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Sensory profile characterisation and typicality assessment of DO Bairrada and GI Beira Atlântico red wines

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Todas as correções determinadas pelo júri, e só essas, foram efetuadas.

O Presidente do Júri,

Porto, _____/_____/_____

Abstract

The distinctive Portuguese wines from Beira Atlântico region, encompassing the designation of origin (DO) Bairrada and the Geographical Indication (GI) Beira Atlântico, were investigated by a wine expert panel through descriptive analysis and through assessment of typicality. For that 19 trained tasters performed a blind sensory evaluation of 21 representative wines from those designations. The variables considered were the colour tone and color intensity, aroma intensity, 18 aroma variables and 14 taste variables. Typicality was investigated through a single question, where the assessor was asked to score if the sample is a good or bad example of the type. Of the 21 wines selected, 7 were classified as GI or Regional, 8 as DO and 6 as "Clássico". Although wines belonging to this smaller group weren´t bottled and labeled with Clássico mention, they were considered as such for research purposes, since wine professionals and consumers recognizes them as having the necessary characteristics to be categorized as Clássico wines.

Firstly differences were analyzed between wine types considering all variables followed by clusters analyses confirmation. We couldn´t find any difference between Regional and DO Bairrada wines in terms of typicality and sensory profile. However the small group of "Clássico" wine was clearly identified by the tasters as being more typical, with also significant differences on sensory evaluation. Secondly, centered means analysis (CMA) of the 18 aroma and 14 taste items were performed to identify which of them are considered to be more distinctive. Thirdly an exploratory factor analyses (EFA) by the principal component method (PCM) was applied to data, allowing identification of 5 vectors which aggregate the aroma items and 4 vectors which aggregate taste items. Finally data collected from a sample of 20 questionnaires from Coutinho (2012), based on cognitive knowledge of 20 wine experts interviewed over the same 18 aroma variables and 14 taste variables, was analyzed under the same principal components (PC) and compared. This new methodology proposed by Coutinho (2012) is presented as a valid alternative to conventional methodologies for sensory profile characterization of wine regions.

The 21 wines representatives of GI Beira Atlântico and DO Bairrada can be defined as being medium-high intensity, ruby colored wines, having a woody & spice, ripe fruit aroma profile with also herbal and mineral aromas. On taste they tend to have a pronounced component of acidity & astringency, balanced with a smooth & sweet taste component, with a very persistent finish.

SENSORY PROFILE BAIRRADA BEIRA ATLÂNTICO RED WINE TYPICALITY

Resumo

Os vinhos portugueses da região Beira Atlântico, abrangendo a denominação de origem (DO) Bairrada e a indicação geográfica (IG) Beira Atlântico, foram investigados através de análise descritiva e avaliação de tipicidade. Para tal um painel de 19 especialistas, que incluiu enólogos, académicos e formadores de opinião, levou a cabo uma prova cega sensorial de 21 vinhos representativos da região. As variáveis estudadas foram a tonalidade e intensidade de cor, intensidade aromática bem como 18 descritores para avaliação do aroma e 14 descritores para as sensações de boca. A tipicidade foi investigada com uma única pergunta, tendo sido pedido ao provador que avaliasse cada amostra em função de se tratar de um bom ou mau exemplo de um vinho tinto típico da Bairrada. Entre os vinhos selecionados, 7 foram classificados como IG ou Regional, 8 como DO e 6 como "Clássico". Apesar dos vinhos pertencentes a este último grupo não terem sido engarrafados e rotulados com a menção Clássico, foram considerados como tal para fins de investigação, decisão esta suportada pelo facto de diversas entidades da fileira do vinho os reconhecerem como tendo as características necessárias para serem classificados como vinhos Clássico da Bairrada.

Primeiro, foram analisadas as diferenças entre os 3 tipos de vinho, considerando todas as variáveis em estudo, seguido de análise de clusters para confirmação dos resultados encontrados. Não se verificaram diferenças significativas entre os grupos Regional e DO Bairrada, quer na avaliação de tipicidade quer na análise dos descritores sensoriais. No entanto, o grupo que compõe os vinhos "Clássico" foi claramente identificado pelos provadores como sendo mais típico, apresentando também diferenças significativas em vários descritores de avaliação sensorial. Em segundo lugar foi realizada uma análise de médias centradas para todos os descritores de aroma e de sensações de boca, identificando-se assim quais os mais distintivos. Em terceiro lugar uma análise factorial exploratória pelo método de componentes principais foi aplicada aos dados, tendo-se identificado cinco vetores que agregam os descritores de aroma e quatro vetores que agregam os descritores de sensações de boca. Por último, dados coletados a partir de uma amostra de 20 questionários obtidos por Coutinho (2012), com base na experiência e conhecimento cognitivo de 20 especialistas entrevistados sobre os vinhos da região Beira Atlântico, para as mesmas 18 variáveis de aroma e 14 variáveis de sensações de boca, foram analisados e comparados tendo em conta as mesmas componentes principais. Esta

nova metodologia proposta por Coutinho (2012) apresenta-se como uma alternativa válida às metodologias convencionais para caracterização do perfil sensorial de regiões vitivinícolas.

