thus, variance between winemaking processes and between addition or absence of Viura grapes was compared with variance among the wines to determine which attributes and parameters were process or/and grape variety dependent. Because of the very conservative analysis of data, *F*-values higher than 2 were considered as indicators of significant differences.

Physicochemical means across time points and sensory means of the wines across judges and time points were submitted separately to canonical variate analysis (CVA) to maximise the separation among the groups according to the studied effects. Only the attributes and parameters differing significantly in the two-way ANOVA were considered. One two-dimensional plot for types of wine (the four combinations of process and grape variety) and attributes was produced separately for sensory data and for physicochemical data.

Finally, physicochemical parameters were projected onto sensory data to show possible correlations between sensory and physicochemical parameters.

Results and discussion

Physicochemical parameters

Physicochemical differences between CM and DS wines are shown in Table 3. While free SO_2, total SO_2 and ethanol contents were higher in CM than in DS wines, values of total acidity, volatile acetic acidity, reducing sugars, relative density, total dry extract, glycerol and colour intensity were lower in CM wines.

Free and total SO_2 values are related to the sulphite addition practices in each winery and no conclusive information could be obtained. Also, ethanol content depends on some factors not related to the winemaking process, including fermentation temperature, sugar content of the must or some compounds affecting yeast activity. This could be the reason for contradictory results found in the literature about ethanol content differences between CM and DS wines. Thus, while Carnacini and Del Pozzo (1985) reported higher ethanol content in CM wines, possibly due to formation of ethanol from malic acid in anaerobiosis (Alvarez et al. 1988), other authors found no differences (Navarro et al. 1988) or found lower alcohol content in CM wines (Carroll 1986), possibly due to the dilution effect caused by the vacuole juice of stems (Mesias and Ough 1984).

The lower acidity found in CM wines could be due to the partial metabolism of malic acid in the entire grape (Ribéreau-Gayon et al. 1976) and agrees with reports by many authors (Carnacini and Del Pozzo 1985, Fuleki 1974, Jaime et al. 1974, Rizzon et al. 1999, Flanzy 2003). Despite the difference found for acidity and despite CM wines having been reported as higher in pH (Ribéreau-Gayon et al. 1976, Carroll 1986, Navarro et al. 1988, Rizzon et al. 1999), no differences were found in this study, perhaps because of the effect of the potassium accumulation observed in Rioja wines (Ruiz 1992).

Volatile acetic acidity could be influenced greatly by several factors including winemaking practices, wine exposure to air and yeast species in each winery (Zoecklein et al. 1995). Results in the literature comparing volatile acidity in CM and DS wines are quite contradictory (Navarro et al. 1988, Lõrincz and Vas 1998). In the present study, an interaction effect for volatile acetic acidity between process and grape variety showed the inappropriateness of this parameter for differentiating between CM and DS wines.

The lower reducing sugar content found in CM wines has been reported by some authors (Ribéreau-Gayon et al. 1976, Flanzy 2003), although others (Navarro et al. 1988) found no differences. At any rate, the absolute concentration or residual sugars found in the wines studied here, as well as the differences between them, are unlikely to be of sensory significance.

Although Jaime et al. (1974) and Ribéreau-Gayon et al. (1976) reported lower glycerol content in DS wines than in CM wines, the DS wines of the present study possessed a higher content of glycerol. This could be due to a higher glycerol production by glyceropyruvic fermentation in DS wines, although other factors such as initial sugar content, fermentation temperature, yeast species and pantothenic acid might also influence the final glycerol content in the wine (Boulton et al. 1996). The observed higher values of glycerol and the longer skin-contact maceration in DS winemaking, which increases the extraction of many substances present in the skins, could explain the higher relative density and

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Table 3. Physicochemical parameters of wines produced by carbonic maceration (CM) or destemming (DS) from Tempranillo alone (T) or with added Viura (T + V)†.

Parameter	Process‡				Grape variety‡				Process × grape variety‡	
	CM (Mean ± SEM)	DS (Mean ± SEM)	*F*	*P*	T (Mean ± SEM)	T + V (Mean ± SEM)	*F*	*P*	*F*	*P*
Total acidity (g/L)	3.9 ± 0.1	4.5 ± 0.1	**11.49**	**0.0040**	4.2 ± 0.1	4.2 ± 0.1	0.24	0.6297	1.69	0.2131
Volatile acetic acidity (g/L)	0.39 ± 0.01	0.44 ± 0.01	**4.38**	**0.0538**	0.45 ± 0.01	0.38 ± 0.01	**6.00**	**0.0271**	**6.24**	**0.0246**
Free SO_2 (mg/L)	21 ± 2	16 ± 1	**2.45**	**0.1380**	19 ± 2	18 ± 1	0.15	0.7047	0.55	0.4681
Total SO_2 (mg/L)	49 ± 3	38 ± 2	**2.96**	**0.1061**	42 ± 3	45 ± 2	0.13	0.7207	1.13	0.3054
Anthocyanins (mg/L)	575 ± 19	593 ± 21	0.11	0.7423	632 ± 19	530 ± 18	**9.14**	**0.0085**	0.02	0.8954
Reducing sugars (g/L)	1.9 ± 0.1	2.4 ± 0.1	**9.05**	**0.0088**	2.1 ± 0.1	2.1 ± 0.1	0.07	0.8009	0.02	0.8961
Relative density (20°C)	0.9914 ± 0.0001	0.9932 ± 0.0001	**28.92**	**<0.0001**	0.9925 ± 0.0002	0.9920 ± 0.0002	1.14	0.3018	0.12	0.7349
Total dry extract (g/L)	24.8 ± 0.2	28.5 ± 0.2	**57.11**	**<0.0001**	27.0 ± 0.3	26.0 ± 0.3	**2.83**	**0.1134**	0.02	0.8918
Glycerol (g/L)	6.5 ± 0.1	8.0 ± 0.1	**39.03**	**<0.0001**	7.4 ± 0.1	7.1 ± 0.2	0.45	0.5147	0.63	0.4394
Ethanol % (v/v)	13.95 ± 0.07	13.60 ± 0.05	**3.35**	**0.0873**	13.75 ± 0.06	13.82 ± 0.08	0.06	0.8174	0.13	0.7189
Total polyphenol index (abs_{280})	60 ± 1	64 ± 1	1.22	0.2860	65 ± 1	59 ± 1	**2.92**	**0.1078**	0.03	0.8573
Colour intensity ($abs_{420} + abs_{520} + abs_{620}$)	9.769 ± 0.262	11.691 ± 0.316	**5.15**	**0.0385**	11.435 ± 0.308	9.839 ± 0.291	**3.42**	**0.0840**	0.01	0.9352
pH	3.79 ± 0.02	3.73 ± 0.02	1.08	0.3159	3.81 ± 0.02	3.71 ± 0.02	**2.18**	**0.1603**	0.12	0.7298
Tannins (g/L)	2.47 ± 0.05	2.67 ± 0.06	1.58	0.2282	2.67 ± 0.05	2.44 ± 0.06	**2.26**	**0.1532**	0.00	0.9452
Tonality (abs_{420}/abs_{520})	0.634 ± 0.009	0.596 ± 0.009	1.99	0.1792	0.619 ± 0.009	0.612 ± 0.010	0.10	0.7576	0.00	0.9689

†Mean and standard error of mean (SEM), *F* statistics and *P*-values from the model: process + grape variety + process*grape variety + wine (process × grape variety).
‡Factors tested against wine (process × grape variety) as the error term.
Values in bold indicate differences considered significant ($F > 2$).
SEM: standard deviation/square root of the number of values averaged in this mean.

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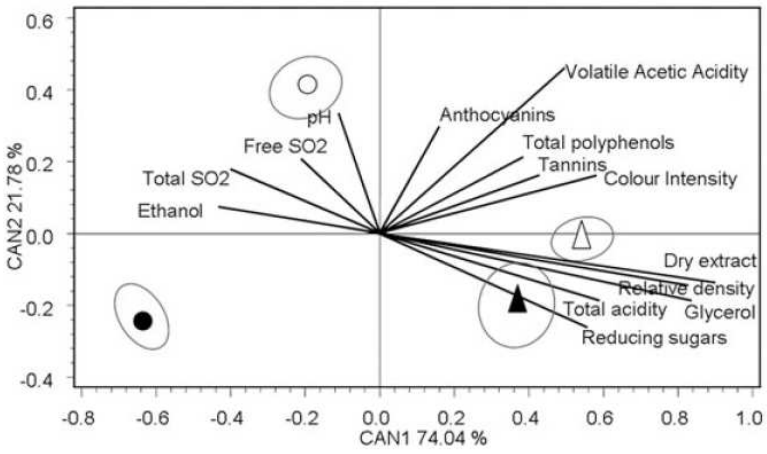

Figure 1. Canonical variate analysis plot of physicochemical data for significant parameters. Parameter loadings and factor scores for carbonic maceration wines (circles) made with Tempranillo (○) or Tempranillo and Viura (●), and for destemming wines (triangles) made with Tempranillo (△) or Tempranillo and Viura (▲). Ellipses at 90% of confidence. CAN, Canonical variable.

total dry extract values found in DS wines. These results are in agreement with those reported by other authors (Carnacini and Del Pozzo 1985, Carroll 1986, Alvarez et al. 1998).

Due to the cited substance passing from the skins to the juice during skin-contact maceration, and also due to the lower polyphenol content in wines made with stems by adsorption phenomena or because of co-polymerisation with tannins (Mesias and Ough 1984), CM wines have been reported as being lower in polyphenols and anthocyanins (Fuleki 1974, Jaime et al. 1974, Carroll 1986, Alvarez et al. 1998, Rizzon et al. 1999, Gómez-Miguel and Heredia 2004, Spranger et al. 2004, Castillo-Sanchez et al. 2006). However, no differences for these parameters were found in the present study. In spite of this and although no differences for tonality were found, colour intensity in DS wines was higher than in CM wines, in agreement with Ribéreau-Gayon et al. (1976), Rizzon et al. (1999), Gómez-Miguel and Heredia (2004), Spranger et al. (2004) and Castillo-Sanchez et al. (2006).

No differences for tannin content due to the winemaking process were found in this study. Two phenomena could be acting in opposing directions and could explain such a lack of difference. On one hand, tannins pass from skins to wine during the skin-contact period, and this passage increases with the time of contact (Cheynier et al. 2003), which is usually longer in DS wines. Also, as tannin extraction is related to ethanol concentration, a lower tannin extraction could be expected in CM wines as the skin-contact period in this wine is largely limited to the anaerobic phase, when ethanol concentration is still low. On the other hand, tannins pass from stems to juice during the anaerobic phase in CM wines (Mesias and Ough 1984), which does not occur in DS wines because stems are removed.

Wines with Viura addition presented significantly lower pH, although there were no differences for total acidity. The lower total dry extract, tannins, anthocyanins and total polyphenol index in wines made with Viura addition would be related to the lower polyphenol content in the skins of white grapes. The lower colour intensity in wines with Viura addition could be explained by a dilution of the colour provided by the red grape skins.

The plot from canonical analysis of physicochemical parameters is shown in Figure 1. The first canonical variable explains 74.04% of the variance and separates CM wines (characterised by higher values of ethanol and free and total SO_2) from DS wines (characterised by higher dry extract, relative density, glycerol, total acidity, reducing sugars and colour intensity). The second canonical variable explains 21.78% of the variance and slightly separates wines made entirely with Tempranillo from those with Viura grape addition (characterised by lower values for pH, anthocyanins and volatile acetic acidity).

Sensory attributes

Results of ANOVA of sensory data are displayed in Table 4. Six sensory attributes showed different scores depending on the winemaking process used: licorice, tree fruit and red berry aroma, alcoholic and red berry flavour, and acidity. Panellists perceived higher acidity in CM wines. This result is not in agreement with what could be expected since CM wines are commonly defined as less acid than DS wines (Fuleki 1974, Jaime et al. 1974, Etaio et al. 2007). Licorice aroma was scored higher for DS wines, although, as far as we know, no studies have been reported about the influence of winemaking processes on this attribute. Although there were no significant differences for alcoholic aroma, CM wines presented higher alcoholic flavour, which has also not been reported as a sensory difference between these two types of wine.

Regarding the fruit character, CM wines were higher in red berry aroma and flavour, as described by Versini and Tomasi (1983), whereas DS wines revealed higher tree fruit aroma. Thus, the expected higher fruity aroma in CM wines resulted in qualitative differences within fruity aroma according to the type of wine. A possible explanation for the higher scores for tree fruit aroma in DS wines could be that, not being identified with a specific fruit subfamily, their fruity character was considered

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Table 4. Sensory attributes of wines produced by carbonic maceration (CM) or destemming (DS) from Tempranillo alone (T) or with added Viura (T + V)†.

Aroma attributes	Process‡				Grape variety‡				Process × grape variety‡	
	CM (Mean ± SEM)	DS (Mean ± SEM)	*F*	*P*	T (Mean ± SEM)	T + V (Mean ± SEM)	*F*	*P*	*F*	*P*
Licorice	2.34 ± 0.05	2.47 ± 0.05	**9.33**	**0.0080**	2.41 ± 0.05	2.40 ± 0.05	0.05	0.8331	0.33	0.5716
Tree fruit	2.78 ± 0.04	2.92 ± 0.05	**6.42**	**0.0229**	2.85 ± 0.05	2.84 ± 0.05	0.00	0.9993	1.42	0.2526
Red berry	2.82 ± 0.05	2.70 ± 0.06	**2.59**	**0.1284**	2.75 ± 0.06	2.78 ± 0.06	0.11	0.7430	0.00	0.9763
Floral	2.57 ± 0.05	2.48 ± 0.05	1.19	0.2917	2.48 ± 0.05	2.57 ± 0.05	1.36	0.2612	0.49	0.4940
Alcoholic	3.68 ± 0.04	3.67 ± 0.05	0.16	0.6955	3.66 ± 0.04	3.69 ± 0.05	1.16	0.2989	0.60	0.4513
Herbaceous	2.45 ± 0.04	2.49 ± 0.05	0.60	0.4521	2.45 ± 0.05	2.49 ± 0.04	0.40	0.5371	0.01	0.9281
Aroma intensity	4.23 ± 0.04	4.22 ± 0.04	0.13	0.7270	4.21 ± 0.04	4.23 ± 0.04	0.11	0.7438	0.02	0.8905
Dark berry	2.55 ± 0.05	2.55 ± 0.06	0.00	0.9615	2.56 ± 0.05	2.54 ± 0.05	0.02	0.8781	0.03	0.8744
Flavour attributes										
Alcoholic	3.88 ± 0.04	3.79 ± 0.04	**4.81**	**0.0445**	3.81 ± 0.04	3.86 ± 0.04	1.36	0.2622	0.10	0.7516
Red berry	2.64 ± 0.05	2.54 ± 0.05	**2.46**	**0.1375**	2.58 ± 0.05	2.60 ± 0.05	0.04	0.8386	0.13	0.7269
Licorice	2.60 ± 0.04	2.63 ± 0.05	0.60	0.4499	2.61 ± 0.05	2.62 ± 0.05	0.03	0.8586	**3.09**	**0.0991**
Floral	2.31 ± 0.04	2.31 ± 0.04	0.02	0.8839	2.29 ± 0.04	2.33 ± 0.04	0.54	0.4748	1.97	0.1809
Tree fruit	2.60 ± 0.04	2.63 ± 0.04	0.02	0.8839	2.62 ± 0.04	2.61 ± 0.04	0.54	0.4748	1.97	0.1809
Flavour intensity	4.11 ± 0.03	4.11 ± 0.03	0.05	0.8320	4.10 ± 0.03	4.12 ± 0.03	0.26	0.6174	0.43	0.5200
Herbaceous	2.61 ± 0.04	2.64 ± 0.05	0.26	0.6185	2.62 ± 0.05	2.63 ± 0.04	0.01	0.9102	0.08	0.7873
Dark berry	2.55 ± 0.04	2.56 ± 0.05	0.02	0.8918	2.57 ± 0.05	2.54 ± 0.04	0.13	0.7209	0.20	0.6584
Taste and mouthfeel										
Acidity	4.41 ± 0.03	4.32 ± 0.03	**9.46**	**0.0077**	4.34 ± 0.03	4.40 ± 0.03	**2.86**	**0.1113**	**2.55**	**0.1315**
Body	4.23 ± 0.04	4.24 ± 0.05	0.02	0.8802	4.26 ± 0.04	4.21 ± 0.04	1.23	0.2858	0.02	0.8832
Bitterness	3.72 ± 0.04	3.68 ± 0.04	0.77	0.3928	3.70 ± 0.04	3.70 ± 0.04	0.03	0.8645	1.26	0.2797
Astringency	4.29 ± 0.05	4.32 ± 0.05	0.03	0.8685	4.35 ± 0.05	4.25 ± 0.06	0.62	0.4429	0.20	0.6600
Balance	4.25 ± 0.06	4.30 ± 0.06	0.26	0.6205	4.28 ± 0.06	4.28 ± 0.06	0.00	0.9955	0.53	0.4769
Persistence	4.42 ± 0.04	4.45 ± 0.05	0.19	0.6715	4.44 ± 0.05	4.42 ± 0.05	0.20	0.6621	0.06	0.8143
Appearance attributes										
Colour intensity	4.72 ± 0.10	5.01 ± 0.09	1.28	0.2756	5.13 ± 0.09	4.55 ± 0.09	**6.23**	**0.0247**	0.01	0.9390
Colour hue	5.10 ± 0.09	5.04 ± 0.09	0.24	0.6287	5.21 ± 0.09	4.91 ± 0.08	**3.44**	**0.0835**	0.11	0.7424

†Mean and standard error of mean (SEM), F statistics and p-values from the model: process + grape variety + process × grape variety + wine (process × grape variety).
‡Factors tested against wine (process × grape variety) as error term.
Values in bold indicate differences considered significant ($F > 2$).
SEM: standard deviation/square root of the number of values averaged in this mean.

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more generic by the panellists. Significant differences for dark berry aroma or flavour were not found.

Formation of molecules responsible for herbaceous character, such as hexan-1-ol and 3-hexen-1-ol, has been reported to be lower in CM wines (La Notte et al. 1992, Lõrincz and Vas 1998, Spranger et al. 2004) because of the limited formation of these compounds from fatty acids in anaerobic conditions. Nevertheless, no differences were found by the panellists in either herbaceous aroma or herbaceous flavour. Thus, if differences in the concentration of compounds related to herbaceous character exist, these findings suggest that they were not large enough to be perceived by the panellists.

Carroll (1986) reported less astringency for CM wines, and Rizzon et al. (1999) reported less body and less balance for CM wines in a study in Cabernet Franc, although without reporting sensory descriptive analysis. There is no conclusive data in the literature about the influence of winemaking on these three attributes. No differences were found for the wines of this study. It could be expected that the higher values of DS wines for dry extract, relative density, glycerol content and total acidity could lead to a higher body for these wines. The lack of differences between DS and CM wines in regard to body could be due to the higher ethanol content and higher alcoholic flavour of CM wines, since ethanol contributes to increase the body perception.

Although many physicochemical studies have been done, no comprehensive sensory reports have been found in relation to appearance attributes. Alvarez et al. (1998) and Rizzon et al. (1999) reported less colour intensity for CM wines, although without reporting sensory descriptive analysis. This could be due to the fact that in winemaking by DS, the alcoholic fermentation takes place in the presence of grape skins. Both Alvarez et al. (1998) and Rizzon et al. (1999) reported 5 days of skin maceration for traditional vinification (DS). In CM winemaking, the major part of the alcoholic fermentation takes place after crushing and removal of the grapes. Until this moment, many of the grapes are entire or ruptured and the volume of free must is low, so the skin to must contact is low compared with DS winemaking. In addition, the ethanol concentration of this must is low; thus, the favourable effect of ethanol on colour compound extraction is lower than in DS winemaking. However, colour intensity data from the wines of the present study were not differently scored depending on winemaking process. Further work is required to determine the basis for these observations. There was also no difference between CM wines and DS wines in colour hue.

Addition of Viura grapes had an influence on both the appearance attributes and the acidity. Viura addition did not significantly change any aroma or flavour attribute. Wines made with Tempranillo and Viura were perceived more acid, which is in accordance with many observations made by experts on wine from RA (Etaio et al. 2007). However, this difference took place only for CM wine, whereas in DS wines, scores were not consistent (data not shown) and would be the reason for the significant interaction between process and grape variety factors. Perceived colour intensity and purple tone were significantly lower in wines with Viura grape addition. It could be considered that this is simply a result of the addition of Viura grapes diluting the colour intensity of the wines.

A CVA plot of four wine types and significant attributes is shown in Figure 2. The first canonical variable explains 85.87% of the variance among the four groups and contributes to differentiation among them mainly according to the winemaking process. Whereas the first variable does not clearly differentiate between DS wines made with or without Viura grape addition, it distinguishes CM wines made only with Tempranillo from CM wines with Viura addition. CM wines with Viura addition were those that differentiated most from the other three groups. The large confidence ellipses for DS wines made only with Tempranillo reveals higher heterogeneity within this type of wine in comparison with the other three wine types.

The first canonical variable accounts for acidity showing that CM wines made with addition of Viura are more acid than CM wines made only with Tempranillo and still more acid than DS wines, whereas there is no difference within DS wines. The cited interaction between process and grape variety factors for acidity would explain

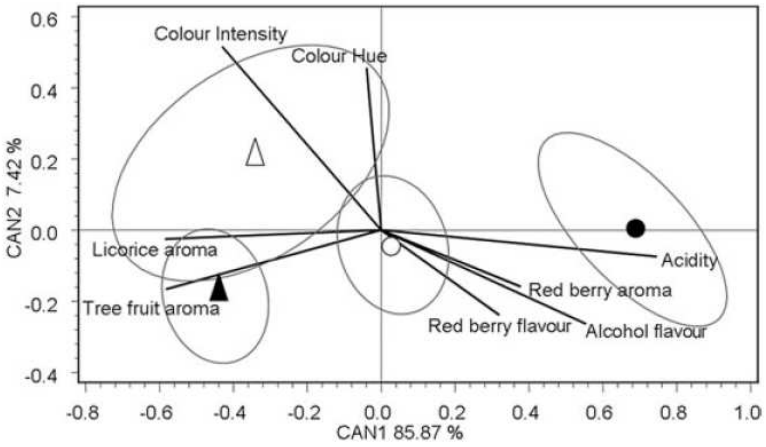

Figure 2. Canonical variate analysis plot of sensory data for significant parameters. Attribute loadings and factor scores for carbonic maceration wines (circles) made with Tempranillo (○) or Tempranillo and Viura (●), and for destemming wines (triangles) made with Tempranillo (△) or Tempranillo and Viura (▲). Ellipses at 90% of confidence. CAN, Canonical variable.

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this. It would mean that addition of Viura grapes affected acidity differently according to the winemaking process used. Despite this and according to the ANOVA results, the winemaking process had a greater effect on acidity than Viura grape addition.

The first canonical variable is highly negatively correlated with licorice aroma and separates licorice-characterised DS wines from CM wines, mainly those containing Viura grapes. The first canonical variable also contrasts different fruity characters, showing that CM wines are characterised by red berry and DS wines by tree fruit. This separation could support the hypothesis that, when specific fruit subfamilies were not identified, the panellists could have scored the fruity character of DS wines as the more generic tree fruit. Alcoholic flavour was clearly related to CM wines.