Os vinhos IG Beira Atlântico e DO Bairrada podem ser definidos como tendo cor rubi, de intensidade média-alta, caracterizados pelas componentes aromáticas amadeirado & especiado e fruta madura, complementado por aromas herbais e minerais. Quanto às sensações de bocas, estes vinhos tendem a apresentar uma componente de acidez & adstringência, balanceada por uma componente doce & suave, com um final muito persistente.

PERFIL SENSORIAL BAIRRADA BEIRA ATLÂNTICO VINHO TINTO TIPICIDADE

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List of abbreviations

CMA - Centered Means Analysis

DA - Descriptive Analysis

DO - Designation of Origin

EFA - Exploratory Factor Analyses

GI - Geographical Indication

PC - Principal Components

PCA – Principal Component Analysis

PCM - Principal Component Method

PDO - Protected Designation of Origin

1. Introduction

1.1 GI Beira Atlântico and DO Bairrada

Beira Atlântico region, as we know it today, only exists since 2011 and it had been emanated from the older and broader region known as Beiras. Beira Atlântico region comprises vineyards from districts of Coimbra, Leiria and Aveiro with a total annual production of almost 300.000 hl, whose wines can be labeled with Geographical Indication (GI) “Beira Atlântico”, although most of them are yet not bottled with this designation (www.ivv.pt).

Inside Beira Atlântico region we can fund the protected denomination of origin (PDO) “Bairrada” with around 75.000 hl of wine per year being bottled under this appellation, which represent 25% of the total wine production in Beira Atlântico vineyards. Created in 1979, comprises approximately 1.250 km2, with no more than 10.000 ha of vineyards, and is located on the coastal strip of the central region of Portugal, between the urban centers of Aveiro and Coimbra (www.infovini.com). The production of wine in the region dates back to Roman times, making proof of that the carved “lagares” in granitic rocks (anthropomorphic “lagares”) where the wine was produced. Already in the reigns of D. Joao I and D. Joao III, were taken measures to protect wines from this area of the country, given its quality and social and economic importance (www.ivv.pt).

The tradition of these wines dating back to the reign of D. Afonso Henriques, who authorized the plantation of vineyards in the region, with the condition of being given a quarter of the wine produced. Wine production in Bairrada Region has existed since the founding of the country as an independent unit and takes on an important role in the economic development and cultural identity of the region (www.ivv.pt). Wine is of vital importance in the economy of the region due to the large number of companies in this sector responsible for boosting the remaining companies of the region by creating new job opportunities and increasing annual business turnover (Brás, Costa, Buhalis, 2010).

Between the mountains of Bussaco and Caramulo (also delimitating the Dão region) and the Atlantic beaches, Bairrada has a mild, maritime climate with abundant rainfall (between 800 to 1100 mm/year). The winters are long and cool, the summers hot, tempered by the winds from the west and north-west dominant in those regions closer to the sea. Although much of the Bairrada region is hilly, the majority of the vineyards are on flatter land. Vineyards are often divided into a multitude of small plots. The soils come from various geological eras, but are predominantly poor. They are primarily divided between calcareous clay terrain and long sandy bands, constituting a wide

variety of soil types, depending on which element is predominant. Vines are cultivated mainly in clay or calcareous clay soils, although exceptions exist.

Sparkling wine production is very important for the economy of the Bairrada area in Portugal. This region is traditionally the main Portuguese wine region for sparkling wine production and has been exporting to other countries. Base wines for sparkling wines need the kind of high acidity that the cool Bairrada climate delivers. Sparkling Bairrada wines may have the fragrance of the Maria Gomes grapes (also known as Fernão Pires), or they may be more steely, based perhaps on Arinto, Bical and Cercial, sometimes with some Chardonnay. There are also “blancs de noirs” based on quickly-pressed Baga, which is the traditional local red grape. It makes tannic wines that can have high acidity if under-ripe, but if ripened and handled well, can give rich, dense fruity reds that age into elegant wines of great complexity. It is admitted that the wooded and smoked character in aged red wines, even without wooden casks contact, is related to the Baga variety and to the clay-limestone soils where lies the best rated red wines, with also good sun exposure and drainage.

Since 2003, a multiplicity of other grapes has been permitted in DO Bairrada wines, such as Portuguese varieties Touriga Nacional and Alfrocheiro as well as the international grapes of Cabernet Sauvignon, Pinot Noir, Syrah and Merlot. Red Bairrada these days comes in panoply array of styles. The mention “Clássico” which is now resurrecting is possible when red wines are vinified with a more restricted range of varieties, containing at least 50% of Baga, from musts with a natural alcoholic strength of at least 12.5% and a minimum of 30 months of aging.

Predominant amongst white grapes is the fragrant Maria Gomes, while Arinto, Bical, Cercial and Rabo de Ovelha can be made into steely, long-lived whites (www.winesofportugal.com)

1.2 An overview of wine typicality concept

The concepts of terroir, geographical indication, and wine typicality, each incorporate the notion that wines from delimited geographical regions can be perceived as different (Parr, 2009). Sensory characterization of food and beverages has amongst its aims detection of unique or distinguishable qualities in a product, a potential source of which is place of origin (Green et al., 2011). Fine wine classification and identification systems have long considered source of origin an inherent criterion, with renowned wines identified by their geographical location, rather than by their grape varietal (Green et al., 2011).

Wine is one product whose concept of typicality is prevalent (Maitre et al., 2010). According to Mueller et al. (2010), product expectations at the initial purchase and intrinsic sensory attributes during product consumption influence the repurchase decision. Thus, when consumers choose a wine bottle based on its identity or terroir, it is because they believe that there is a combination of sensory attributes that differentiates that wine from the others. A wine is typical when some of its characteristics, which reflect both its origin and terroir, can be identified and make it recognizable as belonging to a distinctive type (Charters and Pettigrew, 2007; Maitre et al., 2010). Therefore, typicality includes sensory, technical, and environmental dimensions (Cadot et al., 2010).

Typicality and quality used to be correlated and are based on intrinsic cues such as pleasure and appearance, gustatory, and potential characteristics (Charters and Pettigrew, 2007). It does not mean that a typical wine is always good, but the concept could reduce the risk of an incorrect purchase. Thus, after taking into account a range of price according to the consumption occasion, consumers base their purchase decision on extrinsic factors such as brand, packing design, critic´s rating scores, and typicality (Mueller et al., 2010). If the expectation of the wine is achieved, the possibility of repurchase increases, conferring an added commercial value. For this reason, recognition of typicality has become an economic factor for wine regions and winemakers.

It has been suggested that belonging to a protected designation of origin (PDO) makes a wine special and recognizable. Some definitions of typicality make a link between PDO, typicality and ‘‘terroir” (Casabianca et al., 2005). Evaluating typicality is important for the wine sector, even though it is not yet an established science. The typicality concept is supported by the existence of a common memorized prototype which represents the image of all the previous experiences of wines from the type (Casabianca et al., 2005).

1.3 Protected Designation of Origin recognition and typicality

Some studies have reported that wine experts learn to categorize wines according to the varietal and are able to recognize them blind, while the identification of origin is less successful (Ballester et al., 2008). The investigation of PDO typicality is not straightforward, as it seems that there is more sensory overlapping between close PDO than between wines made with different grape varieties. The existence of a defined and distinguished sensory space in an PDO is not obvious and the results depend on the samples choice, the professional tasters selection and the PDO itself (Maitre et al.,

2010). In order to explore the matter of PDO typicality, Perrin et al. (2008) proposes a global methodology for typicality evaluation in several steps and used a method adapted from Ballester (2004). She has been working on different PDOs from the Pays de la Loire (France). In the case of Anjou white wines (the appellation of Savennières) no consensus was fund between the assessors in categorizing the wines according to the PDO. 12 wines were studied, including 4 Savennières and 8 other white wines from a geographic proximity. The study showed sensory overlap between Savennières appellation and others in a geographic proximity. The second study dealt with Anjou Brissac red wines, including five pairs of wines delivered by five different producers, each pair included one Anjou village Brissac wine and one Anjou village. In this case, the consensus between the 14 professionals from Brissac (red wines) was strong enough to detect differences between wines. It seems that, inside this appellation, local wine experts were able to recognize, in blind, wines from this PDO, in comparison with wines from the same area, outside the PDO. The typicality results seem to depend upon taster's previous knowledge of the PDO.

In another study, sensory analysis was performed on 41 commercially available red Niagara Peninsula Bordeaux-style wines to determine differences that might support the designation of three sub-appellations: "Lakeshore", "Lakeshore Plain" and "Bench". Sensory descriptive profile had significant regional differences for most attributes, while discriminant analysis using region as the classification criteria showed that the separation into the three classes was nonsignificant although there was some differentiation between "Lakeshore" and "Lakeshore Plain" wines (Kontkanen et al., 2005).