The second canonical variable accounts only for 7.42% of the total variance and contributes very little to separate between wine types. It explains appearance attributes, where DS wines made only with Tempranillo were the highest in colour intensity and hue.

Relation between physicochemical parameters and sensory attributes

Projection of significant physicochemical parameters on sensory after correlating them with mean values of significant sensory attributes (Figure 3) showed that, as could be expected, colour intensity evaluated by the panel was correlated with total polyphenol index, colour intensity but mainly with anthocyanin content. These physicochemical parameters were related to wines made only with Tempranillo grapes. In fact, these wines presented significantly higher values for polyphenol index, colour intensity and anthocyanin content and were scored as higher in colour intensity compared with wines made with Tempranillo and Viura. In the case of colour hue, the physicochemical parameter more directly related to this appearance attribute, tonality, was not significantly different between wines made only with Tempranillo and wines made with Tempranillo and Viura. This result could be due to colour intensity influencing colour hue scoring, thereby leading panellists to score wines with higher colour intensity as the wines higher in colour hue (more purple). The small angle in Figure 3 between the vector of scored colour hue and the vector of scored colour intensity would support this explanation.

Ethanol content was correlated with alcoholic flavour, showing that ethanol content contributes to this sensation in the mouth. However, as previously stated, no significant differences were found for alcoholic aroma. Noble and Shannon (1987) reported significant higher ethanol aroma intensity in Zinfandel wines with 14.51–15.60% (v/v) ethanol compared with Zinfandel wines with 12.60–13.70% (v/v) ethanol. This ethanol content difference is larger than the difference found in the present study between CM and DS wines. It is therefore unlikely to have been enough to be perceived by the panellists upon aroma evaluation, although the possible interaction of other aromatic volatile compounds on the perception of ethanol aroma has to be considered as well. The significant difference for alcoholic flavour suggests that ethanol content differences were more apparent retronasally than orthonasally.

Scoring of the acidity attribute was opposite to total acidity, showing that scoring of acidity by the panel was not determined by acid content. The higher glycerol and reducing sugar content found in DS wines could in part explain this result by diminishing the perception of acidity. Nevertheless, the absolute concentration of these compounds and the concentration differences found between CM and DS wines are unlikely to have been enough to be identified as a sweet sensation or as a difference in sweetness, respectively.

Conclusion

Many differences were found between non-strict CM wines and DS wines. CM wines had a higher content in alcohol and lower values for glycerol, reducing sugars,

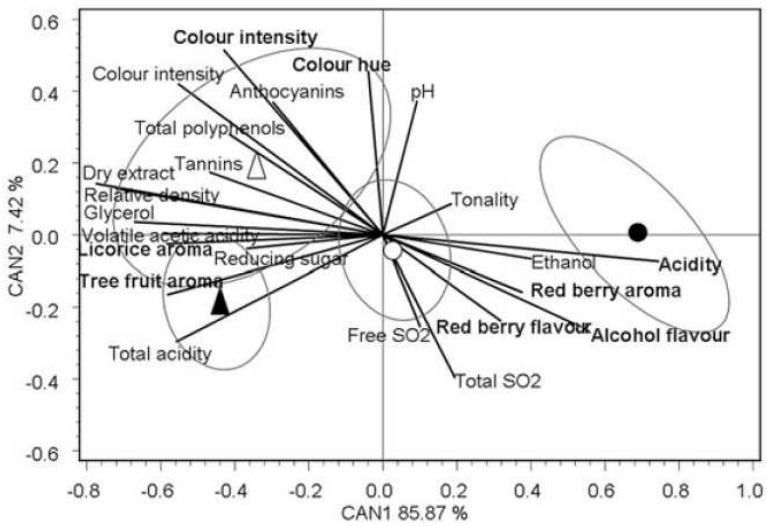

Figure 3. Projection of physicochemical parameter loadings on canonical variate analysis plot of sensory data. Sensory attribute (in italics in the plot) and physicochemical parameter loadings and factor scores for carbonic maceration wines (circles) made with Tempranillo (○) or Tempranillo and Viura (●), and for destemming wines (triangles) made with Tempranillo (△) or Tempranillo and Viura (▲). Ellipses at 90% of confidence. CAN, Canonical variable.

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acidity, density, total dry extract and colour intensity, some of which may be due to the longer skin maceration times in DS wines. CM wines were characterised by a higher red berry aroma and flavour, higher alcoholic flavour and higher acidity, but were lower in licorice aroma and tree fruit aroma in comparison with DS wines.

Although some differences were found when adding Viura white grapes to Tempranillo red grapes for making red wine, this factor did not prove to be so decisive. Wines with Viura presented lower values for some colour-related parameters such as anthocyanins, total polyphenol index and colour intensity, and also for total dry extract and tannins. Although no differences were found for total acidity, wines with Viura addition presented lower pH. From a sensory point of view, wines with Viura addition were lower in colour intensity and in purple hue. Also, in accordance with one of the suggested purposes of adding Viura to make red wine, wines with Viura were higher in perceived acidity. Neither aroma nor flavour differences were found.

Ethanol content was correlated with alcoholic flavour, whereas colour intensity was correlated with total polyphenol index, colour intensity and mainly with anthocyanin content.

Findings of the present work provide winemakers information to be considered when choosing winemaking process and when deciding whether to add Viura grapes or not, depending on the sensory characteristics that they wish to enhance in the wines.

As all the wines were from a single vintage, further studies would be required to determine the validity of these findings across several vintages. Also, because all the wines of the study were collected without undergoing typically postfermentation clarification and filtering treatments, further studies may be required to determine if these practices would diminish or enhance the differences found through this study.

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Article 3

Sensory attribute evolution in bottled young red wines from Rioja Alavesa.

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ORIGINAL PAPER

Sensory attribute evolution in bottled young red wines from Rioja Alavesa

Iñaki Etaio · Francisco José Pérez Elortondo · Marta Albisu · Edurne Gaston · Pascal Schlich

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Abstract The evolution of 19 bottled young red wines from Rioja Alavesa was studied through 9 months. Twenty-four sensory attributes (including appearance, aroma, flavor, taste and mouth-feel) were evaluated at four times (at 1, 3, 5 and 9 months after bottling) by a ten-member panel. Fifteen physicochemical parameters were also analyzed at these four times. Effect of winemaking process (carbonic maceration vs. destemming), and grape variety (only Tempranillo vs. Tempranillo with a white variety) on wine evolution was considered too. Data were analyzed by analysis of variance. Nine sensory attributes changed significantly through the time: red berry aroma and flavor, body, balance, purple hue and color intensity increased, whereas alcoholic aroma and flavor, and astringency decreased. Almost all the physicochemical parameters changed significantly through the time. The winemaking process and the addition of white grapes did not influence sensory and physicochemical evolution.

Keywords Sensory evolution · Trained panel · Young red wine · Rioja wine · Carbonic maceration · Tempranillo · Viura

I. Etaio · F. J. Pérez Elortondo (✉) · M. Albisu · E. Gaston
Laboratorio de Análisis Sensorial Euskal Herriko Unibertsitatea (LASEHU), Facultad de Farmacia, Universidad del País Vasco-Euskal Herriko Unibertsitatea, Paseo de la Universidad, 7, 01006 Vitoria-Gasteiz, Spain
e-mail: franciscojose.perez@ehu.es

I. Etaio
e-mail: inaki.etaio@ehu.es

M. Albisu
e-mail: marta.albisu@ehu.es

P. Schlich
INRA, UMR 1214, 21000 Dijon, France

P. Schlich
CNRS, UMR 1214, 21000 Dijon, France
e-mail: schlich@cesg.cnrs.fr

P. Schlich
UMR 1214, Université de Bourgogne, 21000 Dijon, France

Introduction

Wine is a complex beverage that evolves through the time both from a physicochemical, and from a sensory point of view. Compared to barrel aged wines, young red wines have a "shorter life" and their evolution through the first year is very important, since it determines the sensory properties of the wine and therefore customer acceptance.

Changes in young wine composition during evolution have been largely studied. Volatile analysis has been widely used to study how the different volatile compounds, many of them determining wine aroma and flavor, change through the time in white wines [1–3], and in red wines [4–6]. There are also many studies that consider the evolution of physicochemical parameters, especially the evolution of color-related parameters in red wines [7–10].

Regarding sensory analysis, there are some studies about the influence of different storage factors (mainly temperature) on sensory characteristics of white wines [3, 11–13]. However, studies considering sensory evolution in red wines without barrel aging by using trained panels are scarcer [9, 14, 15].

In sensory quantitative descriptive analysis, a trained panel scores the intensities of different sensory attributes perceived in the product. This technique combined with univariate or multivariate statistic analysis has been widely used to characterize different wines [16–20].

Rioja Alavesa (RA) is one of the three sub-areas included in Rioja Qualified Designation of Origin (D.O·C. Rioja). RA has some particular characteristics such as soil composition (95% chalky-clayey), climate (Mediterranean/Atlantic climate protected from the north winds by a mountain range), and many little wineries that still make wine by the traditional method of non-strict carbonic maceration (CM). Traditionally, young red wines from RA are not barrel aged, and are commonly recommended for consumption during their first year.

Carbonic maceration was described for the first time by Flanzy [21], although in the case of RA wines CM is not strict, since open tanks are used, SO_2 is added, CO_2 is not added and it is not fundamental that all the grapes be intact [22]. CM was the only method used in Rioja until the introduction in the late XVIII century of destemming (DS) or Bordeaux method, the method most extensively used worldwide to make wine by removing the stems and crushing the grapes. CM wines are said to be for early consumption [23], because of the progressive loss of their "fresh" and fruity aromas through the first months. This opinion is widely extended in RA, and could suggest that sensory evolution may be different between CM and DS wines, although no reports about possible differences in sensory evolution have been found.

Tempranillo (*Vitis vinifera* L.) is the indigenous and preferential variety in RA and represents around the 96% of the planted red varieties (data from the Regulatory Council, http://www.riojawine.com). Many wineries add small amounts (less than 15% in total grape weight) of accepted white varieties (mainly Viura, *Vitis vinifera* L.) to make red wine, which is authorized by the Regulatory Council of D.O·C. Rioja. However, no reports about the influence of this practice on wine sensory evolution have been found.

This work is part of a more complete research work (supported by the Association of Wineries from Rioja Alavesa and the Administration of the Basque Country) to characterize and to get to know more about the young red wines from RA, in order to improve their sensory properties [24, 25]. The main objective of the present study was to study the sensory evolution over a period of 9 months of young red wines from RA stored in bottles at cellar temperature. Physicochemical evolution was considered too. Possible influence of winemaking process (CM vs. DS) and white grape addition (Tempranillo vs. Tempranillo plus Viura) on wine evolution was also studied.

Material and methods

Wines

Nineteen 2005 vintage wines from 12 wineries of different RA villages were studied. Of the 19 wines, 10 were made by CM (5 of them entirely with Tempranillo red grape variety and 5 with Tempranillo and 8–15% in weight of Viura white grape variety), and 9 by DS (5 of them entirely with Tempranillo variety and the other 4 with Tempranillo and 8–15% of Viura variety). Grapes were harvested with a °Brix ranging from 21.2 to 24.8. Wines were made according to the usual winemaking process of each winery. Depending on the winery wild yeast or added yeast carried out the alcoholic fermentation. Fermentation was made in stainless steal vats (capacity around 30,000 L) and fermentation period varied from 5 to 11 days depending on the winery. Fermentation temperatures did not reach 32 °C in any of the wines, fluctuating from 20 to 30 °C for the majority of the wines. In DS winemaking, wines were kept in skin maceration several days (2–7 depending on the winery). Maceration after alcoholic fermentation was not generally used for MC wines, although a short maceration (1–3 days) was carried out in some wineries. All the wines underwent malolactic fermentation. Most wineries added tartaric acid to adjust the pH (commonly 0.5–1.0 g tartaric acid/kg grape). Final pH of the wines was 3.78 ± 0.14. As methods used to clarify, filter and stabilize the wines differed from one winery to another, winemakers were instructed to solely remove lees by decanting before collecting the wines, in order to avoid additional operations that could influence the characteristics of the wines.

Wines were transferred into 20-L demijohns, and sulphur dioxide adjusted if there was less than 22 ppm sulfite. After racking for 2 weeks at 8 ± 2 °C, wines were bottled at the second week of January 2006. Bottles of 750-mL were used, and agglomerate cork stoppers were fitted after removing head-space air from the bottle-neck by vacuum generation. The bottom volume (approximately 6 L) of each demijohn was discarded to avoid sediments.

All the bottles were stored lain down in a cellar (relative humidity of $90 \pm 5\%$ and temperature of 12 ± 3 °C). The bottles were picked up from the cellar a week before the sensory and physicochemical analyses were carried out. At the laboratory, the wines were kept at 8 ± 1 °C. The day before the tasting session, wines were placed in a cellar at 16 ± 2 °C until served.

Attribute selection and panel training

Eighteen panelists, most of them experienced in sensory descriptive analysis, were selected on the basis of interest and availability. Some of the panelists left the panel during the study due to different circumstances (labor changes, pregnancy), and others missed too many sessions. Ten panelists (three men and seven women with an average age of 38.8) evaluated all the 19 wines at the 4 time points, and only their data were considered for analysis.

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Terms were generated and discussed through 6 sessions by evaluating 14 young red wines from RA as described in Etaio et al. [25], mainly by using wine pair comparison. Wine aroma wheel [26], and a list of attributes (collected from the literature and from a previous discussion with a group of experts on RA wines) were also used to facilitate term generation and discussion. Eight attributes were selected for aroma: aroma intensity, floral, tree fruit (related to a generic aroma that could be associated to apple, pear or apricot), red berry, dark berry, herbaceous, liquorice and alcoholic. It was decided by consensus to maintain these attributes for flavor evaluation in mouth too. The selected taste and mouth-feel attributes were acidity, astringency, bitterness, body, balance, and aromatic persistence (included in this group in accordance with the tasting procedure). Although prickly sensation was initially considered, it was later removed due to lack of internal agreement in the panel. Color hue and color intensity were the chosen attributes for appearance evaluation, according to the previous experience with young red wines from RA [24].

Simultaneously with attribute selection, chemical quantitative combined references were developed through 18 sessions. The chosen attributes combined in each reference were clearly different so as to avoid possible confusion. Intensity of each attribute in the reference was adjusted by discussion with the panel. Reference composition is shown in Table 1, and reference development is described in Etaio et al. [25].

Once all the references were developed, panelists were trained during 12 additional sessions. In the 30th and 31st sessions, the panelists were also instructed in the use of

Table 1 Sensory reference composition and processing

Attribute	Reference concentrate composition (kept frozen)	Final processing of the reference
Aroma intensity Flavor intensity Global flavor persistence	200 μL solution of linalool (1% v/v) and geraniol (1% v/v) in ethanol absolute 6 mL licorice solution[a] 0.25 mL raspberry flavoring[b] 25 mL ethanol absolute 20 mL table red wine	Defrost and carry to a total volume of 500 mL with table red wine
Red berry Herbaceous	0.4 mL raspberry flavoring 20 μL solution of hexenol-3-cis (1% v/v) in ethanol absolute 2.5 g tannic acid powder[c] 45 mL of base wine[d]	Defrost and carry to a total volume of 400 mL with base wine
Floral Dark berry	0.16 mL berry flavoring[e] 160 μL solution of linalool and geraniol (1% v/v) 50 mL base wine	Defrost and carry to a total volume of 400 mL with base wine
Licorice Alcoholic	14 mL licorice solution 32 mL ethanol absolute	Defrost and carry to a total volume of 400 mL with base wine
Tree fruit		240 mL of commercial grape juice + 160 mL of table red wine + 16 mL ethanol
Acidity (low intensity) Astringency (low intensity) Bitterness (low intensity) Body (low intensity)	15 mL ethanol 0.3 g tannic powder[f] 40 mL water	Defrost and add 205 mL of water and 245 mL of table red wine
Acidity (high intensity) Astringency (high intensity) Bitterness (high intensity) Body (high intensity)	15 mL ethanol 14 mL glycerol 2.75 g tannic powder 0.95 g tartaric acid 0.0150 quinine sulfate 17 mL table red wine	Defrost and carry to a total volume of 500 mL with table red wine
Balance	No reference	

[a] 10 g of licorice paste dissolved in 100 mL of warm water

[b] Raspberry flavor10703-36 (laboratory sample), Givaudan Ibérica S.A., Pla d'en Batlle s/n, 08470 Sant Celoni, Barcelona

[c] Tannic acid J-624, Givaudan Deutschland GmbH Giselherstr, 11, D-44319 Dortmund

[d] Base wine elaborated with commercial table red wine diluted with water (3:1) and added 2 mL ethanol absolute for each 100 mL

[e] 15.63.5411, International Flavors and Fragrances España, Po. de La Castellana 149 28046, Madrid

[f] Oenotannin perfect. Chevallier-Appert, Groupe Oeno france, ZA Alfred Daney. Rue La Motte Picquet 33300, Bordeaux

FIZZ software (Biosystemes, Couternon, Version 2.10 A). The duration of each of these 31 preliminary sessions that run through 6 months was about 1 h and 15 min.

Wine sensory evaluation

The wines were evaluated in four tasting series through 2006. Each series was composed of ten sessions run through 5 weeks (two sessions per week). Considering the fifth of these ten sessions as the date reference, wines were evaluated 1, 3, 5 and 9 months after bottling. A balanced complete block design was used. The 19 wines were evaluated in triplicate by all the panelists through the ten sessions of each series, at a rate of six samples per session. The three replicates were consecutive: all the samples were assessed once, then a second time and then a third time. The 19 samples to be evaluated in each replication were randomly distributed across the corresponding sessions. An extended Latin square type design was used in each session to minimize any bias due to the order of presentation. Wines were randomly coded with three digits.

In each session, panelists were divided into two groups according to panelist availability (one group at 12:00 and the other at 16:30).

The day before the tasting session, references and wines were put in the cellar at 16 ± 2 °C. Sessions were carried out at controlled conditions (temperature 21 ± 2 °C and relative humidity of 60 ± 20%). The bottles of wine were opened immediately before morning tasting and 35-mL samples were served in standard 200-mL wine glasses [27] 5 min before the panelists entered the tasting room. Bottles with the remaining wine were returned to the cellar after displacing the air with inert gas (N_2, Ar and CO_2; Private Preserve, Napa Valley, CA), to be used in the afternoon session. Wine samples and references (which were also served at all the sessions) were presented at 16 ± 2 °C.

References and wines were evaluated in isolated booths according to a previously defined tasting procedure [25], and under the weak light provided by the computer screen to avoid color bias. A minimum time to evaluate the references before starting wine evaluation was established. Intensities of aroma, flavor, taste and mouth-feel attributes in the wines were scored on a continuous linear scale from 1 to 7 points, comparing them with the intensities of the references (placed on point 6 for aroma and flavor attributes and on point 2 and 6 for low and high intensities for taste and mouth-feel attributes). References and samples were expectorated. A minimum waiting time of 1 min was established between sample evaluations. During the waiting time, panelists used unsalted crackers and an insipid liquid jelly solution to eliminate residual sensations and to recover from astringency carryover, and rinsed with water before tasting the next sample. Panelists were able to leave the tasting room to have a rest when necessary. After nose and mouth-attributes were evaluated for all the samples, appearance attributes were evaluated by using six additional glasses with a 25-mL sample volume. Appearance attribute evaluation was carried out under lighting very similar to daylight (color temperature close to 6,500 °K and color rendering index higher than 90). The duration of sample tasting sessions was around 1 h.

Physicochemical analysis

Fifteen parameters were analyzed at the mentioned four times at the Laboratory of Ardo Etxea-Casa del Vino in Laguardia (an official laboratory for the Regulatory Council of Rioja [28]). At each time, each wine was analyzed without replication. Internal standards and at least one repeated sample were used to check the accuracy of each parameter analysis at each time, according to the standardized laboratory protocol.

Total acidity (such as tartaric acid) was analyzed by potentiometric titration up to pH 7 [29]; volatile acetic acidity by spectrophotometry with segmented flow analyzer Traacs 2000 (Bran + Luebbe), measuring the absorbance at 410 nm after reaction with iodine; free SO_2 by spectrophotometry with segmented flow analyzer Traacs 2000 (Bran + Luebbe), measuring the absorbance at 560 nm after reaction with pararosaniline; total SO_2 by spectrophotometry, measuring the absorbance at 405 nm after reaction with Ellman's reactive [5,5′-Dithio-bis(2-nitrobenzoic acid) (DTNB)] as described by Sadegh et al. [30]; reducing sugars by spectrophotometry with segmented flow analyzer Traacs 2000 (Bran + Luebbe), measuring the absorbance at 420 nm after reaction with potassium ferrocyanide; glycerol by the enzymatic method [29]; ethanol % (v/v) by spectrophotometry of near infrared reflectance (N.I.R.) with Technicon InfraAnalyzer 400 as described by Dumolin et al. [31]; relative density (20 °C) by electronic density meter Anton Paar DMA48 according to Density Meter Manual [32]; total dry extract by calculation from the specific gravity of the alcohol free wine [29]; pH by potentiometry with H-plus equipment (Technicon), after calibration with pH standards; tannins by UV/Vis spectrophotometry, as described by Ribéreau-Gayon et al. [33]; anthocyanins by spectrophotometry, measuring absorbance after decoloration with sodium bisulfite, as described by Ribéreau-Gayon et al. [33]; total polyphenol index by spectrophotometry, measuring absorbance at 280 nm [29]; tonality by spectrophotometry, dividing absorbance at 420 nm by absorbance at 520 nm [29]; color intensity by spectrophotometry, adding absorbance at 420, 520 and 620 nm [29].

Data analysis

All statistical analysis was performed using SAS® (SAS institute, Cary, NC, USA).

A complete 3-way analysis of variance model was basically the model used for each sensory attribute:

Model:
Subject + Wine + Time + Subject × Wine + Subject × Time + Wine × Time
Degrees of freedom: 9 + 18 + 3 + 162 + 27 + 54 = 273

In this model, the interaction Subject × Wine × Time was the residual term, since the three replicates at each time were first averaged in order to keep only one score for each wine at each time by each panelist. However, it was not exactly this model which was run, but the same model in which the wine effect was decomposed to take into account the grape variety and the process factors together with their interactions:

Decomposition:
Wine = Grape + Process + Grape × Process + Wine (Grape × Process)
Degrees of freedom: 18 = 1+1 + 1 + 15

Thus, each interaction involving the wine effect and another factor (subject or time) was also decomposed into the sum of the interaction between this factor and each of the four terms of the above decomposition. The final model included 15 terms (354 degrees of freedom) plus the residual (403 degrees of freedom).

Now, the most important aspect of this model was that not only the subject, but also the wine(Grape × Process) is considered as a random effect. Therefore, both heterogeneity of subjects and wine within a given grape and process were taken into account in the statistical inference done on the time effect, and its interaction with the grape and the process factors. We could thus expect this inference to be valid with a different sample of subjects and wines from the same area.

Computation of expected mean squares (run by the GLM procedure of SAS) gave the proper error term for each factor under interest (Table 2).

Regarding physicochemical parameters, data were submitted to a three-way analysis of variance (ANOVA) with time, process and grape as fixed factors and wine within the same process by grape as a random effect. Thus, time variation was contrasted with wine (Process × Grape variety)time as the error term.

Both for sensory attributes, and for physicochemical parameters differences in evolution related to winemaking process or grape variety were stated by significant interactions of time with process or with grape variety.