Johnson et al. (2013) attempt to define the sensory attributes of a number of delimited Australian Shiraz producing regions and suggested that there were some sensory similarities between wines from the same region but some factors impact the sensory profile. Although wines from the same region may have shared similar sensory attributes, the more diverse the region in terms of geography and meso-climate, the more difficult it was to determine those common sensory attributes.

Coutinho (2012) investigated the red wine sensory profile of the 12 protected geographical indications of mainland Portugal and evidence of clusters grouping several wine regions under the same sensory profile suggests that these 12 regions could be grouped into three to five major macro zonings that originate a much broader territorial reading. The author also highlighted the benefits associated to this aggregation in a small country such as Portugal, encompassing a low yield viticulture and a dominance of old vines in small parcels owned by even smaller producers. Scale

factors might result in significant gains in areas such as wine certification, marketing and communication.

1.4 Multiple country wine profile comparison

There have been numerous studies characterizing regional sensory differences in wines and a smaller number of studies have compared the sensory profiles of wines from multiple countries. Parr et al. (2010) used a range of tests to determine if wines from the same grape variety but specific geographic location (New Zealand vs. France) could be distinguished. Panelists were asked to rate 12 wines on typicality, to score the intensity of 10 flavour descriptors, to give their hedonic evaluation on a scale, and finally asked to sort the wines according to their origin. Panelists performed successfully the sorting task, separating wines by geographic origin (between countries and regions inside France) although differences between regions inside New Zealand have not been addressed; the author suggested that assessors had no prior knowledge on New Zealand wines and so no internal reference.

Green et al. (2011) have been investigated the influence of geographical location on volatile composition and perceived flavor profile of Sauvignon wines of New Zealand (Marlborough), French (Sancerre; Loire; Saint Bris), and Austrian (Styria) origin. Results demonstrated that wines from the three sources of origin were separated by sensory analyses, with New Zealand wines dominated by perceived green characteristics, Austrian wines perceived to be fruity (stone-fruit), and French wines relatively subdued in all characteristics measured other than perceived minerality. Statistical association of sensory and chemical data demonstrated that the chemical compounds clustered into three groups, each cluster associated with one source-of-origin. The study has demonstrated differences in perceived sensory characteristics and chemical composition of Sauvignon wines as a function of source of origin, and demonstrated associations between some specific aroma compounds and sensory terms employed by wine professionals.

King et al. (2014) compared Malbec wines from various regions in Mendoza, Argentina and California, USA. The Malbec wines were clearly separated, based on their chemical and sensory profiles, by wine region and country. Malbec wines from Mendoza generally had more ripe fruit, sweetness, and higher alcohol levels, while the Californian Malbec wines had more artificial fruit and citrus aromas, and bitter taste. However, there were similarities among the sensory profiles of the Malbec wines regardless of the region of origin, indicating some inherent qualities in the grape variety.

1.5 Chemical characterization as a complement to sensory wine profile

When wine experts agree on typicality of a category of wines, analytical measurements are useful to characterize the space. More than a thousand flavour compounds have so far been identified in wine and identifying the specific chemical compounds that impart wine desirable sensory characteristics requires a sound knowledge of the chemical composition and sensory properties of wine, or of the compounds concerned in wine (Francis and Newton, 2005). At present, volatile compounds can be analyzed under conditions very closely to those which humans perceive aroma. Gas chromatography and mass spectrometry provide an effective tool for the odourant characterization of wines. Without sensory evaluation, however, the mere knowledge of the precise volatile composition of the wine aroma is inadequate to predict the flavour of the whole system as perceived by a trained sensory judge (Noble and Ebeler, 2002). In fact, aroma compounds can interact synergistically with one another and have masking or suppressing effects at above-threshold concentrations, or additive interactions at sub-threshold concentrations (Francis and Newton, 2005).

Le Fur, Jaffre, and Valentin (2009) characterized the specific Chardonnay olfactory space as recognized by the panel as typical, by analyzing the volatile composition of a large set of wines. González-Álvarez et al. (2011) also established correlations between sets of sensory and chemical data with the aid of multivariate statistical procedures to improve current understanding of the aroma of Godello variety white wines. García-Carpintero et al. (2011) through their instrumental and sensory analysis study with Moravia Agria variety provided a better knowledge of the free and glycosidically bound aroma composition and sensory profile of monovarietal wines elaborated with this grape variety cultivated in La Mancha region.

These works also showed that the typicality measurement is possible with wine experts.

1.6 Research methods for wine sensory evaluation and typicality assessment

A number of papers deal with the question of how typicality can be measured and different methods have been suggested to evaluate wine typicality. Conventional sensory profiling has been used within the framework of the typicality concept (Cadot et al., 2010; Perrin et al., 2008; Maitre et al., 2010). It has been adapted from Descriptive Analysis and it is a well-established methodology for the description of the sensory

dimension although limitations of intensity scoring when describing the odor characteristics of a complex product have been documented in the literature. The Just About Right methodology (JAR) is a direct approach to measure the deviation from ideal levels per attribute. With JAR, assessors directly assess deviations from ideal, usually in terms of labeled scales with the end points “much too weak” to “much too strong”, and the midpoint of the scale labeled as “just about right”. This is a direct measure of the perceived attribute intensities, but it does not directly quantify those (Cadot et al., 2010). JAR is usually expressed as the percentage of respondents who consider the attribute level as too high, too low, and just about right. Also, with JAR, overall liking is collected and deviations from the ideal can be related through penalty analysis.

Ballester (2004) combined different approaches tested previously. He took a global approach to the question of typicality, in order to avoid an analytical and descriptive evaluation, according to the hypothesis that typicality is not only linked to objective and measurable dimensions. He asked his subjects to evaluate the degree of typicality of a wine in its category (wine from a grape type), and among other varieties. Assessors were asked to answer the following question: ‘‘do you think that this wine is a good example or a bad example of what a Chardonnay wine is?” The scale was unstructured and anchored with a ‘‘very bad example” on the left end and a ‘‘very good example” on the right end. This methodology has been used to study Sciaccarello wine (Candelon et al., 2004) and Melon de Bourgogne (Ballester et al., 2008) and have shown successfully typicality of grape varieties, even if some categories overlap.

Several authors have also been applied sorting methodologies. Ballester et al. (2008) used a free sorting task whose assessors were asked to sort samples according to their odour similarity into as many groups as necessary and to give their typicality score and their hedonic one. Free comments method is another powerful tool in evaluating sensory profile and wine typicality. Lawrence et al. (2013) compared this method with classical profiling in a professional context. The two methods underlined similar main odour characteristics of the Cabernet Franc wines but the free comments method was advantageous for highlighting the specific characteristics of a number of products. This method is less time consuming and allows easy characterization of wines and they conclude that free comments method may represent a convenient alternative to conventional descriptive analysis in a wine professional context or a convenient sensory mapping tool for conducting the preliminary phases of sensory studies, such as the generation of attributes. A number of studies have used a very similar procedure referred as the citation frequency-based technique. Campo et al. (2010) made a comparison of conventional descriptive analysis and a citation frequency-

based descriptive method for odor profiling of Burgundy Pinot noir wines. The authors suggested that considering both richness of product characterization and practical aspects, the frequency of citation method might represent a convenient alternative to conventional descriptive analysis when the odor assessment of a complex aroma product is required. Perrin et al. (2008) performed Napping® methodologies in several experiments. Napping can be considered as a variation of a sorting task where assessors are asked to place samples on a large sheet of paper, according to their similarities and differences between the samples. Perrin concluded that this technique gives a global sensory image and most important dimensions. Napping may be better correlated with the typical evaluation because the tasters arrange an "intuitive grouping" where 2 wines are positioned near to each other if they are perceived as identical. However, this method is limited to a smaller number of samples and does not characterize the product itself (Maitre et al., 2010).

Globally, Perrin et al. (2008) demonstrated that the more freedom of the methods; the more the agreement is difficult to reach. On the other hand, the more free, the more the assessors have the opportunity to include additional technical information, as off-notes for instance.

1.7 Type of panel: Consumers vs trained professionals and perceptual vs cognitive knowledge

Although categorizing our perceptions is one of the most basic ways to organize our knowledge, the classification of food sensory perceptions into categories reflecting food sensory concepts is an almost unexplored field. It is commonly accepted that natural categories have an internal organization and that all the items belonging to a category are not equally representative of it. The category is then organized along a typicality gradient from the most to the less representative items where typical items share a lot of features with most of the items in the category and very few with items in other categories.

Ballester et al. (2008) explored the differences in wine categorization between wine experts and novice wine consumers. The odor of two varietal wines, Chardonnay and Melon de Bourgogne, were studied as sensory concepts. They tried to better understand from a cognitive as well as from a perceptual point of view, how the expertise level plays a role in the degree of overlap between the perceived odors of these two types of wine. The analysis of typicality judgments showed large differences between experts' and novices' mental representations of the two types of wine. Experts, unlike novices, showed well defined and common mental representation of the