Since analysis was expected to be rather conservative p values lower than 0.10 were considered significant. Sensory attributes and physicochemical parameters that changed significantly through the time were submitted to canonical variate analysis to maximize the separation among the four times.

The effect of the grape, process and Grape × Process factors on sensory attributes and physicochemical parameters will not be reported in the present article, as it was already reported in an earlier paper [34]. The focus of this paper is on the time effect, and on its interaction with the grape and the process factors.

Results

Sensory attributes

Results of ANOVA for sensory attributes are shown in Table 3. Nine of the 24 attributes changed significantly through the time: red berry and alcoholic aroma, red berry and alcoholic flavor, astringency, body, balance, color hue and color intensity. Figure 1 shows the evolution of these attributes considering the 19 wines as a whole.

Regarding aroma attributes, red berry increased through the time, mainly from month 3 to month 5. Alcoholic aroma tended to decrease initially, and then remained the same.

The pattern of flavor attributes was quite similar. Whereas red berry flavor increased (mainly from month 3 to month 5, but also from month 5 to month 9), alcoholic flavor decreased from month 1 to month 5 and then remained more or less stable.

Regarding taste and mouth-feel attributes, astringency showed a tendency to decrease through the time, whereas body and balance increased, mainly in the first months, and then remained approximately constant.

Table 2 Factors of interest and their error term

Factor	Error term
Time	MS[a](Subject × Time) + MS[Wine(Grape × Process) × Time] − MS(residual)
Time × Process	MS(Subject × Time × Process) + MS[Wine(Grape × Process) × Time] − MS(residual)
Time × Grape	MS(Subject × Time × Grape) + MS[Wine(Grape × Process) × Time] − MS(residual)
Time × Grape × Process	MS(Subject × Time × Grape × Process) + MS[Wine(Grape × Process) × Time] − MS(residual)

[a] *MS* mean square

Table 3 Sensory attributes: F statistics and p values for time effect

	Time		Time × Process		Time × Grape		Time × Process × Grape	
	F	p	F	p	F	p	F	p
Aroma attributes								
Aroma intensity	0.66	0.5843	1.94	0.1553	0.63	0.6058	0.05	0.9860
Floral aroma	0.14	0.9328	1.98	0.1548	1.56	0.2474	0.37	0.7756
Tree fruit aroma	0.74	0.5383	0.52	0.6728	0.47	0.7071	0.77	0.5218
Red berry aroma	**2.69**	**0.0650**	0.24	0.8642	0.24	0.8645	0.92	0.4420
Dark berry aroma	0.79	0.5084	0.73	0.5404	0.21	0.8899	**2.57**	**0.0878**
Herbaceous aroma	1.07	0.3769	0.56	0.6498	2.29	0.1204	0.09	0.9631
Liquorice aroma	1.19	0.3331	0.40	0.7511	0.20	0.8968	**2.80**	**0.0766**
Alcoholic aroma	**4.14**	**0.0153**	1.86	0.1790	0.26	0.8541	1.57	0.2313
Flavor attributes								
Flavor intensity	0.80	0.5054	1.06	0.3838	0.18	0.9062	0.86	0.4758
Floral flavor	0.08	0.9679	2.16	0.1334	0.68	0.5799	0.35	0.7875
Tree fruit flavor	0.25	0.8588	0.24	0.8672	1.52	0.2722	1.29	0.3502
Red berry flavor	**4.75**	**0.0086**	0.55	0.6514	0.29	0.8292	0.48	0.6992
Dark berry flavor	0.96	0.4248	0.64	0.5989	0.19	0.9026	1.14	0.3571
Herbaceous flavor	0.88	0.4637	0.13	0.9384	0.44	0.7277	0.45	0.7204
Liquorice flavor	0.92	0.4451	0.08	0.9711	1.39	0.3437	2.40	0.1182
Alcoholic flavor	**2.43**	**0.0873**	0.91	0.4653	0.56	0.6509	**4.39**	**0.0384**
Taste and mouth-feel attributes								
Acidity	1.71	0.1909	0.12	0.9448	2.41	0.1110	1.46	0.2888
Astringency	**3.76**	**0.0215**	**2.93**	**0.0621**	0.32	0.8119	0.19	0.9032
Bitterness	0.06	0.9809	0.26	0.8516	0.23	0.8722	1.16	0.3519
Body	**5.44**	**0.0048**	0.13	0.9411	0.41	0.7500	1.17	0.3649
Balance	**3.20**	**0.0381**	0.65	0.5882	0.11	0.9541	0.51	0.6758
Persistence	0.20	0.8928	1.15	0.3518	1.35	0.3090	**2.92**	**0.0591**
Appearance attributes								
Color hue	**7.97**	**0.0006**	1.50	0.2563	0.37	0.7767	0.58	0.6380
Color intensity	**4.97**	**0.0069**	0.75	0.5361	0.55	0.6536	**3.71**	**0.0275**

In bold significant effects ($p < 0.10$)

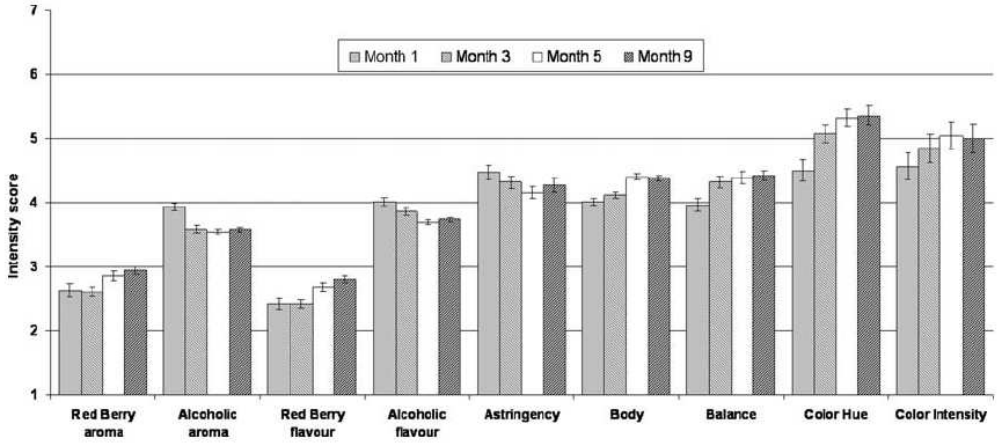

Fig. 1 Evolution of the sensory attributes that changed significantly through the 9 months. Data are expressed as wine mean and its 90% CI

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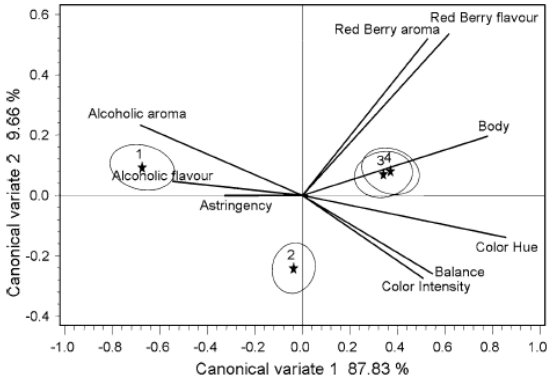

Fig. 2 CVA plot of sensory data for significant attributes. Attribute loadings and factor scores for the four times (1, 3, 5 and 9 months). *Ellipses* at 90% of confidence

Color hue and color intensity increased from month 1 to month 5, and then remained approximately constant.

Slightly significant interactions between process and time were found for astringency (Table 3). This can be explained by the fact that, although both CM wines and DS wines underwent a similar evolution regarding astringency (decreasing up to month 5 and then increasing slightly), astringency decreased more markedly from month 1 to month 3 in DS wines, whereas in CM wines the most marked decrease occurred from month 3 to month 5 (data not shown). White grape addition did not present any effect on sensory evolution. For five attributes, the interaction among time, process, and grape variety was slightly significant. This is a very complicated situation which is almost impossible to interpret.

Figure 2 shows the CVA plot for sensory attributes with significant evolution. First canonical variate explains 87.83% of the variance among the four times, while second canonical variate explains 9.66% of the variance. The four time points are mainly distributed across the first canonical variate, where the wines as a whole developed from more alcoholic and astringent wines to more balanced wines, with more body, higher in red berry, purpler and with higher color intensity. As can be seen in Fig. 2, month 3 and month 4 are almost completely overlapped, showing that there is no sensory evolution from month 5 to month 9.

Physicochemical parameters

Results of ANOVA for physicochemical parameters are shown in Table 4, as well as the mean and its 90% CI of each parameter at each time considering the 19 wines as a whole. All the parameters changed significantly through the time. Parameters that increased through the time were volatile acetic acidity and tonality. Total tartaric acidity, reducing sugars, relative density, glycerol, total polyphenol index, color intensity and pH showed a slight decrease through the time, whereas the decrease of free SO_2, total SO_2 and anthocyanin content was more marked. In the case of total dry extract, ethanol and tannins there was an initial decrease and then an increase, with significant but slight changes for these three parameters.

Process influenced evolution of some physicochemical parameters, as may be observed from the interactions between process and time for four parameters: volatile acetic acidity, total SO_2, relative density, and total dry extract. Volatile acetic acidity decreased in the third time (5th month) for CM wines and then increased, whereas DS wines presented a slight but constant increase (d.n.s.: data not shown). Total SO_2 values stabilized in the third time (5th month) in CM wines, whereas in DS wines the values continued decreasing (d.n.s.). Relative density of DS wines maintained almost constant through the time, whereas values for CM wines decreased slightly but continuously (d.n.s.). Total dry extract showed a similar pattern for both kinds of wines, decreasing and then increasing, but with a more marked increase for DS wines (d.n.s.).

Addition of white grapes had an effect in only two parameters: volatile acetic acidity, and total polyphenol index. Volatile acetic acidity showed a similar pattern for wines made with and without Viura grape addition, but wines made only with Tempranillo variety had a slightly higher increase from 5th month to 9th month (d.n.s.). Patterns for total polyphenol index were similar too, although the decrease from 5th month to 9th month was slightly more marked in wines made only with Tempranillo (d.n.s.).

Figure 3 shows the CVA plot for physicochemical parameters. First canonical variate explains 61.19% of the variance among the four times, while second canonical variate explains 31.61% of the variance. Wines evolved from higher content in free SO_2 and total SO_2 and higher acidity to wines with higher volatile acetic acidity and higher tonality. Third time (5th month) is clearly deviated from the linear evolution represented by the other three times.

Discussion

Studies about sensory evolution in bottled wines using sensory trained panels are few and are mainly focused on white wines, so results for many attributes used in this study can not be contrasted with data from other authors.

According to the results of the present study, young red wines from RA need some months (about half a year) to better express their red berry aroma and flavor. Whereas the other fruity attributes (tree fruit and dark berry) do not evolve significantly through the 9 months, the red berry character not only remains, but also increases after the first

Table 4 Physicochemical parameters: wine mean and its 90% CI at each time and F statistics and p values for time effect

Parameters	Month 1 Mean and 90% CI[b]	Month 3 Mean and 90% CI[b]	Month 5 Mean and 90% CI[b]	Month 9 Mean and 90% CI[b]	Time		Process × Time[a]		Grape × Time[a]		Process × Grape × Time[a]	
					F	p	F	p	F	p	F	p
Total tartaric acidity (g/L)	4.3 ± 0.18	4.2 ± 0.19	4.2 ± 0.18	4.1 ± 0.17	**27.20**	**<0.0001**	0.17	0.9163	0.95	0.4252	0.54	0.6598
Volatile acetic acidity (g/L)	0.39 ± 0.025	0.42 ± 0.027	0.41 ± 0.028	0.44 ± 0.032	**31.87**	**<0.0001**	**2.26**	**0.0944**	**3.27**	**0.0297**	1.07	0.3723
Free SO_2 (mg/L)	25 ± 3.3	21 ± 3.0	17 ± 2.9	11 ± 2.5	**258.69**	**<0.0001**	0.59	0.6254	0.43	0.7329	1.63	0.1955
Total SO_2 (mg/L)	45 ± 5.1	47 ± 5.2	42 ± 5.1	40 ± 6.0	**16.41**	**<0.0001**	**2.77**	**0.0526**	0.55	0.6508	0.49	0.6885
Anthocyanins (mg/L)	663 ± 38.4	637 ± 33.7	600 ± 32.1	434 ± 27.3	**282.79**	**<0.0001**	0.52	0.6726	0.93	0.4339	0.20	0.8977
Reducing sugars (g/L)	2.2 ± 0.14	2.1 ± 0.15	2.1 ± 0.15	2.1 ± 0.17	**4.27**	**0.0098**	0.70	0.5596	2.00	0.1275	0.82	0.4887
Relative density (20 °C)	0.9924 ± 0.00042	0.9923 ± 0.00044	0.9922 ± 0.00043	0.9922 ± 0.00044	**30.73**	**<0.0001**	**6.71**	**0.0008**	0.65	0.5855	1.26	0.2996
Total dry extract (g/L)	27.2 ± 0.76	26.2 ± 0.84	26.0 ± 0.79	26.7 ± 0.85	**166.57**	**<0.0001**	**7.05**	**0.0006**	1.36	0.2672	**3.58**	**0.0211**
Glycerol (g/L)	7.4 ± 0.35	7.3 ± 0.34	7.2 ± 0.34	7.1 ± 0.34	**15.36**	**<0.0001**	0.02	0.9970	0.01	0.9980	0.18	0.9120
Ethanol % (v/v)	13.88 ± 0.160	13.87 ± 0.160	13.64 ± 0.159	13.84 ± 0.161	**1538.52**	**<0.0001**	0.96	0.4182	0.57	0.6397	0.04	0.9878
Total polyphenol index	63 ± 2.7	63 ± 2.7	62 ± 2.7	61 ± 2.6	**166.25**	**<0.0001**	0.43	0.7303	**3.06**	**0.0375**	0.43	0.7303
Color intensity	10.860 ± 0.7980	10.674 ± 0.7939	10.690 ± 0.7630	10.492 ± 0.7300	**6.04**	**0.0015**	1.92	0.1393	0.55	0.6519	0.90	0.4473
pH	3.77 ± 0.055	3.76 ± 0.057	3.76 ± 0.054	3.75 ± 0.053	**7.47**	**0.0004**	0.35	0.7860	1.70	0.1804	0.60	0.6186
Tannins (g/L)	2.61 ± 0.164	2.56 ± 0.123	2.50 ± 0.112	2.58 ± 0.112	**3.43**	**0.0247**	2.03	0.1229	1.28	0.2921	0.31	0.8179
Tonality	0.603 ± 0.0226	0.607 ± 0.0227	0.613 ± 0.0223	0.639 ± 0.0207	**43.64**	**<0.0001**	0.19	0.9017	0.29	0.8298	1.80	0.1611

In bold significant effects ($p < 0.10$)

[a] Tested against wine(Process × Grape) × Time as the error term

[b] *CI* confidence interval

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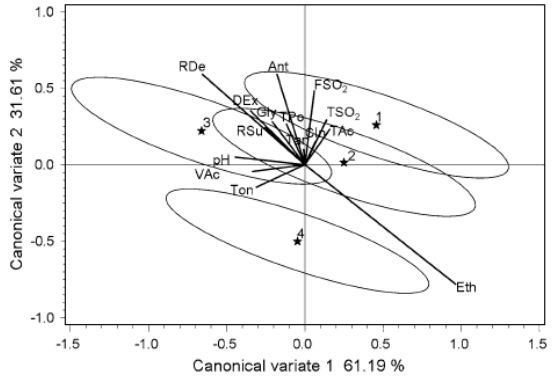

Fig. 3 CVA plot of physicochemical data for significant parameters. Parameter loadings and factor scores for the four times (1, 3, 5 and 9 months). *Ellipses* at 90% of confidence. *VAc* volatile acetic acidity, *RDe* relative density, *Ton* tonality, *TAc* total tartaric acidity, *RSu* reducing sugars, *Tan* tannins, *Ant* anthocyanins, *Gly* glycerol, *Eth* ethanol, *CIn* color intensity, FSO_2 free SO_2, TSO_2 total SO_2, *pH* pH, *DEx* total dry extract, *TPo* total polyphenol index

months after bottling. These results are not in total agreement with the common opinion that young red wines and specifically CM wines are for prompt consumption, because of the loss of fruity character and "freshness" [23, 35]. Sivertsen et al. [15] reported that Cabernet Sauvignon wines stored at 10 °C were similarly scored through the first year regarding "fruit/berry" aroma, and González-Viñas et al. [12] reported that Airén white wines retained their fresh-citric, floral, and apple aroma for up to 18 months stored in the bottle even under uncontrolled commercial warehousing conditions.

Progressive hydrolysis of several volatile esters, especially acetate esters, has been reported and related with the progressive loss of fruity and "fresh" character in young white wines [1–3]. The speed of this hydrolysis process increases with the temperature [36]. If storage temperature is appropriate, the acetate ester content decreases slowly through the months, and the fruity character of wine decreases more slowly. It is logical to suppose that the hydrolysis processes observed in young white wines could be similar to that in young red wines. Thus, it can be suggested that if hydrolysis processes took place in the wines of the present study, they were not very marked. The adequate storage temperature would surely have contributed to keep the fruity characteristics related to the cited volatile compounds. In spite of aromatic esters, other compounds such as ethanol, norisoprenoids (β-damascenone, β-ionone) and dimethyl sulphide may also play an important role in the perception of fruity sensation in red wines, as reported by Escudero et al. [37]. So, changes in these compound concentrations through the wine aging could also influence the evolution of fruity perception. In fact, dimethyl sulphide has been reported as increasing through a 16-week-study in bottled white wines kept at 20 and 30 °C [1], although this compound was not detected in wines kept at 10 °C. A possible increase in this compound concentration in the wines of the present study could also contribute to explain to a certain extent why the fruity sensation perceived by the panel did not decrease with the time.

Regarding the origin of berry notes, although an addition effect of many esters has been reported [37], the molecules responsible of these notes have not been stated enough yet. However, the decrease of alcoholic character through the time (which presented the highest intensity at the first time, 1 month after wine bottling) could explain to a certain extent the increase of red berry character. Alcoholic character could temporally mask the red berry character until the intensity decreased enough to let the red berry character to be better perceived.

The decrease in astringency could explain that wines were scored as more balanced through the time since, according to the criteria explained to the panelists, excessive astringency was considered one of the causes of imbalance. The relation between tannin content and astringency has been largely reported [38–40]. A recent report of Hufnagel et al. [41] also shows that some low molecular weight polyphenols, and a polymeric fraction could play a role in eliciting astringency sensation even greater than that of the procyanidin monomers, dimers and trimers (compounds traditionally considered closely responsible for wine astringency). The progressive decrease in tannins in the wines of the present study could help to explain the progressive decrease in astringency perception (also the slight increase of tannin content from 5th month to 9th month coincided with a slight increase in astringency scores). Some authors [42, 43] have reported reactions of tannins with other molecules to aggregate and form polymers. These big particles are too large to elicit sensory responses, and contribute to explain the progressive loss of astringency in un-oaked red wines.

The formation of aggregates by polymerization of compounds such as tannins and anthocyanins could help to explain the increase of body through the time, providing the wine with a greater sensation of body or "volume" in mouth (which coincided with the mentioned decrease in astringency). The contribution of these polymeric compounds to increase body sensation would be more important than the contribution of some physicochemical parameters directly related to body (relative density, glycerol, ethanol and total dry extract), since body increased while these parameters decreased. Increase in "volume" perception from 6 to 36 months was also observed by Puech et al. [9] in red wines stored in cellar at 14 °C.

Regarding the physicochemical parameters most related to the wine appearance, the observed decrease of anthocyanins

has been previously reported by many authors [7–10]. The slight decrease in color intensity found in the wines of the study agrees with that reported by Castillo-Sanchez et al. [7], although Puech et al. [9] and García-Falón et al. [10] did not observe changes in color intensity through the first year in red wines (Monagas et al. [8] also reported different evolution of color intensity according to the red grape variety). The increase in tonality (measured as Abs_{420}/Abs_{520}) agrees with the reported by many authors [7–10], and may be explained by the reactions of anthocyanins to form more stable oligomeric and polymeric pigments which modify the initial bright-red color to more brick-orange hues, increasing absorbance at 420 nm [44].

In spite of the evolution of these color-related parameters, scores for color hue and for color intensity increased up to month 5. In a study with Cabernet Sauvignon wines stored at 10 °C, Sivertsen et al. [15] reported similar sensory scores for color hue through the first year, but no reports have been found about young red wines becoming purpler and increasing the color intensity through the time. Although there are many factors influencing color characteristics through wine aging, a possible explanation for these results is that progressive decrease in free SO_2 through the studied 9 months led to a progressive lower anthocyanin bleaching by this compound, so purple hue and color intensity increased to a certain extent. This phenomenon had probably a greater effect on the appearance attributes perceived by the panel than the disassociation of anthocyanin complexes occurring in red wines during aging (which leads to a decrease in color intensity and to color browning). The lack of appearance evolution from month 5 to month 9 can reflect the stage when the effects of disassociation of anthocyanin complexes, and decrease in anthocyanin bleaching were of similar importance. From this stage on, disassociation of anthocyanin complexes would predominate, and wines would unavoidably start to loose purple hue and color intensity.

Regarding winemaking effect, although some authors [34, 45–47] have reported an effect of winemaking (CM vs. DS) on several sensory attributes (mainly related to fruity attributes, acidity and color intensity), the existence of only one slightly significant interaction between process and time (for astringency, which also evolves similarly in CM and in DS wines) can lead to consider that sensory evolution of CM wines and DS wines through the first 9 months was similar.

This would not be in agreement with the suggested prompt loss of fruity and "freshness" characteristics through the first months in CM wines compared to with DS wines. It also refutes the opinion held in RA about CM wines evolving faster and expressing their aromatic potential sooner than DS wines (which are said to need more months to express their aromatic potential).

Regarding the addition of small amounts of white grapes to make red wine, although reported as a factor influencing acidity, color hue and color intensity [34], there were no differences in sensory evolution through the first 9 months between the wines made only with Tempranillo grapes and those made with Tempranillo and Viura grapes.

Conclusions

Nine of the 24 sensory attributes studied in the bottled young red wines from RA evolved significantly through the first 9 months. Red berry aroma and flavor increased (mainly from month 5 to month 9), whereas alcoholic aroma and flavor decreased (mainly from month 1 to 3 and from month 1 to 5, respectively). So, wines not only did not lose fruity character in the period of time considered, but also increased it after several months in bottle.

In mouth, there was no significant evolution for tastes, but mouth-feel attributes evolved through the time: astringency decreased, body increased (especially from month 3 to month 5) and balance increased as well (mainly from month 1 to month 3). The increase in body and especially in balance would be probably explained to a great extent by the astringency decrease.

Regarding appearance attributes, wines received increasing scores for color hue (purpler color) and for color intensity up to month 5.

Overall, the wines once bottled evolved during the first half a year, and then their sensory characteristics remained quite stable.

Regarding physicochemical evolution, the 15 parameters studied changed significantly through the 9 months considered. Volatile acetic acidity and tonality increased, total dry extract, ethanol and tannins decreased and then increased slightly, and the remaining parameters (total tartaric acidity, free SO_2, total SO_2, reducing sugars, glycerol, relative density, pH, anthocyanins, total polyphenol index and color intensity) decreased through the time.

Winemaking process did not influence noticeably the evolution of either physicochemical parameters or sensory attributes during the period of time considered, so CM wines did not lose the fruity and "freshness" character faster in comparison with DS wines, as suggested by some experts and winemakers. Addition of small amounts of white grapes in red wine production did not influence wine evolution either.