odor of these two varietal wines and no common mental representations emerged from the novices' typicality judgments. Results also suggest that wine expertise may be more of a cognitive expertise rather than a perceptual one. In another study involving wines from Loire Valley, Cadot et al. (2012) reveals the gap between conceptual typicality and perceptual typicality on the basis of terroir dimensions and sensory attributes. The comparison between the sensory representation of the wine as a concept with descriptive methods highlighted a gap between the conceptual and the perceptual representation of typicality. On the one hand, the conceptual representation was consensual with the soil as the first factor that affects typicality. On the other hand, the perceptual representation was not consensual and highlighted the prevalence of the technical factors, in particular oenological, over the environmental factors. Some conceptual attributes generated by surveys differed from significant attributes determined by perceptual sensory evaluations. Torri et al. (2013) with Projective Mapping for interpreting wine aroma differences as perceived by naïve and experienced assessors showed that criteria driving differentiation of high quality red wine on the basis of their aroma similarities/dissimilarities were different in wine experts and naive consumers. The results suggest that product separation by experts was mainly based on the perceived overall quality rather than on specific sensory differences and product differentiation by consumers was poor and worse than that of experts and trained subjects. Experts seem to mainly refer to a common memorized wine prototype which represents the synthesis of high quality red wines previous tasting experiences and liking can be considered as the main criterion for aroma evaluation by experienced consumers.

1.8 Determinant factors affecting sensory profile and typicality characterizations

All of these studies compared commercial wines that were made using different production methods, making it difficult to determine sensory characteristics unique to the region of origin. Ideally, assessing differences between appellations and sub-appellations should be done by producing wines with minimal oenological intervention, a single winemaker and a single vintage, but lot of factors may have influence in wine sensory profile and typicality.

Cadot et al. (2012) investigated the relationship between the sensory profile of the wines and the ripening stage of the berries (harvest date) and the extraction time (maceration duration). Results obtained suggest that the wine sensory quality

established by the expert panel, is linked as expected to grape quality at harvest, reflected by sugar, tannins and anthocyanin contents, demonstrating de importance of harvest date on the typicality of the wines. This study confirm the importance of phenolic compounds for typicality of wines and shows that multi-parametric models involving phenolic compounds could be a useful tool for managing wine process in order to produce wines with distinctive style. Complementarily, deep research has been done about fractionation of grape and wine proanthocyanidins according to their mean degree of polymerization (Sun et al., 1998), its evolution during berry development (Jordão, Ricardo-da-Silva, Laureano, 2001) and its correlation with bitterness and astringency sensations (Vieira-de-Moura, Ricardo-da-Silva, Laureano, 2007). Parr et al. (2013) have been investigated associations between selected grape-growing and -winemaking factors with sensory and chemical characterization of Sauvignon Blanc wines from New Zealand, and demonstrated that vineyard location, row orientation, type of grape processing at harvest, and oenological manipulations provide means for influencing sensory profile and chemical composition of Sauvignon wines. Parpinello et al. (2015) verified that the quality of Sangiovese red wines was affected to a large extent by the on filed application of biodynamic “preparations” influencing the sensory evaluation when comparing to organic viticultural management practices.

Liu et al. (2015) in their study of instrumental and sensory characterisation of Solaris Danish white wines have demonstrated the huge impact of sulphite management in wine sensory profile. The effect of climate on grape composition and wine characteristics and typicity has also been characterized in many specific viticultural regions and climates worldwide. However, few studies have characterized this effect at global scale considering different climates. Tonietto et al. (2014) characterized the effect of viticultural climate on the typicity of red and white wines in the macro Ibero-American viticultural region, as perceived by expert enologists. This study shows that wine typicity is determined in part by the regional viticultural climate and that the MCC System viticulture indices are significantly related to wine sensory characteristics.

2. Materials and Methods

2.1 Wine samples

The wines studied were commercially available red wines produced in DO Bairrada and GI Beira Atlântico (Table 1). The main differences between these two appellations are that the area of Beira Atlântico is noticeably larger than DO Bairrada, allows higher yields production and a broader range of varieties.

21 wines were selected to represent the diversity of three type of wines produced in these regions, from vintages 2009, 2010 and 2011, with retail prices ranging from 1,29€ to 29,95€ per bottle of 750 ml. Of the 21 wines, 7 were classified as Geographical Indication (GI) or Regional, 8 as Designation of Origin (DO) and 6 as "Clássico". Although wines belonging to this smaller group weren´t bottled and labeled as Clássico, they were considered as such for research purposes, since wine professional and consumers recognizes them as having the necessary characteristics to be categorized as Clássico wines. The six wines selected (in collaboration of Bairrada certification authority) to integrate "Clássico" group shared some common characteristics among them such as: old vineyards, minimum 30 months of aging which 12 of them in bottle, minimum 12.5% of alcohol, Baga variety in a minimum of 85% in lot composition and a maximum yield of 55 hl per ha.

Table 1: Sampling of wines by type, vintage and price

Wine Brand	WineType	Vintage	Price (€)
Ventos da Beira	Regional	2011	1,29
Luis Pato Baga-Touriga	Regional	2011	4,79
Uvas Douradas	DOBairrada	2011	1,79
Encontro	DOBairrada	2011	3,49
Outrora Clássico	"Clássico"	2009	29,95
Aliança	DOBairrada	2011	3,00
Quinta da Dona	"Clássico"	2009	18,50
Marquês Marialva	DOBairrada	2009	2,99
Messias Selection	DOBairrada	2010	2,99
Qtª Foz de Arouce	Regional	2010	14,50
Messias Clássico	"Clássico"	2010	22,75
Frei João	DOBairrada	2009	2,69

FP	Regional	2011	6,90
Sidónio Sousa Garrafeira	"Clássico"	2009	20,00
Cantanhede	Regional	2010	1,99
Frei Telo	DOBairrada	2010	1,89
Luis Pato V. Barrosa	"Clássico"	2010	24,90
Ortigão	Regional	2010	4,99
Qtª Bágeiras Garrafeira	"Clássico"	2009	18,90
Casa de Saima	Regional	2011	3,30
São Domingos	DOBairrada	2010	3,79

2.2 Sensory analysis

The test session consisted of three flights and each flight contained seven wine samples coded with random alphanumeric code, with the order of samples randomized in each flight.

Wine samples were stored and presented at 20 ºC for detection of color, aroma and taste. The bottles were opened immediately before the analysis, and panelists were prevented from seeing their label or shape. They were informed that they were evaluating wines from DO Bairrada and GI Beira Atlântico. However for each wine sample no specific information was provided concerning the grape varieties, type or price.

The environment for tasting was controlled as advised for sensory laboratories and international wine competitions. There was a uniform source of lighting, absence of noise and distracting stimuli, and ambient temperature was around 22ºC. Participants were then seated in separate booths.

The sensory expert panel was composed of 19 judges related to wine industry (winemakers, wine brokers, sommeliers and academic oenology professors), and was selected on the basis of their extensive experience in wine tasting, sensory performances, interest and training to perform wine descriptive analysis (DA).

DA was carried out and the assessors scored the intensity of each attribute using a 10 point structured scale. Scale were anchored with the terms "low intensity" on the left and "high intensity" on the right. The questionnaire (in annex 1) was the same used by Coutinho (2012) and was designed according to the approved International Organization of Vine and Wine method for sensory assessment of wines, thus it is

divided in 3 blocks: visual sensations (Colour), the aromatic sensations (Aroma) and the gustatory and tactile sensations (Taste).

The color was assessed in its intensity and in its tonality, with color patterns of red wines according to the latest studies.

Aroma was evaluated for red wines with 1 overall measure for intensity and 18 aromatic descriptors tended to summarize significant amount of scientific research, many of which already used in the form of aroma wheels (Fischer et al., 1999).

The taste of red wines, measured via tactile and gustatory sensations by the panel of experts was evaluated under 14 descriptors, including the classical essential tastes (sour, sweet, salty, bitter), and adding the result of recent work focused on the tactile sensations resulting from various types of bitterness and astringency and the sensations caused by caustic and drying alcohol sensations (Gawel, Oberholster, Francis, 2000; Gawel, Iland, Francis, 2001).

The same 19 judges assessed also the wine typicality. For each wine the assessors were instructed to answer the question “Do You think this wine is a good or bad example of what a Bairrada wine is?” These instructions were derived from Ballester (2004). The assessors were asked to rate the wines sample´s typicality on a structured scale, 0-10 intensity, anchored at left by “bad example” and at right “good example”.

2.3 Data analysis

Data acquisition was assisted by SPSS software (IBM Statistics SPSS Version 20). Over 14.000 database entries were retrieved, placed in an Excel worksheet and subsequently analyzed using SPSS, which is among the most widely used programs for statistical analysis in social science, and its main added value lies in the diversity of methods of data analysis it provides.

Counts and mean analysis were performed in order to compare various sensory descriptors for the three types of wines. An ANOVA was performed to test differences between wine types and evaluate statistically differences between them, followed by clusters analysis to better understand the interrelationships between the 21 wines. The cluster analysis is a group of multivariate techniques whose primary purpose is to assemble objects (in this case wines based on sensory characteristics that they possess). Cluster analysis classifies objects so that each object is similar to others in the cluster with respect to a predetermined selection criterion. The resulting clusters of objects should then exhibit high internal (within-cluster) homogeneity and high external (between-cluster) heterogeneity. Hierarchical Cluster Analysis was applied in this

research and this methodology was useful to confirm if the types were consistent in terms of colour, nose, taste and typicality.

For typicality assessment, the average typicality scores were achieved and ANOVA was performed. Spearman correlation analysis was also performed to find out which descriptors were closely related to typicality.

Centered means analysis (CMA) of the 18 aroma and 14 taste items was performed to identify which items are considered to be more distinctive of the 21 wines representatives of DO Bairrada and GI Beira Atlântico, followed by the completion of principal components analysis with varimax rotation, sought to explore the possibility of reducing the extends initial space of sensory descriptors on a fewer dimensions - the main components. The number of retained components was based on Kaiser test (according to which the components with an eigenvalue grater or equal to 1 are retained). After reducing the initial space variables a sensory profile was identified.