It would be of great interest to develop complementary studies to compare the evolution of wines stored in vats before bottling with the evolution of the same wines, but bottled and then stored the same time.

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4.2- Development of a method to evaluate the sensory quality and formation of a trained expert panel.

- Book: Arabako Errioxako ardo beltzen kalitatearen ebaluazio sentsoriala egiteko gidaliburua. Ardo gazteak eta barrikako ardo onduak / Guía para la evaluación sensorial de la calidad de los vinos tintos de Rioja Alavesa. Vinos jóvenes y vinos con crianza en barrica.
(Owing to its length it is included only in the CD version of this thesis)

- Article 4: Sensory quality control for food certification: a case study on wine. Method development.

- Article 5: Sensory quality control for food certification: a case study on wine. Panel training and qualification, method validation and monitoring.

Article 4

Sensory quality control for food certification: a case study on wine. Method development.

Etaio, I., Albisu, M., Ojeda, M., F.Gil, P., Salmerón, J., F.J. Pérez Elortondo

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The meaning of PDO should be said the first time that it appears in the text (page 1, line 23).
Vitis vinifera should be written with italic letter (page 5, line 18).

Sensory quality control for food certification: a case study on wine. Method development.

I. Etaio[a], M. Albisu[a], M. Ojeda[a], P.F. Gil[a], J. Salmerón[a], F.J. Pérez Elortondo[a,*]
[a] Laboratorio de Análisis Sensorial Euskal Herriko Unibertsitatea (LASEHU), Facultad de Farmacia, Universidad del País Vasco - Euskal Herriko Unibertsitatea, Unibertsitateko Ibilbidea - Paseo de la Universidad, 7, 01006 Vitoria-Gasteiz
* Corresponding author:
E-mail address: franciscojose.perez@ehu.es
TEL: +34 945013075; FAX: +34 945013014

Abstract

Having specific methods accredited by official Accreditation Bodies to score the sensory quality of food products is a pressing need of the Certification Bodies.

This work explains the development of a specific method for sensory quality control of young red wines from Rioja Alavesa, which was accredited in 2008. In addition to describing the quality parameters, the evaluation methodology, the quality grading and the scoring criteria, this work also describes the development of references of aroma, flavour, taste and mouth-feel, and appearance.

This approach can be very helpful to develop specific sensory quality control methods for other certified products, particularly PDO products but also Protected Geographical Indication, Traditional Speciality Guaranteed or organic products.

Keywords

Sensory quality control; accreditation; young red wine; Rioja Alavesa

1. Introduction

In addition to be accepted by consumers, traditional products must present specific sensory attributes related to a region, elaboration procedure or raw materials (Ballester, Dacremont, Le Fur & Etiévant, 2005; Bertozzi, 1995; Cayot, 2007; Parr, Green, White & Sherlock, 2007).

In the case of products with quality distinctiveness labels, such as Protected Geographical Indication (PGI) or Protected Designation of Origin (PDO), it is necessary to specify the characteristics and it is important to prove a difference of quality between non-certified and certified products (Bertozzi & Panari, 1993; Cayot, 2007). In many cases, trained and monitored panels check the sensory quality of the product and decide whether it fulfils the minimum sensory requirements (appearance, flavour, texture …) to be sold under this label according to the expected characteristics. Nevertheless, appropriate trained panels are not always approached, and in many cases sensory quality evaluation still relies on the so called “expert tasters”, which would not be the recommended approach for sensory quality evaluation (Feria-Morales, 2002).

In addition to “accepted/rejected” decision methods, there are specific methods to score the sensory quality of PDO products such as cheeses (Pérez Elortondo, Ojeda, Albisu, Salmerón, Etayo & Molina, 2007), olive oil (International Olive Oil Council, 2005) or asparagus (Torre, 2002), and also for other products not under PDO denomination, such as cactus pears (Cerezal & Duarte, 2004) and several fishery products by means of Quality Index Method (Baixas-Nogueras, Bover-Cid, Veciana-Nogués, Nunes & Vidal-Carou, 2003; Barbosa & Vaz-Pires, 2004; Huidobro, Pastor & Tejada, 2000; Sveinsdottir, Hyldig, Martinsdottir, Jørgensen & Kristbergsson, 2003). Usually these methods compare the product to be analyzed with the definition of the top or desired

product, and can provide valuable descriptive information to know these products better and their “strong” and “weak” points. Data from these quality controls can be also used to study the sensory quality evolution of the products over the years.

Although still few, the number of specific methods to evaluate and score the sensory quality of traditional products has increased these last years.

In some methods, besides considering the scores, citation frequency of defects by the judges (Pérez Elortondo et al., 2007) is also considered, providing additional information. However, methods where positive attribute citation is considered in quality scoring are even scarcer.

Accreditation of analytical procedures based on ISO 17025 (ISO, 2005) has a history of several years, although the accreditation of specific sensory methods is quite recent and the number of methods accredited is very low when compared with other kinds of analyses. Accreditation of sensory methods for specific products can be considered as an additional step in official quality control, since it assures the technical competence by an external institution (Pérez Elortondo, Bárcenas, Casas, Salmerón & Albisu, 1999). Sensory quality control by accredited methods also increases the guarantee and the quality image of the product. Accreditation is becoming a more and more important tool in the food market in general, and in the market of products with official quality distinctiveness labels in particular.

In the case of wine, as far as we know, there are no accredited methods to evaluate the sensory quality. Several cards to score wine quality have been developed over the last decades: Davis 20-point scale (Amerine & Roessler, 1983; Ough & Baker, 1961), score card for international wine competitions of the International Organisation of Vine and Wine (OIV, 1994); score card of the Union Internationale des Oenologues (reproduced as well in OIV, 1994), score card of the Unión Española de Catadores (reproduced in Del Castillo, 2005), score card of the Faculté d'oenologie de Bordeaux (reproduced in Peynaud & Blouin, 2002), hedonic wine tasting sheet for quality assessment (Jackson,

2000). Nevertheless, in many cases some of the parameters and attributes used are not defined well enough so different judges can understand not exactly the same (what is “body”? what is “balance”? what is “harmony”? What is “complexity”? What is “genuineness”?).

In the same way, the specific criteria to score the quality relative to the parameters that compose the score card are usually not defined enough (e.g., how to consider if an attribute or a defined sensation is characteristic of the wine?). Thus, quality scoring depends to a great extent on the opinion, formation and experience of each expert, which can differ from one expert to another. Guinard, Yip, Cubero and Mazzucchelli (1999) reported differences among brewing experts in the interpretation of the concept of sensory quality in a study with beers, even after many concept alignment sessions.

In addition, wine score cards are usually thought to be used for the evaluation of a wide range of wines (“sparkling wines”, “table red wines” …) so typicalness and specific sensory characteristics of each wine (determined by the region, climate, soil, grape variety, elaboration procedure …) are not considered.

Qualified Designation of Origin Rioja (DOC Rioja) wines are famous worldwide for their quality. However, although there is a procedure to determine whether each wine can be sold with DOC Rioja label, there is not specific method to score the sensory quality of these wines. Rioja Alavesa (RA) is one of the three sub-areas in DOC Rioja and its wines present some specific characteristics due to several factors, such as climate, soil composition, orography, vineyards facing South and many small family wineries still making wine in traditional way (Etaio, Pérez Elortondo, Albisu, Gaston, Ojeda & Schlich, 2008b).

RA young red wines are mainly related to Tempranillo variety (Vitis vinifera L.), which represents the 96.6% of the 11,940 hectares cultivated with red varieties in RA (data from the Regulatory Council 2007, www.riojawine.com).

Although most RA wineries also make barrel-aged wine, young red wine (un-oaked) is considered the most traditional. It represents approximately half of the more than 60 million liters of wine produced in this sub-area.

The wine-producing sector and the local institutions are interested in the development of specific sensory methods and in the creation of expert panels in order to control and improve the quality of RA wines, emphasizing their typical characteristics.

The objective of this work is to explain the method developed to evaluate and score the sensory quality of young red wines from RA. This method was accredited in February 2008 (www.enac.es). An example of results from a sample evaluated once the method was accredited is also shown.

2. Material and methods

2.1. Wines

Ninety young red wines from RA were used for the development of the methodology to evaluate the sensory quality of this product. Wines were mainly provided by ABRA (Association of wineries from RA), comprised of about 120 little and medium wineries from different villages. These samples covered a representative range of the RA wines. Once at the laboratory, all the bottles were registered and given an internal code.

2.2. Sample preparation and evaluation conditions

Wine sample handling was defined at the beginning of the work and it was followed through the different phases of the study. Sample handling was detailed in a standardized technical procedure that was later included in the accreditation scope.

When at the laboratory, the wines were placed in a cellar (17±2ºC) until being used. Bottles were opened just before serving the wines.

Standardized 200-mL wine-tasting glasses (ISO 3591, 1977) were used. Volumes of 35±4 mL and 25±1mL were served by using volumetric pourers for tasting and for appearance evaluation, respectively. Glasses were covered with Petri dishes to avoid volatile losses. Samples were presented codified with three digits. Water and unsalted crackers were provided to the judges to eliminate residual sensations between samples.

Wine evaluation was carried out at the Sensory Laboratory of the University of the Basque Country (www.lasehu.com). According to the purpose of each step, wines were evaluated in the group room or in a room with 7 booths equipped with computer terminals. In the booth room, both temperature (21±2ºC) and relative humidity (60±20%) were controlled. “By nose” and “in mouth” evaluation was carried out firstly under the weak light provided by the computer screen to avoid any colour bias. Appearance evaluation was carried out by using additional glasses and under lighting similar to daylight (colour temperature very close to 6,500ºK and chromatic rendering index higher than 90).

Through the method development wines were scored in paper cards. Once the definitive score card was defined, data from wines evaluated in booths were collected with FIZZ software (Biosystèmes, Couternon, Version 2.10 A).

2.3. Steps to develop the method to assess the sensory quality

After some preliminary meetings with ABRA to define the objectives and the planning of the project 12 experts with a recognized knowledge in RA wines (enologists, winemakers and restaurateurs) were contacted. In addition to having been reported that experts know how to describe the sensations in words better than customers (Bende & Nordin, 1997), judgments of typicality and representativeness of wines is often assessed by wine experts (Ballester et al., 2005; Martin, Etiévant, Le Quéré & Schlich, 1992; Moio, Schlich, Issanchou,

Etiévant & Feuillat, 1993; Parr et al., 2007; Sauvageot, 1994). It was agreed to meet monthly at the sensory laboratory.

The method to evaluate the sensory quality of young red wines from RA was developed through 15 discussion sessions. The duration of each session was about 2 hours and half. Steps carried out were the following:

- *Term generation*: 18 young red wines from RA were tasted and described by the experts through the first three sessions by using wine pair comparison. In the subsequent discussion sessions wines were directly described by the experts. In total, 90 wines were described through the 15 discussion sessions. Terms describing aroma, flavour (retronasal way), taste, mouth-feel and appearance were collected. Regarding the tasting procedure, each expert evaluated the wines freely (using no predefined methodology) during the first sessions. As the tasting procedure was established by consensus all the experts adopted it.

- *Selection of parameters defining the wine quality*: the sensory parameters considered quality determining parameters were chosen by discussion, based on the terms collected through the first four sessions. The main questions used to lead the discussion were: “Does this parameter really influence the sensory quality of the wine or is it of almost no importance?” and “Does this parameter differentiate among wines or is it non discriminative?”.

- *“Top situation” definition and quality grading of each parameter*: This step resembles the so called “quality grading method”, where each quality grade is related to a sensory description and to a numerical score (Costell, 2002). The optimum situation for each parameter was defined by answering this question: “Regarding this parameter, what are the characteristics that a typical young red wine from RA must present to be considered the ideal one?”.

Based on the previous experience with PDO Idiazabal cheese (Pérez Elortondo et al., 2007) a discontinuous 1 to 7 point scale was chosen for scoring each parameter. Point 7 means “top quality”, point 6 “very high quality”, point 5

"high quality", point 4 "medium quality", point 3 "low quality", point 2 "very low quality" and point 1 "null quality". The criteria to score each parameter were established by linking each quality grading (1 to 7) to a sensory description. Thus, the scoring was objectivised.

- *Development of references*: References for the parameters determining the sensory quality were developed to homogenize the vocabulary and the sensory concepts used. These references were also used later to train the panel assessing the sensory quality of the wines.

Many potential references were prepared and presented to the experts. References were discussed and readjusted through the successive sessions until experts agreed that each reference was suitable. After having checked that freezing did not significantly affect the references, they were prepared and kept frozen until the day before being evaluated. Then, they were placed in a cellar (17±2ºC) until served. Once the definitive references were established they were presented to the experts in the following sessions, in order to confirm that they were appropriate. Initially, references were presented identified but as sessions went on references were presented coded to be identified by the experts.

- *Tasting procedure*: the order and the procedure to evaluate the parameters were established by consensus through the first 4 sessions, at the same time that the described stages were developed.

- *Score card*: after defining the parameters to evaluate, the scoring criteria and the order of parameter evaluation, definitive score card was developed.

- *Contribution of each parameter to the overall sensory quality*: assuming that the importance of each parameter on the overall quality of the wine is different, the weight of each parameter was discussed and defined with the experts. Thus, the overall quality score would be calculated by applying a weighting factor to each parameter. A similar procedure has been previously reported for

asparagus with specific denomination Navarra (Torre, 2002) and cactus pears (Cerezal et al., 2004).

2.4. Sample evaluation in a systematic way

Once the whole method was defined, and before starting evaluating samples in a systematic way, some additional necessary steps were carried out: recruitment of potential judges (many of the experts participating in method development were included), judge selection, basic training, specific training, judge qualification and method validation. These steps are explained in detail in Etaio, Albisu, Ojeda, Gil, Salmerón and Pérez Elortondo (2009). After undertaking these steps, in October 2007 the panel started the evaluation of the wines sent to the laboratory from the wineries.

Seven qualified judges attended each session. Wines to be evaluated were randomly presented to the judges to avoid bias due to order of presentation.

Scores and attribute citation were monitored both for the panel and for each judge, according to an internal procedure of the laboratory.

After each evaluation session a confidential form with the results of each wine was sent to the corresponding winery.

3. Results and discussion

3.1. Parameters defining the sensory quality

Terms collected from the wine descriptions of the first sessions were included in a list. Hedonic and inappropriate terms were removed and close terms were grouped. Based on the list of terms and after expert discussion, 8 sensory parameters were defined as sensory quality determining parameters (Table 1).

These parameters are quite common in wine cards although scoring flavour intensity and complexity as quality related parameters is not so common. Experts agreed that these parameters, although less important than aroma intensity and complexity respectively, also contribute to the wine sensory quality and must be considered.

Both aroma and flavour complexity consider the specific attributes that appear in the wine, as well as how they are integrated. Attribute complexity is included in almost all the score cards, although under different denominations: “aroma notes” (score card of the Unión Española de Catadores), “aroma quality” (score card of the Faculté d'oenologie de Bordeaux, hedonic wine tasting sheet for quality assessment, score card for international wine competitions of the OIV), “aroma finesse” and “aroma harmony” (score card of the Union Internationale des Oenologues).

Balance is considered in several score cards (score card of the Unión Española de Catadores, score card of Faculté d'oenologie de Bordeaux). In other cards, when the term “balance” is not considered, “harmony” is used (score card of Union Internationale des Oenologues). Nevertheless, the meaning of these parameters is not usually defined and it seems that it is assumed that the judge has previous understanding of this concept. Moreover, what can be understood as balance situation can be different from one kind of wine to another. For example, an acidity sensation that can be accepted as normal for one kind of wine perhaps is excessive or insufficient for another one, or the same bitterness level can be acceptable for one kind of wine but a marked cause of imbalance for another wine. Reaching a consensus about the definition of the balance concept required an in-depth discussion. Final balance definition (as expressed in Table 1) agrees with the necessary sweetness balancing the sum of acidity, bitterness and astringency sensations suggested by Peynaud et al. (2002). The sweetness sensation included in the definition of balance is not necessarily associated with the sensation elicited by sugar, but with the sweetness caused by other components (mainly ethanol).

Body concept is included in some score cards: score card of the Unión Española de Catadores, score card of Union Internationale des Oenologues, Davis 20-point scale. The “structure” included in the score card of the Faculté d´oenologie de Bordeaux would refer to the body concept as well.

After several discussions about how to score the balance and the body and how to categorize the quality degrees, and also considering that some sensations (astringency, acidity, alcoholic sensation …) are involved in both parameters, it was agreed to consider balance and body together as a combined parameter. Thus, experts felt more comfortable and found it easier to evaluate and score both characteristics together.

Persistence is a very common parameter in wine score cards, sometimes also called “duration” (hedonic wine tasting sheet for quality assessment). In some cards (score card of the Unión Española de Catadores, hedonic wine tasting sheet for quality assessment, score card of Union Internationale des Oenologues) all the sensations remaining after the wine has been spat out or swallowed are considered. In other cards (score card of Faculté d'oenologie de Bordeaux) only flavour sensations (considered as aroma by retronasal way) are taken into account. It was decided that only flavour persistence would be considered and would be considered as a whole (if the overall flavour disappears but one particular flavour remains, it would not be considered for persistence measurement).

Regarding appearance attributes, both colour intensity and colour hue are widely used in score cards (score card of the Unión Española de Catadores, score card of Faculté d'oenologie de Bordeaux, score card of Union Internationale des Oenologues). Experts considered it necessary to take both parameters into account. Colour hue also provides a notion about the “youth” of the wine, which in the case of young red wines is especially important.

Some other possible parameters to be considered were cited by some experts, mainly related to appearance: cloudiness, brightness and “tears”. Regarding cloudiness it was decided that a cloudy wine should not be

commercialized and should be immediately discarded without being evaluated. Regarding brightness and “tears”, in addition to it being very difficult to score and to develop references, the contribution of these parameters to the overall wine quality would be insignificant, as well as the differences among wines concerning these two parameters. So, it was decided not to consider these parameters in wine evaluation.

3.2. Scoring criteria, evaluation procedure and score card

Criteria to score each parameter were established after defining the situation considered optimum in a young red wine from RA (point 7 – “top quality”). Criteria were reached by consensus, unifying the criteria from the experts, looking for a common minimum accepted by all of them.

Regarding aroma and flavour intensity, it was considered that, if no defects were present, the greater the intensity was the higher the score was. To specify the intensity degrees a medium intensity reference was developed by discussion with the experts. This reference was located at point 4 in the scale and was used for both aroma and flavour intensity, so these parameters were scored in each wine by comparison with the reference, as described in Figure 1.

“Top” quality in aroma complexity would be determined by the presence of the three “key” aromas considered characteristic of RA young red wines: ripe fruit, licorice and floral. These aromas have also to be adequately integrated (no aromas excessively masking the others) to be awarded the maximum score. So, the presence of these three aromas does not necessarily mean a score of 7. To define the other quality degrees, the presence of both desirable attributes and defects was considered (Figure 2). It was decided that if aroma defects were present the score would be 1, 2 or 3 according to the importance of the defect. Referring to sensory quality evaluation in coffee, Feria-Morales (2002) remarked the importance of identifying the key attributes for each specific kind of product to face the tendency to use those attributes applied by the trade, which many times may not be appropriate. Parr et al. (2007) reported passionfruit, green capsicum and boxwood as specific characteristics

contributing importantly to the typicality of Marlborough Sauvignon blanc wine style. Guinard & Cliff (1987) reported “uniqueness” of Carneros Pinot noir wines within California, being characterized by intense fresh berry, berry jam, cherry, and spicy aromas.

Regarding flavour complexity it was decided by consensus to follow the same criteria as for aroma (Figure 2), since the flavour attributes expected for a “top” quality wine would be ripe fruit, licorice and floral, and well integrated as well.

Regarding balance and body, it was stated that the top young red wine from RA must be balanced and present a very high body. Balance situation was described as medium acidity, with no appreciable or slight astringency and preferably without bitterness (although a very slight bitterness could be acceptable). As shown in Figure 3, when there are no causes of imbalance (taste or mouth-feel sensations standing out excessively, according to the explained situation) the wine is considered balanced and the score depends on the body (the higher the body the higher the score). When there are causes of imbalance the scores are in the low part of the scale, mainly determined by the number and the importance of the imbalance causes and not so much by the body.

When scoring global flavour persistence, the possible presence of flavour defects (a defect already perceived when evaluating flavour complexity and remaining after spitting the wine out or even a defect arising after the wine has been spat out) was firstly considered. If present, the score would be 1, 2 or 3 according to their importance, whatever the persistence time is. If no defects are present the scoring depends on the persistence time. Criteria for scoring global flavour persistence are shown in Figure 4. Also, a reference with a medium persistence (point 4 in the scale: 5-7 seconds) was available.

The criteria decided upon to score the colour hue was the purpler the hue the higher the quality score. For colour intensity the deeper the colour the higher the quality score would be. To specify the quality degrees it was

necessary to have some references to compare to, so a colour reference with a scale for colour hue and for colour intensity was developed. These appearance parameters were scored according to the criteria shown in Figure 5.

The procedure to evaluate and score the eight parameters is shown in Figure 6. It was decided to evaluate first all the “by nose” and “in mouth” parameters in the half-light (under the very weak illumination provided by the computer screen). Then, colour hue and colour intensity were evaluated under illumination conditions similar to daylight. Thus, any bias in scoring of the rest of the parameters due to wine appearance was avoided, since appearance perception has been reported as a factor conditioning the assessment of the other sensations (Morrot, Brochet & Dobourdieu, 2001; Parr, White & Heatherbell, 2003; Tromp & Van Wyk, 1977).

In each session and previous to wine evaluation, reference of aroma intensity, flavour intensity and global flavour persistence was evaluated following the steps described to evaluate these parameters in wines. Each judge had also a handbook with all the information necessary to evaluate and score the wines.

The score card (paper version) for wine quality scoring is shown in Figure 7. Aroma intensity, flavour intensity, colour hue and colour intensity were scored by marking one of the 7 points of the scale. For aroma complexity and flavour complexity, besides this scale, a list of the most frequent attributes (including the three “key” attributes) and a list of the most common defects in RA young red wines appear. The judges had to mark the perceived attributes and defects (if present) and then give a score in the scale according to the explained criteria. In the same way, for balance and body a brief list with the most frequent causes of imbalance is shown. If a cause of imbalance was perceived it had to be indicated before giving a score. In scoring of global flavour persistence flavour defects had to be indicated (if present) before scoring the parameter.

Citation frequency of attributes, defects and imbalance causes through discussion sessions was considered to create the lists included in the score

card. As could be expected, since few of the evaluated wines presented defects, the citation frequency of defects and causes of imbalance (except for astringency) was very low. However, experts agreed to include in the score card the defects and imbalance causes most frequent in RA young red wines, based on their experience. In fact, the sensory panel to train for wine evaluation would have to be ready to identify these defects and imbalance causes when appear. The score card also includes the "Others" option to write down any attribute, defect or imbalance cause not shown in the list.

3.3. Weight of each parameter in the global quality

The contribution of each parameter to the overall quality of the wine is shown in Table 2. By establishing parameter weightings it is possible to provide the wineries with an overall quality score and with partial qualities to know where this overall score comes from and what the strong and weak points of the wine are. As this weighting is not a result in itself, calculation of overall quality from partial qualities remained out of the accreditation scope.

It was decided by consensus that olfactory parameters must represent 30% of the overall quality, parameters evaluated in mouth 60% and appearance parameters 10%. This distribution agrees with the score card of the Unión Española de Catadores. González Hernández, Hardisson de la Torre and Arias León (2002) proposed a weighting of 20% for visual parameters, 32% for olfactory parameters and 48% for parameters evaluated in mouth in a study on red wines from Tacoronte-Acentejo. In the norm for international competitions, the OIV (1994) defined a weight of 8.33% (1/12) for appearance, 25% (3/12) for olfactory parameters, 41.67% (5/12) for parameters evaluated in mouth and 25% (3/12) for "harmony-general impression". Davis wine-score card gives 20% of the total scoring to appearance parameters, 30% to olfactory parameters, 40% to parameters evaluated in mouth and 10% to a parameter called "general quality".

As shown in Table 2, the parameters which contribute most to the overall quality in the method described in the present article are balance and body,

aroma complexity and flavour complexity, in this order. On the other hand, colour intensity and colour hue are the parameters which contribute least to the overall quality.

3.4. Development of references

References of aroma and flavour (including defects) are detailed in Table 3. Most of the references were prepared from a mother-solution. With the exceptions indicated in Table 3, references were prepared in a base wine (BW) to make the perception of these sensations as close as possible to the perception in wine. The BW was defined by discussion with the experts looking for a base with an overall wine aroma and flavour but without any outstanding characteristics. After discussing over several potential BWs, the chosen one was composed of 75 mL of a commercial red table wine, 25 mL of water and 2 mL of absolute ethanol. The commercial wine used for BW preparation was very neutral and, because of its very large and controlled production, was very homogeneous throughout the year.

Except for acetic attribute (due to the very unpleasant sensation in mouth), the same reference was used for both aroma and flavour evaluation.

References were quantitative or qualitative depending on the parameter considered. Combined reference for aroma intensity, flavour intensity and global flavour persistence was quantitative since the required characteristic was a defined intensity (for aroma and flavour intensity) or a length of time of a sensation (for global flavour persistence). This reference presents an aroma intensity of 4, a flavour intensity of 4 and a global flavour persistence of 4 in the scale.

References for attributes and defects of aroma and flavour were qualitative, since a specific sensation was required and no a specific intensity. Herbaceous and lactic sensations were the exception. Experts agreed that lactic and herbaceous aroma/flavour in wine must be considered as attributes or defects according to the intensity perceived. Thus, these references would be

both qualitative and quantitative: in addition to being used to train the panel to identify herbaceous and lactic aroma/flavour, if the intensity in wine is similar or lower than the reference intensity these aromas/flavours are considered attributes; if higher, they are considered defects.

Regarding balance, a reference for each of the most frequent causes of imbalance was developed (Table 4). References were prepared in the above-mentioned commercial red table wine, with the cause of imbalance clearly standing out. Besides this, it was agreed that evaluation and discussion of many wines is essential to unify the criteria about considering when a wine is balanced or imbalanced.

With regard to body sensation, attempts were made to develop several references (low, medium and high body) by diluting wine or by adding substances such as ethanol, glycerol, tartaric acid and commercial tannins in different concentrations. However, experts did not feel comfortable with them and they considered more adequate to reach a consensus about the different levels of body by tasting and discussing many wines, in a similar manner as with balance. So, wine tasting and discussion would be especially important for panel training regarding balance and body.

Reference for colour hue and colour intensity was developed by designing it with Microsoft Office Word 2003 (Redmond, WA, USA) using the RGB colour coordinates, and by printing it on transparent film (Staedtler, Lumocolour; thickness of 100 μm) with a colour printer (Lexmark Z605; used inks: InkTek LMI-1026C colour and LMI-1016D black). After discussion through several sessions the definitive reference for appearance parameters was established. Coordinates for each score of colour hue and colour intensity are shown in Table 5. Judges scored these two parameters in wine by comparison with the horizontal scale (for colour hue) and with the vertical scale (for colour intensity) of the reference (Figures 8a and 8b).

3.5. Quality scores and resulting report for a real sample: an example.

Each of the seven judges attending the session gave a score to each of the eight parameters. The seven scores collected for each parameter in a sample were then averaged. If any of the seven scores did not come within the mean ± 2 units, this score was considered an outlier and the mean was recalculated without including it. Standard deviations were also calculated from the raw data for monitoring purposes (as explained in Etaio et al., 2009). Once the means of the eight parameters were obtained the weighting factors shown in Table 2 were applied to calculate the overall quality.

Table 6 shows the results of a real sample evaluated once the method was accredited and the wines were evaluated in a systematic way.

Regarding presence of attributes, defects and imbalance causes, the criteria reported by Pérez Elortondo et al. (2007) in PDO Idiazabal cheese was used: an attribute, defect or imbalance cause is considered present in the wine sample when it is cited by at least 5 of the 7 judges. In the particular case of herbaceous and lactic, if attribute and defect citation frequencies are lower than 5 but the sum of both citation frequencies is equal to or higher than 5, then it is considered that the attribute is present (and no the defect).

Figure 9 shows the first part of the confidential report sent to the winery. In addition to some data about the analysis (report number, wine reception date, analysis date, report emission date, reference of the analysis method) the report includes the score mean of each of the eight parameters, but not the overall quality. As already mentioned, the overall quality score is not included in the accreditation scope, so it cannot be indicated in the report with the logo of the accreditation body. Aroma and flavour attributes and defects, and imbalance causes with a citation frequency equal to or higher than 5 are expressly included in the report.

Figure 10 shows the second part of the report, where spider diagrams represent the citation frequency of all the aroma and flavour attributes and

defects, as well as imbalance causes. These diagrams provide the winemaker with more detailed information of wine description. As explained in an enclosed letter sent to the winery, attributes, defects and imbalance causes with citation frequency lower than 5 are not considered to be present in the wine, but this information may be of interest to the winery as well (e.g., a citation frequency of 3 or 4 for a defect should lead to suspect that this wine perhaps has a problem, although not evident).

4. Conclusions

Still nowadays, there is an evident lack of specific methods to be used by certification bodies in sensory quality control of products with quality distinctiveness labels. These methods and their practical application must be independent, technically competent and as objective as possible. With the example of a specific product (the young red wine from Rioja Alavesa), the present work shows that it is possible to develop specific methods for sensory quality control.

In the development of methods for traditional products typicity has to be necessarily considered. To do this, the participation of a team of experts with great knowledge of the product is required.

The development of specific methods is approached with certification purposes and complements the information from consumers, with the aim to be the product better oriented to the consumer expectations without losing typicity. Among the successive steps carried out, quality grading of the different parameters by using decision trees showed to be an interesting tool to objectivise the scoring.

In addition to numerical scores, consideration of attribute citation frequency contributed to provide a more complete description of the products.

Development of references for aroma, flavour, taste and mouth-feel, and appearance attributes was also very important to homogenize the concepts and to train the panel assessing the quality of the product.

Besides certification bodies, quality control by specific methods is an interesting tool for the producers since the sensory quality of their products can be assessed in a defined and systematic way. It makes possible to know their products better and the aspects to be improved on, thus enhancing the quality image as well.

The experience described in the present work may be very useful to other laboratories dealing with the development of sensory methods for quality control of food products, not only for PDO products but also for other products with quality distinctiveness labels. In this sense, this work represents a very exhaustive methodology that may be simplified if the product to work on is not so specific.

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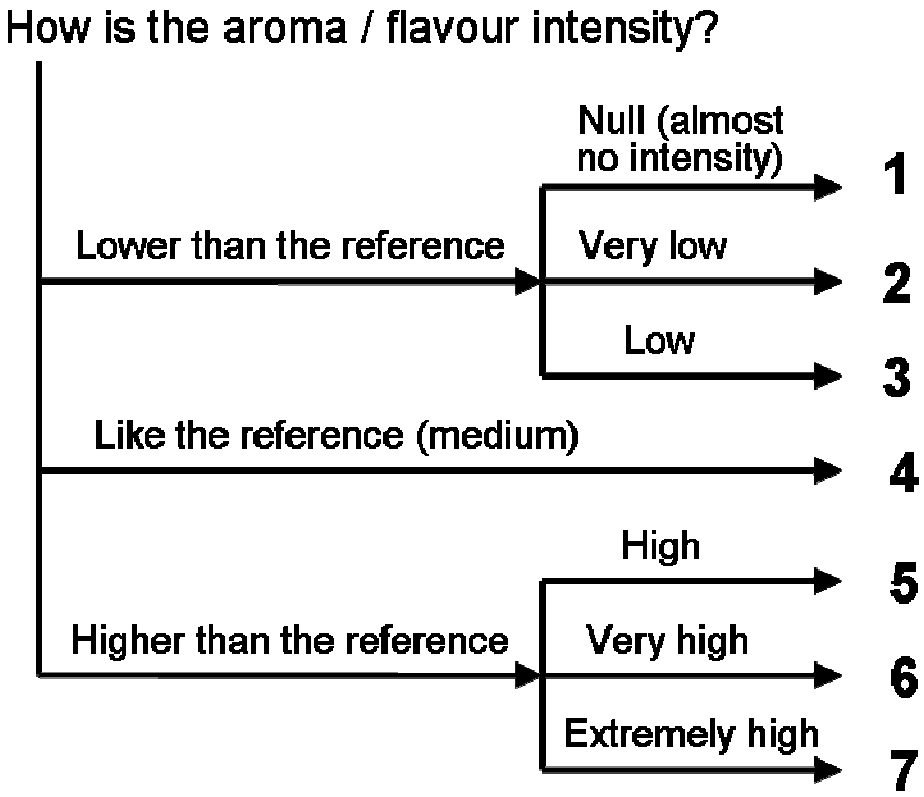
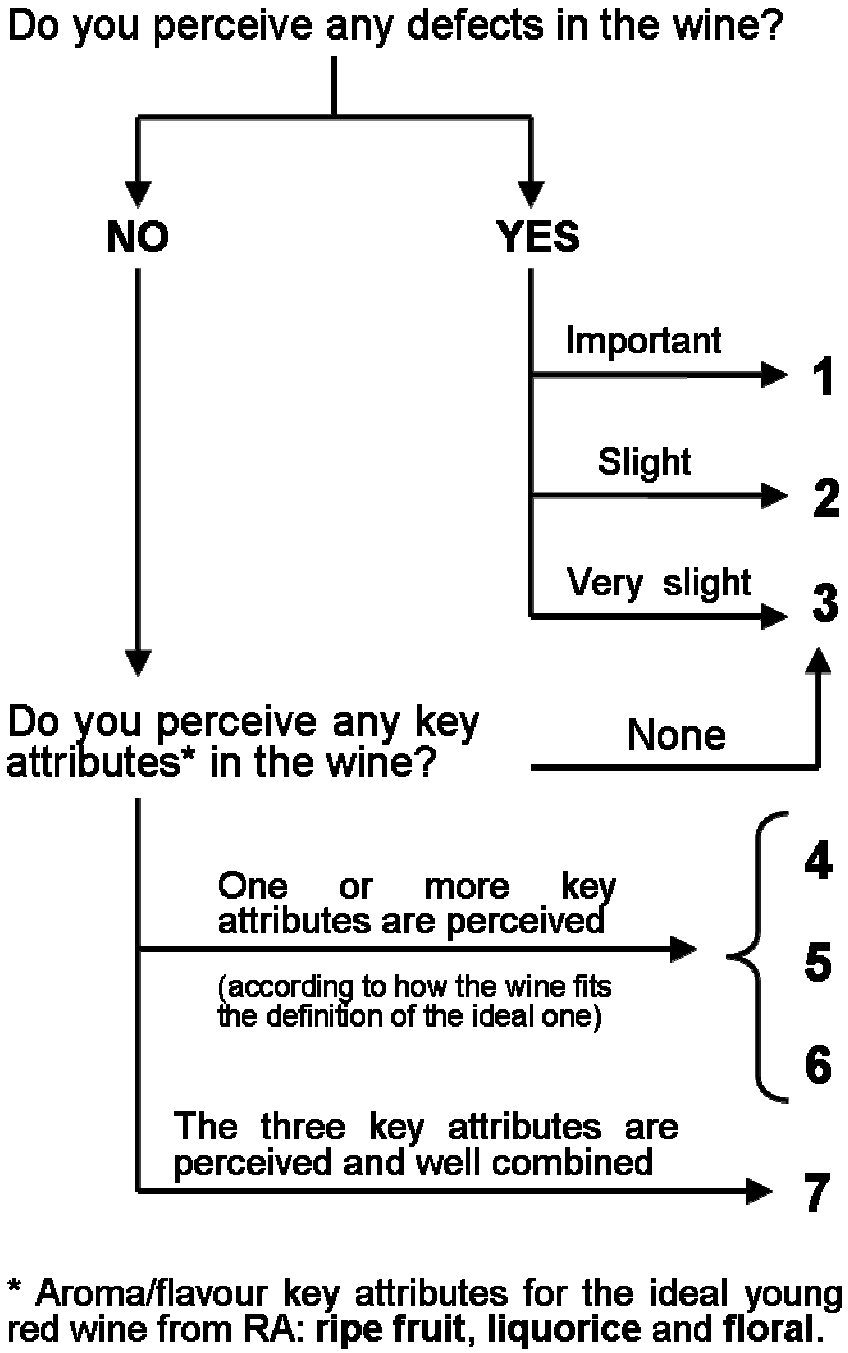
Figure 1. Decision diagram to score aroma intensity and flavour intensity.



* If an aroma/flavour defect is percived do not consider it for intensity evaluation. Just consider non-defect aroma/flavour intensity. Thus, if a defect predominates the score will be in the low part of the scale.

Figure 2. Decision diagram to score aroma complexity and flavour complexity.



* Aroma/flavour key attributes for the ideal young red wine from RA: **ripe fruit, liquorice** and **floral**.

Figure 3. Decision diagram to score balance and body.

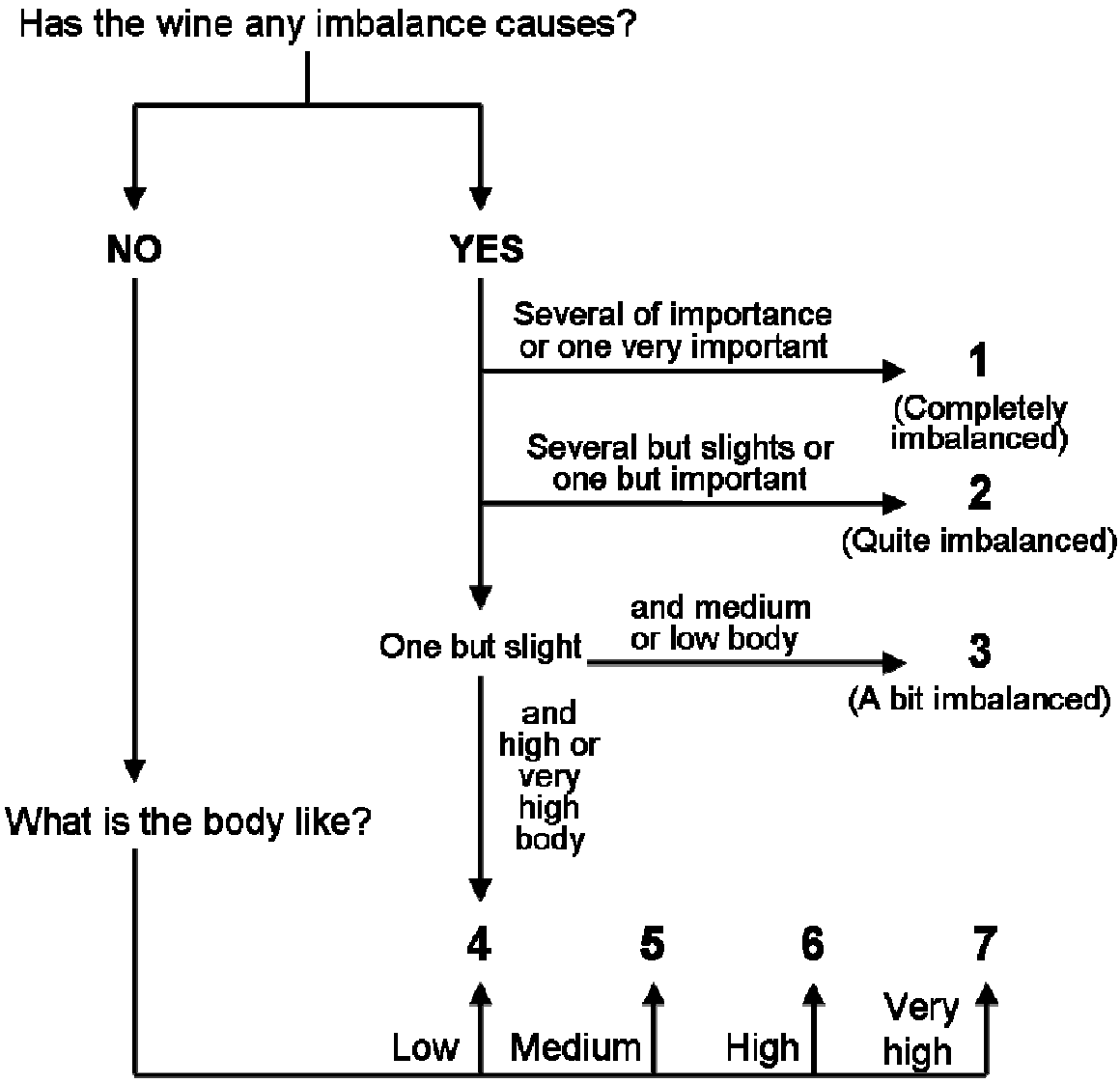


Figure 4. Decision diagram to score global flavour persistence.

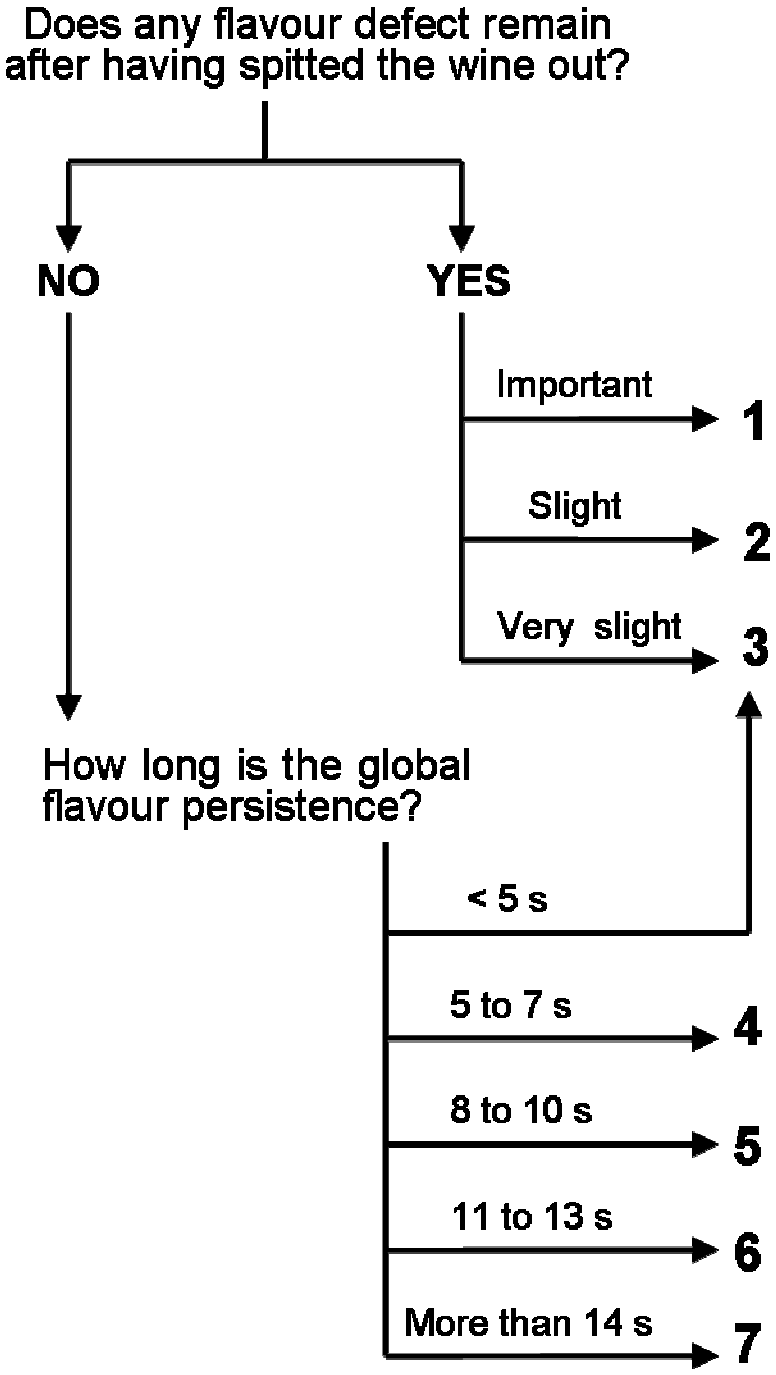


Figure 5. Decision diagram to score colour hue and colour intensity.

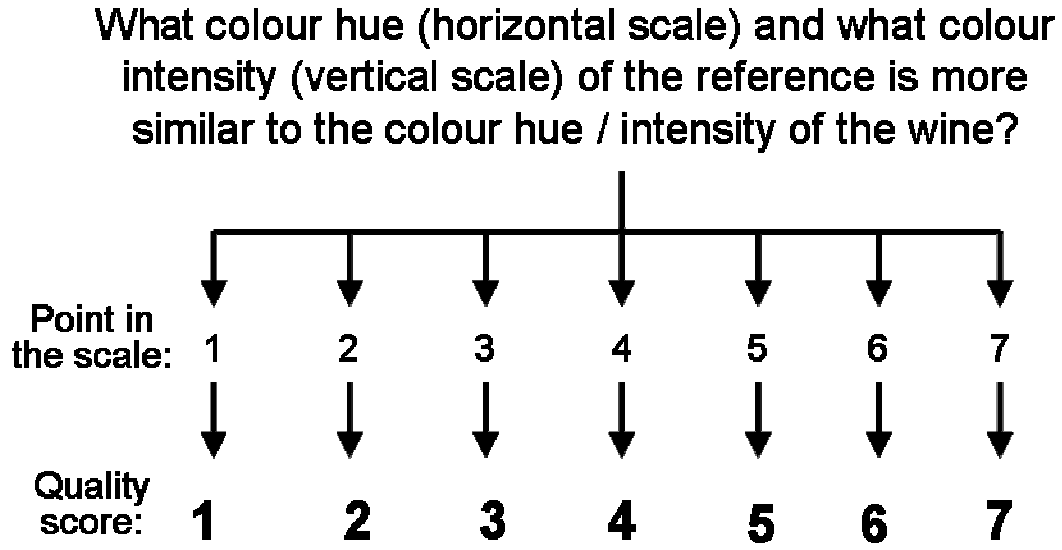


Figure 6. Procedure to evaluate and score the young red wines from Rioja Alavesa.

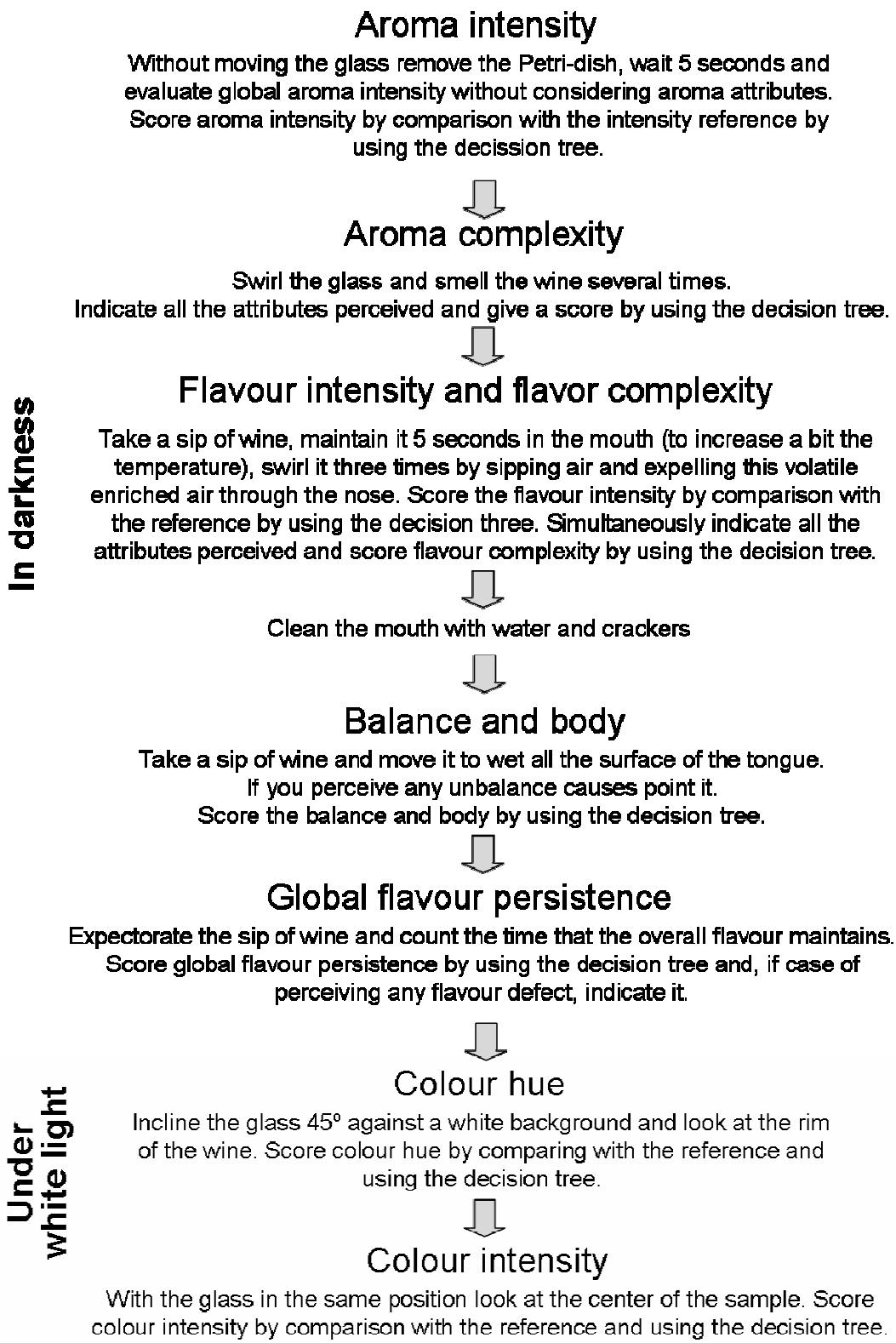
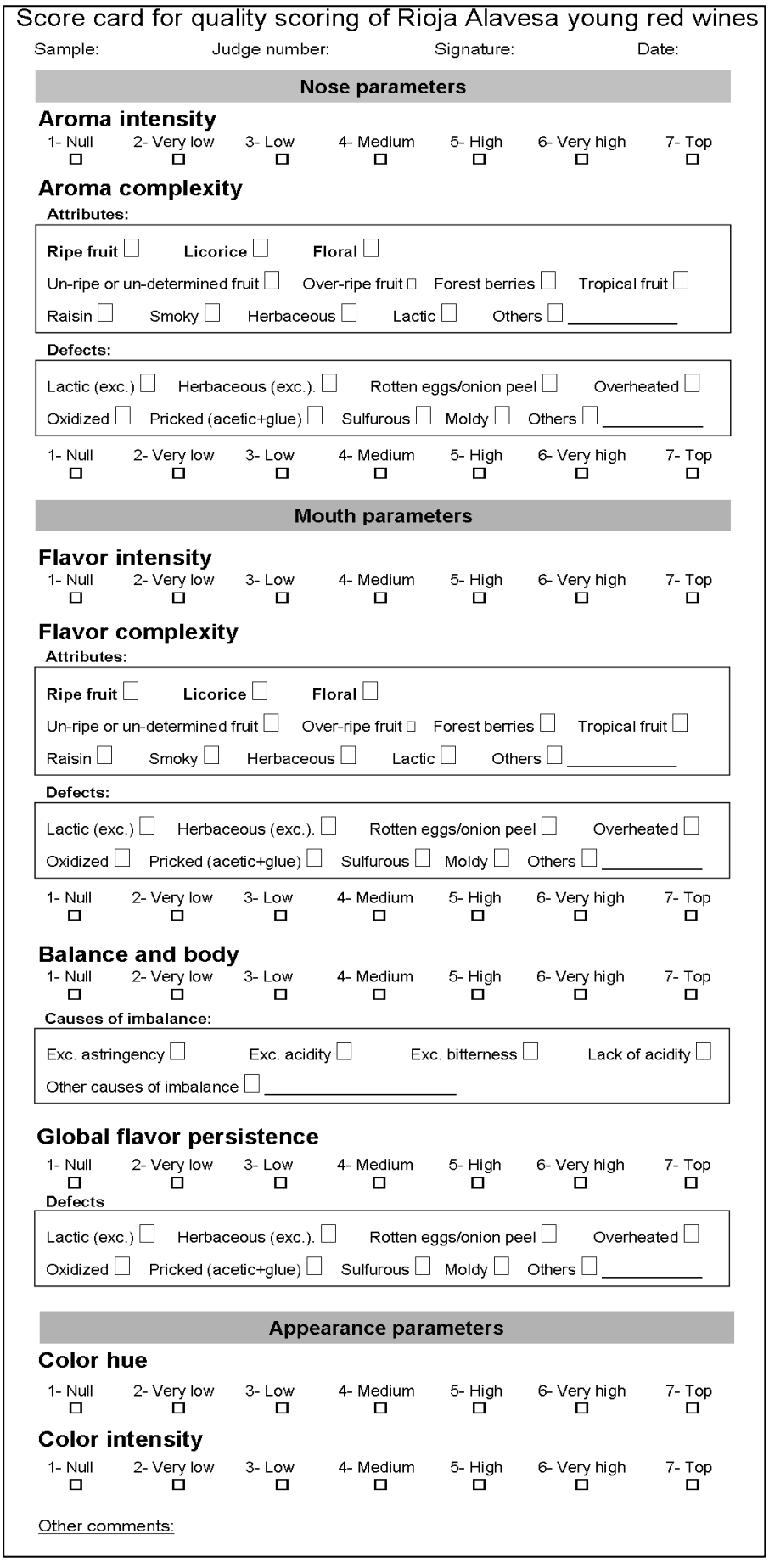


Figure 7. Score card for quality scoring of young red wines from Rioja Alavesa.



Score card for quality scoring of Rioja Alavesa young red wines

Sample: Judge number: Signature: Date:

Nose parameters

Aroma intensity

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Aroma complexity

Attributes:

Ripe fruit ☐ **Licorice** ☐ **Floral** ☐

Un-ripe or un-determined fruit ☐ Over-ripe fruit ☐ Forest berries ☐ Tropical fruit ☐

Raisin ☐ Smoky ☐ Herbaceous ☐ Lactic ☐ Others ☐ _____

Defects:

Lactic (exc.) ☐ Herbaceous (exc.). ☐ Rotten eggs/onion peel ☐ Overheated ☐

Oxidized ☐ Pricked (acetic+glue) ☐ Sulfurous ☐ Moldy ☐ Others ☐ _____

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Mouth parameters

Flavor intensity

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Flavor complexity

Attributes:

Ripe fruit ☐ **Licorice** ☐ **Floral** ☐

Un-ripe or un-determined fruit ☐ Over-ripe fruit ☐ Forest berries ☐ Tropical fruit ☐

Raisin ☐ Smoky ☐ Herbaceous ☐ Lactic ☐ Others ☐ _____

Defects:

Lactic (exc.) ☐ Herbaceous (exc.). ☐ Rotten eggs/onion peel ☐ Overheated ☐

Oxidized ☐ Pricked (acetic+glue) ☐ Sulfurous ☐ Moldy ☐ Others ☐ _____

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Balance and body

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Causes of imbalance:

Exc. astringency ☐ Exc. acidity ☐ Exc. bitterness ☐ Lack of acidity ☐

Other causes of imbalance ☐ _____

Global flavor persistence

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Defects

Lactic (exc.) ☐ Herbaceous (exc.). ☐ Rotten eggs/onion peel ☐ Overheated ☐

Oxidized ☐ Pricked (acetic+glue) ☐ Sulfurous ☐ Moldy ☐ Others ☐ _____

Appearance parameters

Color hue

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Color intensity

1- Null ☐ 2- Very low ☐ 3- Low ☐ 4- Medium ☐ 5- High ☐ 6- Very high ☐ 7- Top ☐

Other comments:

Figures 8a and 8b. Colour hue and colour intensity evaluation in wine by comparison with the developed reference.

Figure 9. Report sent to the winery with the results of the wine.

Analysis report

Report number: 5-S08-08

Asociación de Bodegas de Rioja Alavesa
C/ Berberana, 5
01300 Goardia-Laguardia (Araba-Alava)

Analyzed wine:

Winery:

Reception date: 09/05/2008

Analysis date: 28/05/2008

Method identification: "PNTM-03 Sensory evaluation of uoung red wine from Rioja Alavesa"

Aroma intensity	Aroma complexity	Flavour intensity	Flavour complexity	Balance and body	Global flavour persistence	Colour hue	Colour intensity
4.3	4.4	4.4	4.7	4.3	4.6	4.9	3.3

Attributes:

Aroma: Ripe fruit, Forest berry, Tropical fruit
Flavour: Ripe fruit, Tropical fruit

Defects and imbalance causes:

Observations:

Signature of the laboratory manager:

Report sending date: 30/05/2008

Uncertainty levels of the analysis are at client disposal.
Results of this analysis refer only to the wine analyzed.
This report cannot be reproduced without laboratory approval.

Figure 10. Graphics sent to the winery with citation frequency of attributes, defects and imbalance causes.

Facultad de Farmacia — Laboratorio de Análisis Sensorial
Universidad del País Vasco — Euskal Herriko Unibertsitatea
Paseo de la Universidad 7 01006 Vitoria-Gasteiz
ENAC ENSAYOS Nº 472 / LE 1020

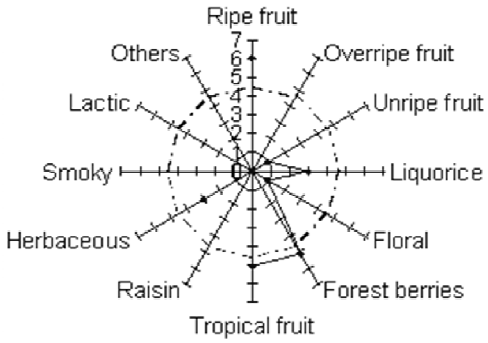
Analysis report

Report number: 5-S08-08

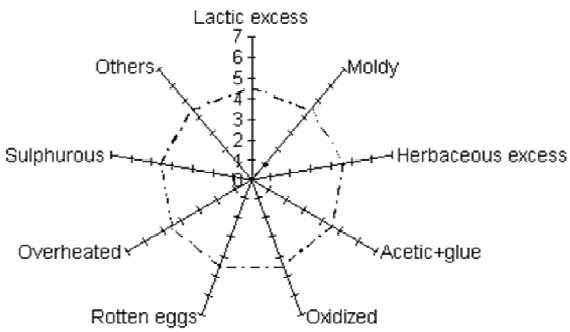
Analysis date: 28/05/2008

The next graphics show the citation frequency of attributes, defects and imbalance causes. When they are out from the discontinuous line (citation frequency ≥5) they are considered to be present in the wine.

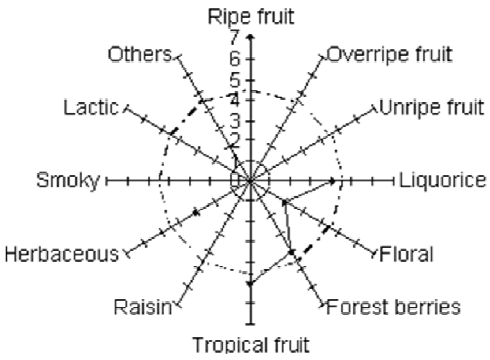
Aroma attributes



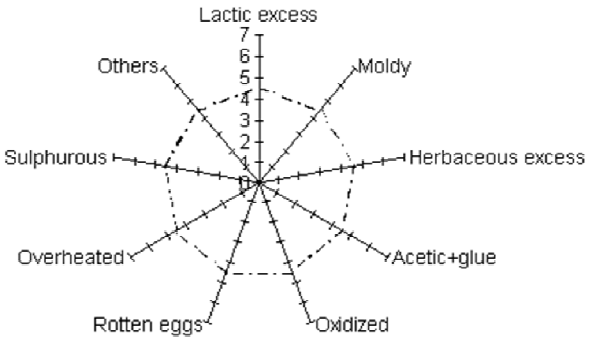
Aroma defects



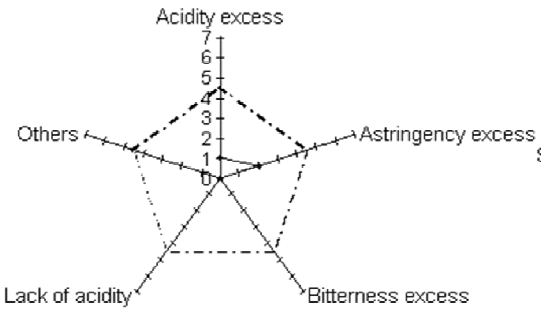
Flavour attributes



Flavour defects



Imbalance causes



Global flavour persistence

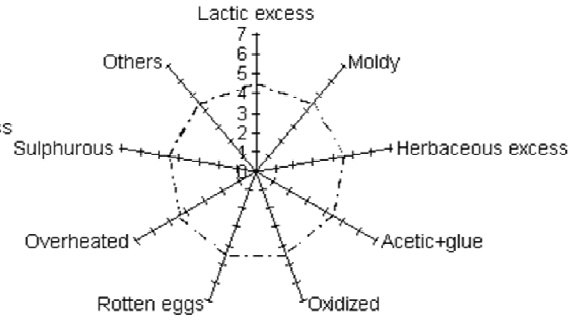


Table 1. Parameters determining the sensory quality in young red wines from Rioja Alavesa.

Parameter	Definition
Aroma intensity	Global intensity of aroma (orthonasal perception).
Aroma complexity	Amount and type of aroma attributes (orthonasal perception), and how they are integrated.
Flavour intensity	Global intensity of flavour (retronasal perception).
Flavour complexity	Amount and type of flavour attributes (retronasal perception), and how they are integrated.
Balance and body	Balance: Situation when acidity, astringency, and bitterness (if present) are compensated by sweetness. No sensation stands out by excess (neither by defect, in the case of acidity). Body: Intensity of taste and, especially, mouth-feel sensations. Consistency, density, “volume” in mouth.
Global flavour persistence	Duration of overall flavour (no taste or mouth-feel sensations) that remains after the wine has been spitted out.
Colour hue	Colour shade of the thin border layer of the wine in the glass.
Colour intensity	How easily the light goes through the wine in the glass; colour "deepness".

Table 2. Weight of each parameter in the overall quality of young red wines from Rioja Alavesa.

Parameters	Weight in the overall quality (%)	
"By nose" parameters	30	
Aroma intensity		12
Aroma complexity		18
"In mouth" parameters	60	
Flavour intensity		10
Flavour complexity		15
Balance-Body		25
Global flavour persistence		10
Appearance parameters	10	
Colour hue		6
Colour intensity		4
Total		100

Table 3. Composition of aroma and flavour references (adapted from Etaio, Albisu, Gaston, Ojeda, Gil & Pérez Elortondo, 2008a).

Attribute / defect	Mother-solution (MS)	Aroma / flavour reference preparation
Aroma intensity/ flavour intensity / global flavour persistence[a]	300 µL of butyl acetate and 300 µL of ethyl valerate in a final volume of 30 mL of absolute ethanol.	Add 150 µL of MS to 400 mL of a mix of commercial wines (100 mL of oaked red table wine + 300 mL of unoaked red table wine)
Ripe fruit	300 µL of butyl acetate in a final volume of 30 mL of absolute ethanol.	Add 250 µL of MS to 50 mL of BW
Forest berries	50 µL of “raspberry” flavour (International Flavors and Fragances) and 250 µL of “blueberry” flavour (Givaudan) in a final volume of 30 mL of absolute ethanol.	Add 200 µL of MS to 50 mL of BW
Tropical fruit	300 µL of isoamyl acetate in a final volume of 30 mL of absolute ethanol.	Add 30 µL (for aroma) or 9 µL (for flavour) of MS and 2 mL (for aroma) or 1,2 mL (for flavour) of juice of sliced pinneaple to 50 mL of BW
Raisin	Commercial wine made with raisins of Pedro Ximenez variety	Add 10 mL of Pedro Ximenez raisin wine to 40 mL of BW
Floral	300 µL of linalool and 300 µL of geraniol in a final volume of 30 mL of absolute ethanol.	Add 25 µL of MS to 50 mL of BW
Liquorice	10 g of liquorice paste dissolved in 100 mL of distilled water	Add 2,5 mL of MS to 50 mL of BW
Smoky	300 µL of commercial liquid smoke aroma in a final volume of 30 mL of absolute ethanol.	Add 500 µL of MS to 50 mL of BW
Lactic	300 µL de diacetyl in a final volume of 30 mL of absolute ethanol.	Add 250 µL of MS to 50 mL of BW
Herbaceous	300 µL of cis-3-hexen-1-ol in a final volume of 30 mL of absolute ethanol.	Add 150 µL of MS and 0,12 g of tannin acid to 50 mL of BW

Table 3 (continuation).

Attribute / defect	Mother-solution (MS)	Aroma / flavour reference preparation
Rotten eggs / onion peel	25 µl of ethanethiol in a final volume of 100 mL of distilled water.	Add 200 µL of MS to 50 mL of BW.
Sulphurous		Dissolve 0,04g of potassium metabisulphite in 50 mL of BW.
Acetic		Add 1 mL (for aroma) or 0,2 mL (for flavour) of acetic acid to 50 mL of BW.
Glue		Add 15 µL of ethyl acetate to 50 mL of BW.
Oxidized[a]		Add 20 mL of commercial "fino" wine to 35 mL of commercial red table wine.
Mouldy	100 µg of 2-methyl-isoborneol in a final volume of 100 mL of distilled water - ethanol (8:2).	Add 70 µL of MS to 50 mL of BW.
Overheated[a]		Heat in a saucepan 100 mL of commercial red table wine until boiling; then remove.

[a] These references are not prepared in base wine (BW)

Table 4. Composition of references for the most frequent causes of imbalance (adapted from Etaio et al., 2008a).

Reference	Composition[a]
Excess of acidity	0,8 g of tartaric acid
Excess of astringency	1,5 g of commercial tannins (Oenotannin Perfect)
Excess of bitterness	0,012 g of quinine sulphate
Excess of alcoholic/burning sensation	24 mL of absolute ethanol

[a] References prepared by adding the mentioned substances to 400 mL of commercial red table wine.

Table 5. Coordinates of the reference of colour hue and colour intensity (reproduced from Etaio et al., 2008b).

	Point in the scale						
	7	6	5	4	3	2	1
Colour hue (RGB coordinates; horizontal scale)							
Red	204	204	210	211	211	211	211
Green	0	0	0	0	0	50	60
Blue	215	190	165	125	96	75	60
Colour intensity (% of shading; vertical scale)	90	75	65	55	45	35	25

Table 6. Result chart of a real wine sample: individual scores, mean and standard deviation of the eight parameters, overall quality calculation and attribute citation frequencies.

	Aroma intensity	Aroma Complexity	Flavour Intensity	Flavour Complexity	Balance and body	Global Flavour Persistence	Colour Hue	Colour Intensity
Judge 1	3	3	4	4	4	4	4	3
Judge 2	4	5	5	5	5	5	5	4
Judge 3	4	6	4	5	5	5	3	3
Judge 4	5	4	5	5	4	5	6	4
Judge 5	5	4	4	4	3	4	5	2
Judge 6	4	5	5	5	5	5	5	3
Judge 7	5	4	4	5	4	4	6	4
Panel mean and standard deviation	4.3 ± 0.76	4.4 ± 0.98	4.4 ± 0.53	4.7 ± 0.49	4.3 ± 0.76	4.6 ± 0.53	4.9 ± 1.07	3.3 ± 0.76
Weighting factor	0.12	0.18	0.10	0.15	0.25	0.10	0.06	0.04
Overall quality	4,41							

Citation frequency of attributes, defects and imbalance causes (in bold when citation frequency ≥5)

Aroma attributes and defects	Flavour attributes and defects	Imbalance causes	Flavour defects in persistence
Ripe fruit 6 **Tropical fruit** 5 **Forest berries** 5 Liquorice 3 Herbaceous 3 Floral 1 Unripe fruit 1 Moldy (defect) 1	**Ripe fruit** 7 **Tropical fruit** 5 Forest berries 4 Liquorice 4 Herbaceous 3 Floral 2	Astringency excess 2 Acidity excess 1	

Article 5

Sensory quality control for food certification: a case study on wine. Panel training and qualification, method validation and monitoring.

Etaio, I., Albisu, M., Ojeda, M., F.Gil, P., Salmerón, J., F.J. Pérez Elortondo

In revision process in Food Control.

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Asunto: Your Submission

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Title: Sensory quality control for food certification: a case study on wine.
Panel training and qualification, method validation and monitoring.
Food Control

Dear Dr Elortondo,

I am pleased to inform you that the Editor and a reviewer have now commented
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before it could be published in FOOD CONTROL.

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To authors for revision and to shorten and reduce to number of figures and tables. It is all right to
quote reference of other paper submitted to FOOD CONTROL.
Also quote % of passes to maximum of 3 significant figures.
eg. table 1 94.44 --- 94.4%
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Reviewer #1: This work is very interesting and novel and it is well written.
But the authors should make some changes in the manuscript.
I think it cannot make a mention of a paper that is not published (page 3,
line 18; page 5, line 4; page 6, line 6; etc).
The authors should describe the used references (page 5, line 4); I think it
is necessary to understand the work.
The Table 6 is not described in the text of the manuscript.
The Table 4 doesn't have a good separation of the columns, it is not clear.
The meaning of PDO should be said the first time that it appears in the text
(page 2, line 18).

Sensory quality control for food certification: a case study on wine. Panel training and qualification, method validation and monitoring.

I. Etaio[a], M. Albisu[a], M. Ojeda[a], P. F. Gil[a], J. Salmerón[a], F. J. Pérez Elortondo[a,*]

[a] Laboratorio de Análisis Sensorial Euskal Herriko Unibertsitatea (LASEHU), Facultad de Farmacia, Universidad del País Vasco - Euskal Herriko Unibertsitatea, Unibertsitateko Ibilbidea - Paseo de la Universidad, 7, 01006 Vitoria-Gasteiz

* Corresponding author:

E-mail address: franciscojose.perez@ehu.es

TEL: +34 945013075; FAX: +34 945013014

Abstract

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: judge selection, basic and specific training, qualification of judges (individual performance checking) and method validation (panel performance checking). Other procedures necessary to demonstrate technical competence in a permanent way (monitoring of panel and judges at each session, quality controls and judge 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.

Keywords

Sensory quality control; method validation; panel training and monitoring; method accreditation.

1. Introduction

The development of methods to assess in an objective way the sensory quality of specific foods, mainly PDO products, 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: judge selection, basic and specific training, judge qualification and method validation. Only when a method provides reliable results (repeatability, reproducibility and discrimination ability) can it be accredited according to ISO 17025 (2005a).

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

Regarding judge selection and training there are many standards and publications (ASTM-STP 758, 1981; ASTM E1499-97(2003), 2003; Bressan & Behling, 1977; International Olive Oil Council, 2007; ISO 8586-1, 1993; ISO 5495, 2005b; ISO 8587, 2006; ISO 8586-2, 2008; Issanchou, Lesschaeve, & Köster, 1995; Lyon, 2002; Muñoz, Civille, & Carr, 1992). There are also many reports for panel performance measurement (Bárcenas, Pérez Elortondo, & Albisu, 2000; Brien, May, & Mayo, 1987; 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, Ojeda,

Albisu, Salmerón, Etayo, & Molina, 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, Albisu, Ojeda, Gil, Salmerón, Pérez Elortondo, 2009), this work shows the approach and criteria followed at the Sensory Laboratory of the University of the Basque Country (www.lasehu.com) for judge selection, basic training, specific training, judge qualification and method validation. This paper also presents the criteria for continuous monitoring of the panel and individual judges, quality controls and judge re-qualification carried out throughout the systematic evaluation of wine samples, once the method was accredited in February 2008 (www.enac.es).

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

2. Material and methods

2.1. Judges

The number of judges participating in each of the steps explained this work varied due to three main reasons: (i) some minimum requirements had to be overcome in each step to pass on to the next one; (ii) some judges left the panel during the project due to labor matters; (iii) continuous monitoring and yearly requalification of expert panel members resulted in some small changes from time to time in panel composition.

Most of the judges had previous experience in sensory descriptive analysis, mainly in cheese and wine evaluation. Among the 31 judges who started specific training 14 were wine experts (8 of them participated in the method development).

2.2. Handling of wine samples and references

Wines were registered at the laboratory with an internal code and were placed in a cellar (17±2ºC) until evaluation. Bottles were opened just before starting serving the wines.

Composition of references used in this work is described in Etaio et al. (2009). References were prepared and frozen at -26ºC. The day before being evaluated, they were defrosted and placed in the cellar at 17±2ºC.

Wines and references were served in standardized 200-mL wine-tasting glasses (ISO 3591, 1977) by using volumetric pourers. Sample volumes were 35±4 mL and 25±1mL for tasting and for appearance evaluation, respectively. Glasses were covered with Petri dishes to avoid volatile losses. For references to be tasted in mouth 15-20 mL were served in plastic glasses. With the exception of initial phases of training (where references were presented identified), wine samples and references were presented codified with three digits.

2.3. Wine and reference evaluation and data treatment

Wines samples and references for panel training were evaluated in the group room. Wine samples and references for judge qualification, method validation and quality control were evaluated in booths equipped with computer terminals. Both the temperature (21±2ºC) and relative humidity (60±20%) of the booth room were controlled.

Except for appearance parameters (evaluated under illumination similar to daylight: colour temperature very close to 6,500ºK and chromatic rendering index higher than 90), the evaluation of wine samples and references was carried out under the weak light provided by the screen of the computer, in order to avoid any colour bias.

The evaluation procedure and the criteria to score the eight sensory parameters (aroma intensity, aroma complexity, flavour intensity, flavour complexity, balance and body, global flavour persistence, colour hue, colour intensity) is described in Etaio et al. (2009). Water and unsalted crackers were provided to the judges to eliminate residual sensations between samples.

Data from wines evaluated in booths were collected with FIZZ software (Biosystèmes, Couternon, Version 2.10 A). Wines evaluated in the group room were scored by filling in the score card published in Etaio et al. (2009). Data regarding reference identification were collected by using normalized forms included in the accreditation scope.

Statistical descriptive analysis and simple mean comparison tests (t test) were used according to each test (as described in each section), since more sophisticated statistic analyses were not essential. Data were analysed using Microsoft Excel 2003 (Redmond, WA, USA).

3. Results and discussion

3.1. Judge selection and basic training

Both 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 judges, as well as to evaluate their sensory sensibility and capacity to describe and communicate 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. In this meeting each candidate filled in a questionnaire to collect information related to the suitability for sensory analysis (aptitude for foods, communication, health, availability…).

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 the selection 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% of the candidates) achieved the required 75% of the tests, while the other eight candidates (29.6%) stayed between 60% and 75% of the tests passed. After repeating once non-passed tests all of them reached 75%.

As shown in Table 1, the tests that proved more difficult to be passed were the taste identification, taste ranking and aroma description tests. The easiest tests to pass were the colour ranking, description of texture, triangle test with sapid substances and colour vision tests.

Candidates who passed the selection phase attended basic training. The aim of the basic training tests was to provide the potential judges with some elementary tools used in sensory analyses and with a basic training on food evaluation prior to training them in specific products. Basic training was composed of 12 tests distributed through four sessions, as described by Pérez Elortondo et al. (2007). These tests included smell and sapid substance recognition, scale use and attribute development and use.

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 that passed the selection tests started the basic training tests, although 3 of them did not attend all the sessions for labor or sick leave reasons. Twenty-two candidates (91.7% of the candidates) reached at the

first attempt 75% of the tests and two candidates (8.3%) reached it after repeating some tests. As shown in Table 2, the most difficult test to be passed was the use of scales with one-dimensional descriptors of aroma. The achieved percentage for the other tests ranged from 79.2 to 100%.

3.2. Specific training and judge qualification

Thirty-one judges (20 from the described round of selection and basic training 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., 2009). Five judges left the panel during the specific training for different reasons (changes in labor situation, pregnancy and lack of interest).

Specific training extended through 15 sessions (90-120 minutes each one). References of aroma, flavour, taste and mouth-feel were presented throughout these sessions to the judges. Initially, references were identified but later they were presented codified to check the difficulties to identify them. The number of wines to evaluate in each session increased from 1 in the first session (where the methodology and the criteria to score were explained in detail) to 9 wines as the training phase progressed. Initially, all the wines were tasted and commented on in the group room. Progressively, some wines were tasted in booths to become the judges familiar with evaluation procedure by using FIZZ software. Anyway, several wines were discussed in the group room in all the training sessions.

After specific training, the ability of each judge in reference identification and in wine evaluation was checked by qualification tests. Passing the qualification tests means that the judge is ready to be included in the expert panel to evaluate the product in a systematic way.

As no reports of specific tests for judge qualification were found, tests were designed at the laboratory. Qualification tests were distributed in three sessions. The first session dealt with identification of the references evaluated

in the specific training. Twenty samples of aroma attributes and defects, 20 samples of flavour attributes and defects and 10 samples of causes of taste and mouth-feel imbalance were presented in three separated series to the judges in the booths. All the attributes, defects and imbalance causes included in the score card were included in the tests. Some repeated references and some base wine samples (without any attribute, defect or imbalance causes) were also included in order to avoid reference identification by elimination. References were presented in 10-reference blocks separated by a brief rest to avoid sensory fatigue. Judges filled in specific normalized forms with the reference identification and signed them.

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 were presented in triplicate and wines C and D once). In the third session the same eight samples were evaluated (those samples coming from the same bottle or from the same wine batch were considered as being the same sample). Special attention was given to the selection of samples in order to assure previously that the selected samples are quite different regarding some parameters. Otherwise, the selection of very similar samples could lead to interpret that the panel is not discriminative, when in fact it is able to differentiate between samples.

Wine samples were evaluated in booths following the criteria and methodology developed for evaluation of young red wines from RA (Etaio et al., 2009).

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

Only the judges who passed all the qualification tests would be included in the expert panel. The judges who did not pass the qualification 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.

Results of qualification tests are detailed in Table 4. Ten of the 26 judges (38.5% of the total) passed all the tests in the first round. Eight more judges (accumulative percentage of 69.2%) passed all the tests after repeating the non-passed tests only once, and two more judges (accumulative percentage of 76.9%) achieved qualification after repeating some of the tests twice. These 20 qualified judges made up the expert judge panel to evaluate the product in a systematic way. It 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 judges (50%) passed them at the first attempt. It was also observed that judges with a higher attendance to the training sessions generally passed reference identification tests more easily, showing the importance of training in reference evaluation.

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 5.

The method validation process was carried out by 13 of the expert judges. Seven expert judges 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. The acceptability limit was established 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, separately for wines A and B. Thus, as there were two wines and eight sensory parameters to evaluate 16 SDR values and 16 SDRr values were obtained (Table 7). The highest SDR values and the highest SDRr values correspond to balance and body of wine A. Considering the highest standard deviation in repeatability and in reproducibility the laboratory established an acceptability limit of 0.5 for repeatability and 0.8 for reproducibility.

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.

Table 7 shows the results of uncertainties calculation for repeatability and reproducibility in scores, as well as the results of validation session for these two parameters. All the SDR and SDRr values were inside the 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 8. 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 aroma and flavour and forest berry flavour in wine A, and smoky flavour 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 8). 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 aroma 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 9 shows the citations for attributes with a CF ≥ 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 (including defects and imbalance causes) appearing in the score form must be validated to assure that the expert panel was able to identify each of them in wine samples. As it was not possible to validate the 36 attributes during the described validation sessions, it was agreed to validate them through the wine evaluation sessions to perform throughout the year.

As no similar reports were found, it was decided 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 (5 or more of the 7 expert judges cited it, according to the criteria explained in Etaio et al., 2009) and identified it again in the same wine but in another session, this attribute would be validate. It would demonstrate that the identification of this attribute in the first session was not made by chance.

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, although instead of base wine they would be prepared with wine as matrix.

3.4. Continuous monitoring of the panel and judges

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 7 judges attending the session. Session development and data treatment are explained in Etaio et al. (2009). Monitoring of each session was carried out in two ways:

a) panel monitoring: it was based on controlling the score dispersion within the panel in each session. 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 8 parameters), as proposed by Pérez Elortondo et al. (2007).

When explained criteria were not fulfilled measures had to be taken. 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 to the results of panel monitoring, in eight sessions (40% of the sessions) the standard deviations equal or higher than 1 exceed 15% of total cases. When the most problematic wines were tasted again in the next session, results fulfilled the established requirements. Parameters with the most cases of standard deviation equal to or higher than 1 were aroma complexity (30.6 % of the wines), flavour complexity (24.8 %), global flavour persistence (22.3%) and balance and body (21.5%).

Parameters with the least number of panel deviations were colour intensity (2.5% of the wines), colour hue (5.0%), flavour intensity (14.0%) and aroma intensity (15.7%).

b) individual monitoring of expert judges: it was based on studying the deviations in scores and deviations in attribute citation. It was established that the score provided by each judge to each parameter of each sample should be equal to the panel mean rounded to the closest entire number or to the next lower or higher entire number (e.g., if the panel score mean is 3.7 it will be rounded up to 4, and the scores admitted as acceptable will be 3, 4 and 5). The number of cases in which this requirement is not fulfilled must be less than 15% of the total cases (number of samples x 8 parameters) for each judge.

With regard to the results, the described requirement was not fulfilled in 6 cases (4.3% of the total possible cases: 20 sessions x 7 judges). As occurred with panel, aroma complexity, flavour complexity, balance and body, and global flavour persistence were the most problematic parameters (7.4%, 6.5%, 5.9% and 5.8% of individual deviations, respectively; deviations calculated over 121 wines x 7 judges). Colour intensity (1.5%), colour hue (2.2%), aroma intensity (3.1%) and flavour intensity (3.8%) were the parameters with the least number of individual deviations.

Regarding attribute citation (including defects and imbalance causes), it was established that each judge should indicate at least 50% of the attributes considered present in the samples by the panel (noted by 5 or more judges). Besides, with the aim of avoiding judges citing a lot of attributes to fulfill this requirement, it was established that the number of attributes cited only by one judge should not be higher than 3 multiplied by the number of samples evaluated in the session.

There were 3 cases (2.1% of the total possible cases: 20 sessions x 7 judges) where a judge did not identify 50% of the attributes cited by the panel in a session. There were no cases of a judge citing an excessive number of

attributes, although on 3 occasions attribute citation by excess was just within the limit.

When performance requirements were not fulfilled by the panel (usually because of poor performance of one or more judges) or by individual judges, interviews with the judges involved were held to discuss the harmonization of their results with the results of the panel. A judge would be removed from the panel when his/her performance was very bad and/or frequently did not fulfill the requirements. This judge 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 judge fulfilled all the criteria, then the judge would be reincorporated to the panel.

In each session, an informative report about personal performance in the previous session was provided to each judge. An example of a personalized informative report is shown in Figures 1 and 2. This report collects data from the panel (mean scores and attribute citation) and from each judge (scores and deviations, and attribute citation).

When a judge did not attend any evaluation or training sessions through 5 consecutive weeks, she/he would be removed temporally from the panel. To be included again the judge had to follow the same procedure as a judge 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 (included in the accreditation scope) a quality control has to be performed each 150 samples at least, and if the number of samples in the year is lower than 150 at least once a year. 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 (including defects and causes of imbalance) in wine to check the reproducibility in attribute identification by the panel. Each attribute identified by the panel (cited by 5 or more judges) throughout the year must be submitted at least to one quality control. For this control, when an attribute was identified by the panel in a sample, this sample (the same bottle or another bottle from the same batch) 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 were not identified, sample would be discussed in group and the presence or absence of this attribute in the sample would be agreed on.

3.6. Judge requalification

Expert judges have to repeat and pass requalification tests at least once a year to demonstrate that they are still capable of evaluating satisfactorily young red wine from RA according to the method. As tests and criteria for requalification are the same as those for qualification, both qualification for new judges and requalification for expert judges can be performed at the same time. If an expert judge successfully passes the requalification tests she/he will continue as a member of the expert panel and must repeat requalification tests within a year. If an expert judge does not pass one or more of the tests she/he will have the opportunity to repeat non-passed tests up to two times. If after repetitions tests are not passed, this judge will be removed from the panel (she/he will not be considered a qualified judge) and will have the opportunity to do the qualification tests the next time they take place. If the judge passes them, then she/he will be readmitted.

Requalification tests, in addition to providing information about judge suitability, helped to keep the judges alert, avoiding relaxation and undervaluation of training.

4. Conclusions

The procedures described in this paper (judge 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, mainly those products with quality distinctiveness labels. 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 to be developed can also be increased or decreased.

Availability of the potential judges has to be considered as one of the most important factors (if not the most important) 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 judges not reaching the requirements at the first attempt but also for judges missing some sessions.

Regular assistance to training sessions and to evaluation assays is necessary to get progressively the judge more fitted in the panel, especially when typicity and features regarding some complex concepts are considered in the method.

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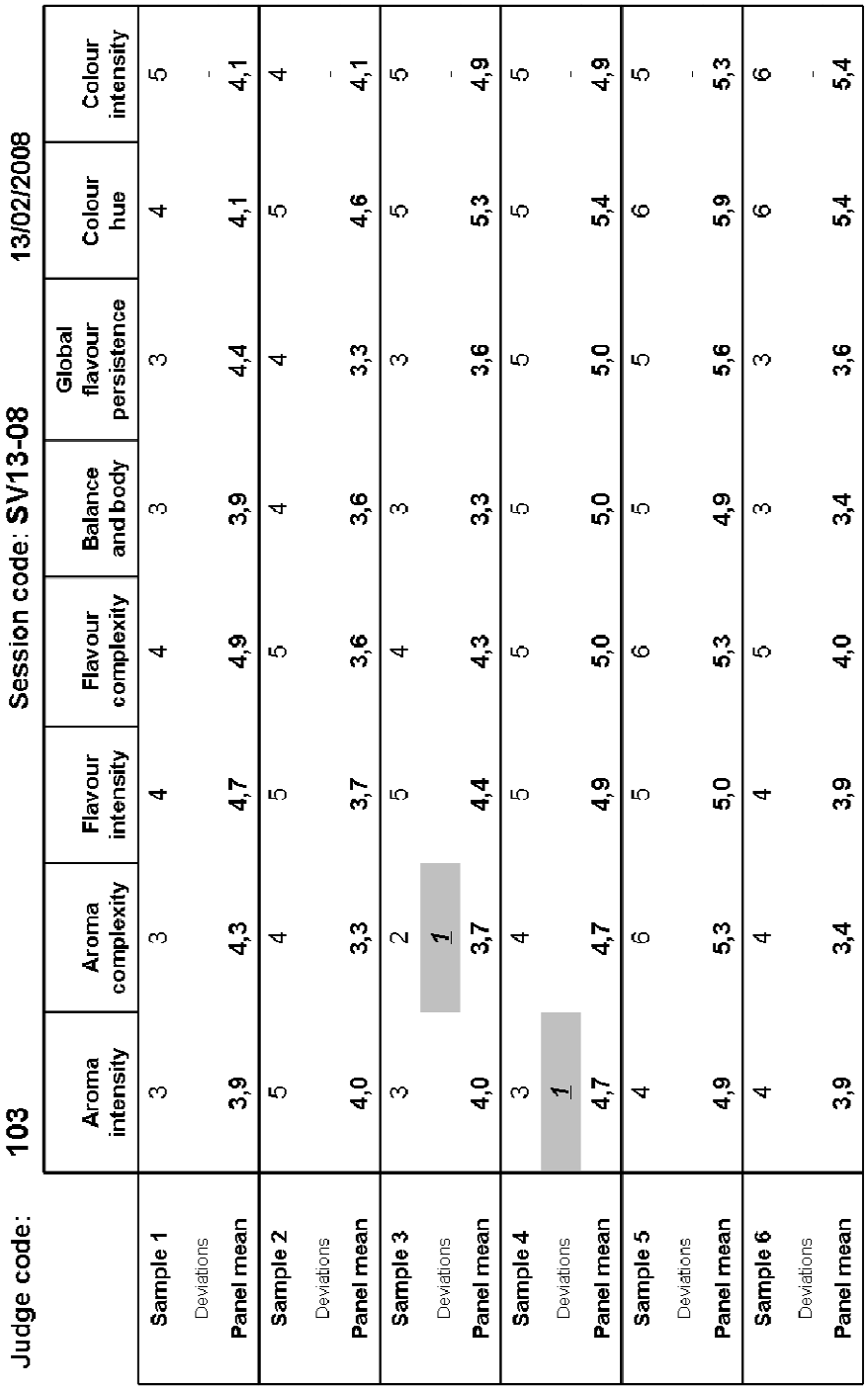
Figure 1. Example of a personalized informative report of a session for judge feed-back: report of scores.



Judge code: 103 Session code: SV13-08 13/02/2008

	Aroma intensity	Aroma complexity	Flavour intensity	Flavour complexity	Balance and body	Global flavour persistence	Colour hue	Colour intensity
Sample 1	3	3	4	4	3	3	4	5
Deviations								-
Panel mean	**3,9**	**4,3**	**4,7**	**4,9**	**3,9**	**4,4**	**4,1**	**4,1**
Sample 2	5	4	5	5	4	4	5	4
Deviations								-
Panel mean	**4,0**	**3,3**	**3,7**	**3,6**	**3,6**	**3,3**	**4,6**	**4,1**
Sample 3	3	2	5	4	3	3	5	5
Deviations		*1*						-
Panel mean	**4,0**	**3,7**	**4,4**	**4,3**	**3,3**	**3,6**	**5,3**	**4,9**
Sample 4	3	4	5	5	5	5	5	5
Deviations	*1*							-
Panel mean	**4,7**	**4,7**	**4,9**	**5,0**	**5,0**	**5,0**	**5,4**	**4,9**
Sample 5	4	6	5	6	5	5	6	5
Deviations								-
Panel mean	**4,9**	**5,3**	**5,0**	**5,3**	**4,9**	**5,6**	**5,9**	**5,3**
Sample 6	4	4	4	5	3	3	6	6
Deviations								-
Panel mean	**3,9**	**3,4**	**3,9**	**4,0**	**3,4**	**3,6**	**5,4**	**5,4**

Number of samples	6
Number of parameters	48
Number of deviations	2
% of deviations*	**4,2**

*Acceptability: ≤15 %

Figure 2. Example of a personalized informative report of a session for judge feed-back: report of attribute citation.

Judge code: 103 **Session code: SV13-08** **13/2/2008**

Cells in grey colour: attributes (including defect and imbalance causes) present in the sample (cited by at least 5 of the 7 judges).
Cells = 1 : Attribute present in the sample and cited by the judge. Cells = 0 : Attribute present in the sample but not cited by the judge.
Cells = OY (Only you): Attribute cited only by you in this sample.

AROMA ATTRIBUTES	RF	OF	UF	Lic	Flo	FB	TF	Rai	Her	Smo	Lac	Oth
Sample 1	0											
Sample 2								OY				
Sample 3	1			0								
Sample 4	1						0					
Sample 5	1						1					
Sample 6	1											

AROMA DEFECTS	ExL	Mol	ExH	Pri	Oxi	RE	OH	SO2	Oth
Sample 1									
Sample 2									
Sample 3			OY						
Sample 4									
Sample 5									
Sample 6									

FLAVOUR ATTRIBUTES	RF	OF	UF	Lic	Flo	FB	TF	Rai	Her	Smo	Lac	Oth
Sample 1	1			1					1			
Sample 2								OY				
Sample 3	1			0								
Sample 4	1						0					
Sample 5	1						1					
Sample 6	1											

FLAVOUR DEFECTS	ExL	Mol	ExH	Pri	Oxi	RE	OH	SO2	Oth
Sample 1									
Sample 2									
Sample 3									
Sample 4									
Sample 5									
Sample 6									

CAUSES OF IMBALANCE	EAc	EAs	EBi	LAc	Oth
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					
Sample 6		1			

DEFECTS IN GLOBAL FLAVOUR PERSISTENCE	ExL	Mol	ExH	Pri	Oxi	RE	OH	SO2	Oth
Sample 1									
Sample 2									
Sample 3									
Sample 4									
Sample 5									
Sample 6									

Attributes: RF: ripe fruit; OF: Over-ripe fruit; UF:unripe fruit ; Lic : licorice; Flo : floral; FB : Forest berries ; TF : tropical fruit ; Rai: raisin; Her : Herbaceous ; Smo : Smoky ; Lac: lactic; Oth: others.

Defects: ExL: excess of lactic; Mol: moldy; ExH: Excess of herbaceous; Pri: Pricked (acetic+glue); Oxi: oxidized; RE: rotten eggs; OH: overheated; Oth: others

Causes of imbalance: EAc: excess of acidity; EAs: excess of astringency; EBi: excess of bitterness; LAc: lack of acidity; Oth: others.

Attributes (including defects and causes of imbalance) present in the samples (cited by 5 or more judges)	21
Attributes (including defects and causes of imbalance) present in the samples (cited by 5 or more judges) and cited by the judge	16
Attributes (including defects and causes of imbalance) present in the samples (cited by 5 or more judges) but not cited by the judge	5
% of Attributes (including defects and causes of imbalance) correctly cited by the judge*	76,2

*Acceptability: ≥ 50 %

Number of attributes (including defects and causes of imbalance) cited only by you	3
Maxim number of attributes (including defects and causes of imbalance) that could be cited by you only (3 per sample)	18

Table 1. Results of selection tests.

Test[a]	Reference	% of passes[b]
Colour vision test	Ishihara test	94,44
Taste identification test	ISO 3972, 1991	33,33
Duo-trio test with sapid substances	ISO 10399, 2004b	88,89
Triangle test with sapid substances	ISO 4120, 2004a	96,30
Ranking test	UNE 87023, 1995	
of colour		100,00
of aroma		77,78
of taste		55,56
of texture		83,33
Description test	ISO 8586-1, 1993	
of aroma		64,81
of texture		96,30

[a] Each test was done twice by each judge.
[b] Repetitions of non-passed tests by judges not reaching the established 75% are not considered in this table.

Table 2. Results of basic training tests.

Test	Reference	% of passes[a]
Aroma pairing test	ISO 8586-1, 1993	95.8
Paired comparison test	ISO 5495, 1983	
with aroma substances		79.2
with taste substances		95.8
Duo-trio test	ISO 10399, 2004	83.3
Use of scales with one-dimensional parameters	ISO 4121, 2003	
of aroma		41.7
of taste		87.5
Use of scales with multidimensional parameters	ISO 4121, 2003	
of aroma		87.5
of flavour-taste		95.8
of texture		87.5
Food product profiling	ISO 6564, 1985	
aroma attributes		100
flavour-taste attributes	ISO 6564, 1985	91.7
Texture profiling of food products	ISO 11036, 1994	95.8

[a] Test repetition of non-passed test by judges not reaching the established 75% are not considered in this table.

Table 3. Description of parameters studied in judge qualification.

Studied parameter	Calculations	Criteria to pass the test
Identification of references of aroma, flavour and imbalance causes: ability to identify the references used through the training.	$aroma\ reference\ identification = \frac{No\ ref\ ide}{20} x100$ $flavour\ reference\ identification = \frac{No\ ref\ ide}{20} x100$ $imbalance\ reference\ identification = \frac{No\ ref\ ide}{10} x100$ $total\ reference\ identification = \frac{No\ ref\ ide}{50} x100$ *No ref ide*: Number of references correctly identified.	To identify correctly ≥50% of references of aroma, flavour and imbalance causes (considered separately) and ≥65% of all the references as a whole.
Discrimination ability in scores: Ability to give different scores to wines that have different quality regarding the considered sensory parameter.	t-Student test (with data from A and B wines from all the judges and from the two sessions as a whole) → parameters with significant differences were discriminative. $CI = \frac{\lvert \bar{x}_A - \bar{x}_B \rvert}{\sqrt{I_1^2 + I_2^2}}$ *CI*: Compatibility index. Calculated for each judge and sensory parameter. $\bar{x}_A$: mean of the scores given by the judge to the corresponding parameter in the six samples from wine A. $\bar{x}_B$: mean of the scores given by the judge to the corresponding parameter in the six samples from wine B. I_1 and I_2: reference values of uncertainties (corresponding to the value of standard deviation). According to internal technical criteria the established values were 0.6.	To reach a CI > 1 for at least 50% of the sensory parameters that resulted discriminative for the panel.
Repeatability in scores: ability to give the same or similar scores when the same wine is evaluated in replicate in the same session.	$SDR = \frac{SD\ s1wA + SD\ s2wA + SD\ s1wB + SD\ s2wB}{4}$ *SDR*: standard deviation in repeatability. Calculated for each sensory parameter and for each judge. Average of the standard deviations (SD) in the two sessions (s1 and s2) considering only the wines evaluated in triplicate (wA and wB).	To reach a SDR ≤ 0.6 (the adopted reference value) for at least 50% of the sensory parameters.
Reproducibility in scores: ability to give the same or similar scores when the same wine is evaluated in replicate in different sessions.	$SDRr = \sqrt{Var\ bet\ s^2 + Var\ rep^2}$ *SDRr*: standard deviation of reproducibility. Calculated for each sensory parameter and for each judge. Only wines evaluated in triplicate (A and B) were considered. *Var bet s*: Variance between sessions. The standard deviation of the standard deviations of the two sessions. *Var rep*: Variance of repeatability. It is the average of the standard deviations of the two sessions.	To reach a SDRr ≤ 0.6 (the adopted reference value) for at least 50% of the sensory parameters.

Table 3 (continuation).

Studied parameter	Calculations	Criteria to pass the test
Identification of attributes and defects in wine: ability to identify the attributes and defects present in the wines.	$CF = \frac{Cit\ att}{Max\ cit\ att\ pos} x100$ *CF*: citation frequency. Calculated for the panel and for each judge. *Cit att*: Times that one attribute is cited in a wine. *Max cit att pos*: Maximum times that this attribute can be cited in this wine. For each wine evaluated in triplicate in both 2nd and 3rd sessions (wines A and B) the six samples were computed together. For each wine evaluated once in each session (C and D) the two samples were computed together. Attribute/defect identification was calculated separately for aroma and for flavour. Each attribute was linked to the respective wine.	To reach a CF ≥ 50% for at least the half of the attributes with a CF ≥ 50% for the panel.

Table 4. Results of judge qualification tests.

Judge number	Qualification in reference identification (session 1)					Qualification in attribute identification in wine (sessions 2 and 3)		Qualification in scoring (sessions 2 and 3)			Qualification tests overally
	Aroma (%)	Flavour (%)	Imbalance causes (%)	Total (%)	Reference identification	% aroma identification[a]	% flavour identification[a]	Discrimination	Repeatability	Reproducibility	
1	95	95	80	92	P	60.0	57.1	P	P	P	P
2	65	60	90	68	P	80.0	85.7	P	P	P	P
3	70	65	60	66	P*	60.0	100.0	P	P	P	P*
4	80	60	50	66	P*	60.0	57.1	P	P	P	P*
5	65	70	70	68	P	80.0	71.4	P	P	P	P
6	60	65	40	58	NP	100.0	85.7	P	P	P	NP
7	65	65	70	66	P*	80.0	71.4	P	P	P	P*
8	60	65	80	66	P**	100.0	85.7	P	P	P	P**
9	80	60	70	70	P	100.0	71.4	P	P	P	P
10	75	85	60	76	P*	100.0	71.4	P	P	P	P*
11	45	50	50	48	NP	NA	NA	NA	NA	NA	NP
12	25	15	60	28	NP	100.0	100.0	P	P	P	NP
13	60	70	80	68	P	80.0	83.3*	P*	P	P	P*
14	90	90	100	92	P	80.0	57.1	P	P	P	P
15	85	65	90	78	P	60.0	85.7	P	P	P*	P*
16	80	70	70	74	P**	100.0*	71.4	P	P	P	P**
17	80	70	50	70	P	80.0	85.7	P	P	P	P
18	65	60	80	66	P*	100.0	100.0*	P*	P	P	P*
19	50	45	40	46	NP	NA	NA	NA	NA	NA	NP
20	70	80	60	72	P	80.0	85.7	NP	P	P	NP
21	75	80	90	80	P	100.0	100.0	P	P	P	P
22	90	85	50	80	P	80.0	85.7	P	P	P	P
23	70	80	100	80	P	80.0	100.0	P	P	P	P
24	80	80	40	72	NP**	80.0	85.7	P	P	P	NP**
25	65	65	70	66	P*	100.0	85.7	P	P	P	P*
26	70	80	80	76	P	80.0	50.0	P	P	P	P

P: Passed; NP: Not passed; NA: Not attended.
* After repeating one or several tests once.
** After repeating one or several tests twice.
[a] Calculated as follows: (attributes with a CF ≥ 50% for the panel and with a CF≥ 50% for the judge / total number of attributes with a CF≥ 50% for the panel) x 100.

Table 5. Parameters studied in method validation and criteria to pass each test.

Studied parameter	Criteria to pass the test
Repeatability in scores: ability to give the same or similar scores when the same wine is evaluated in replicate in the same session.	Standard deviation in repeatability (SDR) must be ≤ 0.5 (value established after carrying out the sessions to calculate the uncertainties).
Reproducibility in scores: ability to give the same or similar scores when the same wine is evaluated in replicate in different sessions.	Standard deviation in reproducibility (SDRr) must be ≤ 0.8 (value established after carried out the sessions to calculate the uncertainties).
Repeatability in attribute identification: ability to identify the same attributes (including defects) when the same wine is evaluated in replicate in the same session.	The citation difference among the replications of the same wine in the same session must be ≤ 2 for at least 80% of the attributes with a CF ≥ 50%. The two sessions are considered separately. There are considered only the attributes with a CF ≥50% (4 of 7 judges citing it) in any of the three replications of wine A or B in a session.
Reproducibility in attribute identification: ability to identify the same attributes (including defects) when the same wine is evaluated in replicate in different sessions.	The citation difference for an attribute in the same wine between sessions 1 and 2 must be ≤ 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 x 7 judges=21).
Reproducibility in discrimination ability in scores: ability to establish the same sensory parameters as discriminative between two wines in different sessions.	The number of discriminative parameters in the second session must not be < 50% or > 150% of the discriminative parameters in the first session (see Table 6). The sensory parameters discriminative between A and B wines are determined by the t-Student test.
Reproducibility in discrimination ability in attribute identification: ability to establish the same attributes (including defects) as discriminative between two wines in different sessions.	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 6. Acceptability limits for reproducibility in discrimination ability in scores.

Number of discriminative parameters in session 1	Minimum number of discriminative parameters in session 1 that have to result discriminative in session 2	Maximum number of parameters that can result discriminative in session 2
1	0	2
2	1	3
3	2	4
4	2	6
5	3	7
6	3	8
7	4	8
8	5	8

Table 7. Results of sessions for calculating the uncertainties for repeatability and reproducibility in scores, and results of the validation sessions for repeatability and reproducibility in scores.

	Aroma intensity		Aroma complexity		Flavour intensity		Flavour complexity		Balance and body		Global flavour persistence		Colour hue		Colour intensity	
	SDR	SDRr	SDR	SDRr	SDR	SDRr	SDR	SDRr	SDR	SDRr	SDR	SDRr	SDR	SDRr	SDR	SDRr
Uncertainty determination																
Wine A	0.11	0.19	0.29	0.44	0.08	0.14	0.18	0.28	**0.30**	**0.48**	0.21	0.31	0.23	0.32	0.18	0.31
Wine B	0.19	0.35	0.26	0.41	0.18	0.28	0.16	0.26	0.26	0.36	0.23	0.32	0.04	0.07	0.08	0.14
Acceptability limits established	0.5	0.8	0.5	0.8	0.5	0.8	0.5	0.8	0.5	0.8	0.5	0.8	0.5	0.8	0.5	0.8
Validation sessions																
Wine A	0.08	0.11	0.26	0.49	0.22	0.37	0.30	0.51	0.30	0.54	0.30	0.46	0.16	0.29	0.11	0.20
Wine B	0.35	0.47	0.18	0.27	0.14	0.21	0.11	0.16	0.23	0.35	0.30	0.43	0.08	0.14	0.15	0.21
Within the acceptability limits?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

SDR: standard deviation in repeatability; SDRr: standard deviation in reproducibility.
In bold the highest values of uncertainties for repeatability and reproducibility.

Table 8. Attribute citation results for validation in repeatability and reproducibility in attribute identification[a].

		Wine A							
		Citations in session 1				Citations in session 2			
	Attribute	Rep1	Rep2	Rep3	**Total**	Rep1	Rep2	Rep3	**Total**
Aroma complexity									
	Ripe fruit	6	6	7	**19**	7	5	3	**15**
	Licorice	4	3	5	**12**	3	4	2	**9**
	Forest berry	4	4	4	**12**	6	2	1	**9**
	Herbaceous	3	4	5	**12**	3	2	2	**7**
Flavour complexity									
	Ripe fruit	6	6	6	**18**	7	5	4	**16**
	Licorice	5	4	5	**14**	4	4	3	**11**
	Forest berry	3	3	5	**11**	4	3	3	**10**
Balance - body									
	-	-	-	-	**-**	-	-	-	**-**
Global flavour persistence									
	-	-	-	-	**-**	-	-	-	**-**

		Wine B							
		Citations in session 1				Citations in session 2			
	Attribute	Rep1	Rep2	Rep3	**Total**	Rep1	Rep2	Rep3	**Total**
Aroma complexity									
	Ripe fruit	2	2	4	**8**	2	2	3	**7**
	Un-determined fruit	5	5	3	**13**	4	5	4	**13**
	Smoky	2	2	1	**5**	1	4	2	**7**
	Herbaceous	4	3	4	**11**	3	2	3	**8**
Flavour complexity									
	Un-determined fruit	4	5	4	**13**	3	4	5	**12**
	Herbaceous	2	3	3	**8**	3	5	3	**11**
Balance and body									
	Exc. acidity	2	3	3	**8**	2	4	2	**8**
Global flavour persistence									
	-	-	-	-	**-**	-	-	-	**-**

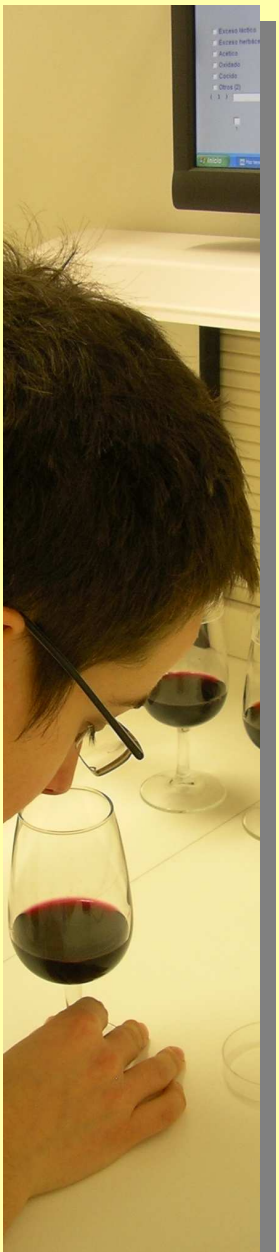
[a] Only attributes with a CF ≥ 50% in at least one of the repetitions (4 or more citations) are included.

Table 9. Attribute citation results for validation in reproducibility in discrimination ability in attribute identification[a].

	Session 1			Session 2			Attribute discriminative in session 1 and in session 2?
Attribute	Citations in wine A	Citations in wine B	Discriminative?	Citations in wine A	Citations in wine B	Discriminative?	
Aroma attributes							
Ripe fruit	19	8	YES	15	7	YES	YES
Un-ripe fruit	2	13	YES	6	13	YES	YES
Licorice	12	5	YES	9	2	NO	NO
Forest berries	12	5	YES	9	1	NO	NO
Herbaceous	12	11	NO	7	8	NO	
Flavour attributes							
Ripe fruit	18	8	YES	16	9	YES	YES
Un-ripe fruit	3	13	YES	5	12	YES	YES
Licorice	14	7	YES	11	4	YES	YES
Forest berries	11	3	YES	10	1	NO	NO
Herbaceous	8	8	NO	7	11	YES	NO
	Discriminative attributes		8	Discriminative attributes		6	

[a] Only attributes with a CF ≥ 50% in at least one of the sessions (11 or more citations) are included.

5- CONCLUSIONS



Regarding the **first research line**, the main conclusions of this thesis are the following:

FIRST – The young red wines from Rioja Alavesa analyzed in this study are characterized by purple hue and high colour intensity. In mouth they have medium acidity, astringency, balance, body and global flavour persistence, and slight bitterness as well. The aroma and flavour intensity is medium and the main aroma attributes are fruity related ones (red and black berry, tree fruit), alcoholic, herbaceous, liquorice and floral.

SECOND – The organoleptic characteristics that best differentiate among these wines are those related to appearance (colour intensity and colour hue) and to some tastes and mouth-feel sensations (astringency, balance, bitterness and acidity). The aroma attributes differentiate among wines to a less extent, with red berry, floral, aroma intensity and black berry as the most important ones. The flavour attributes are the least discriminative ones. Among them, alcoholic and herbaceous aromas are the best to distinguish among the wines.

THIRD – The wines made by carbonic maceration have higher aroma intensity, red berry aroma, alcoholic aroma and acidity than those wines made by destemming. Nevertheless, these have higher liquorice and tree fruit aroma than wines made by carbonic maceration.

FOURTH – Wines made with Viura grape addition have lower colour intensity, colour hue less purple and higher acidity. Addition of this grape variety does not affect significantly wine aroma or flavour.

FIFTH – Sensory evolution of these wines is more marked throughout the first six months in bottle. Red berry aroma and flavour, body, balance, purple hue and colour intensity increase, whereas alcoholic aroma and flavour and astringency decreased. Because of these changes, the organoleptic characteristics of the wines improve through the period considered, mainly due to the increase of fruity character and to the decrease of astringent and alcoholic sensations.
This evolution is not determined by the winemaking process used or by the Viura grape addition.

Regarding the **second research line**, the main conclusions are as follows:

SIXTH – The method developed in this work applied by a panel of expert judges makes possible to evaluate the sensory quality of the young red wines from Rioja Alavesa in a rigorous and reliable way.

SEVENTH – On the basis of this method, sensory quality of these wines is determined by the following eight parameters (ordered from the highest to the lowest contribution to the global quality): balance-body, aroma complexity, flavour complexity, aroma intensity, flavour intensity, global flavour persistence, colour hue and colour intensity.

EIGHTH – To develop methods to evaluate the sensory quality of specific products it is essential to work with a group of people with great knowledge of the product and the sector, especially when typicity of products with quality distinctiveness labels is considered.

NINTH – Decision trees are a very useful tool in order to objectivize the evaluation of the different parameters considered in the method. It also contributes to homogenize the scoring among the panel members.

TENTH – When no suitable reference materials for the attributes considered in the method are available, it is necessary to develop them in order to homogenize the sensory concepts and vocabulary, and also to train new judges. The present work provides the composition and the way of preparing new references for many attributes, which can be very useful for other laboratories.

ELEVENTH – The consideration of attribute citation frequency by the panel is an effective tool to determine the perception degree of an attribute in the product.
This information complements the numerical scores of each parameter, so providing a more detailed description of the product quality.

TWELFTH – In the present work, new procedures and criteria with regard to attribute citation have been developed for expert judge qualification, method validation and control of judge performance. These procedures and criteria contribute to the normalization of sensory analysis methodology and can be very useful for other laboratories and accreditation bodies.

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ANEXOS

Anexo 1.

Abreviaturas

% v/v	Porcentaje sobre volumen
ABRA	Asociación de Bodegas de Rioja Alavesa
ANOVA	Analysis of Variance
BOE	Boletín Oficial del Estado
CAP	Control of Assessor Performance
CVA	Canonical Variate Analysis
DOC	Denominación de Origen Calificada
DOCE	Diario Oficial de las Comunidades Europeas
DOUE	Diario Oficial de la Unión Europea
DOP	Denominación de Origen Protegida
DP	Despalillado
ENAC	Entidad Nacional de Acreditación
GLM	General Linear Model
IOOC	International Olive Oil Council
ISO	International Organization for Standardization
LASEHU	Laboratorio de Análisis Sensorial Euskal Herriko Unibertsitatea
MC	Maceración carbónica
OIV	Organisation Internationale de la Vigne et du Vin
PCA	Principal Component Analysis
PLS	Partial Least Square
PNT	Procedimiento Normalizado Técnico
QDA	Quantitative Descriptive Analysis
QIM	Quality Index Method
RA	Rioja Alavesa
TDS	Temporal Dominance of Sensations
TI	Time Intensity

Anexo 2.

Distribución de las muestras de vino entre las sesiones de las cuatro series

Distribución de los vinos en la 1ª serie*

Nº de la sesión	Vino	Vino	Vino	Vino	Vino	Vino
1	695	796	353	024	467	252
	17	10	8	16	13	20
2	926	483	584	255	141	812
	6	9	5	11	7	15
3	448	962	286	705	543	029
	3	2	18	14	4	19
4**	090	273	724	541	822	639
	1	12	10	15	7	11
5	186	523	639	302	744	860
	13	14	5	18	1	6
6	533	156	074	697	320	451
	3	19	4	16	12	8
7**	528	624	350	802	213	939
	17	20	2	9	20	13
8	322	191	404	027	945	568
	12	9	3	16	10	6
9	653	011	727	190	906	264
	11	14	15	1	18	19
10	564	343	111	227	006	890
	4	5	2	8	7	17

* Se muestra el código de 3 cifras con el que fue presentado cada vino y el código interno del vino (del 1 al 20; el vino 20 fue incluido para que en todas las sesiones hubiera 6 muestras).
** En las sesiones 4 y 7 se evaluaron vinos de dos replicados consecutivos (se muestran con tonos de gris diferentes): en la sesión 4 dos vinos del primer replicado y cuatro vinos del segundo replicado; en la sesión 7 cuatro vinos del segundo replicado y dos vinos de tercer replicado.

Lo anterior es aplicable igualmente a las series 2, 3 y 4.

Distribución de los vinos en la 2ª serie

Nº de la sesión	Vino	Vino	Vino	Vino	Vino	Vino
1	215	969	674	428	051	592
	8	3	20	11	12	19
2	037	626	174	215	311	763
	2	4	10	13	18	16
3	483	751	019	934	202	300
	6	5	7	15	1	14
4	987	704	138	289	572	855
	17	9	14	20	4	2
5	157	944	485	780	321	698
	16	18	3	9	17	12
6	167	696	853	952	324	795
	7	11	6	1	5	13
7	747	682	960	469	321	108
	8	15	10	19	20	12
8	228	526	409	345	760	877
	7	15	11	5	17	9
9	939	110	623	597	426	255
	2	3	10	8	16	6
10	595	878	444	312	293	727
	13	4	1	14	19	18

Distribución de los vinos en la 3ª serie

Nº de la sesión	Vino	Vino	Vino	Vino	Vino	Vino
1	057	428	315	799	541	944
	16	6	7	18	9	12
2	454	768	355	826	297	669
	10	19	15	3	5	8
3	703	621	162	998	326	539
	13	20	11	17	14	2
4	666	934	385	483	117	568
	4	1	3	15	14	13
5	008	934	545	249	712	323
	2	1	16	19	9	11
6	590	137	916	253	369	032
	10	8	7	18	5	17
7	039	723	868	381	210	526
	6	4	20	12	14	20
8	776	113	555	008	229	829
	1	10	9	3	16	19
9	165	712	836	933	049	828
	17	4	12	6	8	13
10	577	906	362	691	248	020
	11	7	2	15	18	5

Distribución de los vinos en la 4ª serie

Nº de la sesión	Vino	Vino	Vino	Vino	Vino	Vino
1	745	492	029	850	566	313
	1	13	10	9	20	16
2	513	664	947	098	381	796
	11	4	6	3	17	18
3	035	767	133	218	486	584
	19	8	2	14	5	7
4	493	919	131	280	984	771
	15	12	6	8	9	18
5	361	210	512	795	946	663
	16	12	5	1	11	4
6	681	452	357	195	938	033
	19	3	17	14	2	15
7	765	927	022	508	184	441
	13	7	20	10	20	18
8	827	932	490	606	153	269
	4	16	2	7	17	15
9	239	797	344	902	018	681
	12	10	14	8	9	3
10	948	096	707	485	874	633
	1	11	13	6	19	5