Data from a sample of 20 questionnaires from Coutinho (2012), based on cognitive knowledge of Beira Atlântico wines, from 20 wine experts interviewed over the same 18 aroma variables and 14 taste variables, was collected and analyzed under the same principal components (PC) and compared.

3. Results and discussion

3.1 Comparing wine types

The first analysis comprises the variables colour, nose intensity and typicality. The colour is evaluated for the tone violet–purple; purple–ruby; ruby–garnet or garnet–brick red and for the intensity in a 0-10 scale. Nose intensity and typicality are also evaluated in a 0-10 scale.

Table 2: Wine type colour, intensity and typicality

Wine type	Variable		Count	Mean
Regional	COL_Tone	Violet–Purple	2	
		Purple–Ruby	55	
		Ruby–Garnet	69	
		Garnet–Brick red	6	
	COL_intens			6,31
	NOSE_intens			5,93
	Typicality			5,78
DO Bairrada	COL_Tone	Violet–Purple	1	
		Purple–Ruby	41	
		Ruby–Garnet	91	
		Garnet–Brickred	19	
	COL_intens			6,41
	NOSE_intens			6,07
	Typicality			5,89
"Clássico"	COL_Tone	Violet–Purple	6	
		Purple–Ruby	36	
		Ruby–Garnet	40	
		Garnet–Brickred	31	
	COL_intens			7,86**
	NOSE_intens			6,89**
	Typicality			7,10**

** statistical significance p-value<0,01

Table 2 shows frequencies and means for those variables indicating that the "Clássico" type was considered to be more colour and nose intense and more typical. An ANOVA[12] was performed to test differences between wine types and it showed that

[1]In implementing the test we have to specify a value for α (significance level) and usually is used α = 0.05, which is a measure of random error bound. The value of α is the maximum probability error one when we reject the null hypothesis.

[2]Normal distribution is considered since the sample is large and the range of the variables is acceptable for the use of Central Limit Theorem. For more detail on ANOVA see, eg, Pestana, Maria Helena; Gageiro, João Nunes (2003); Data Analysis for Social Science - The Complementarity of SPSS; 3rd Edition, Ed Silabo, pp. 254-364; or Maroco, João (2003) Statistical Analysis with use of SPSS, 2nd Edition, Lisbon, Ed Silabo, pp. 109-158; or Pinto, J.Carlos Castro;

the “Clássico” type is statistically different from the others. The tone most referred (mode) was “ruby–garnet” followed by “purple–ruby” consistent in all types.

Table 3: Wine type aroma items

	Wine type		
	Regional	DO Bairrada	“Clássico”
	Mean	Mean	Mean
NOSE_floral	2,11	2,02	2,12
NOSE_dried flowers	2,09	2,22	2,32
NOSE_herbal	3,24	2,95	3,07
NOSE_vegetal	1,90	2,71*	1,96
NOSE_mineral	2,50	2,57	3,11*(r)
NOSE_citrus fruit	1,04	0,82	0,91
NOSE_red fruit	2,90	2,68	2,41
NOSE_black fruit	2,86	2,70	3,33*
NOSE_stone fruit	2,74	2,88	2,89
NOSE_raisin	2,34	2,07	3,10**
NOSE_dried fruit	1,50	1,68	2,14
NOSE_jam	2,44	2,24	3,50**
NOSE_pastry	1,50	1,66	2,46**
NOSE_spice	2,85	3,29	4,03**
NOSE_caramel	1,86	1,69	2,61**
NOSE_woody	3,30	3,66	4,73**
NOSE_chemical	2,05	1,93	2,13
NOSE_animal	1,88	1,81	2,22

* statistical significance p-value<0,05

** statistical significance p-value<0,01

Table 3 shows the results of aroma items for the 3 types of wine. It can be seen, after the ANOVA test, that “Clássico” type is statistically different from the other two on black fruit, raisin, jam, pastry, spice, caramel and woody presence, and different from the regional on mineral presence, having a higher level in all of those items. DO type presented a significant difference on the vegetal item.

The results of the ANOVA test for taste are presented on table 4. It can be seen that the “Clássico” type is statistically different from the other two on grain texture, astringent, full body, alcohol, oily and length items and from the regional type on tactile dryness and rough texture items, having a higher presence level in all of them.

Curto, J.J.Dias (1999), Statistics for Business and Economics - Instruments to Support Decision Making, 1st Edition, Lisbon, Ed Silabo, pp. 365-380.

Table 4: Wine type taste items

	Wine type		
	Regional	DO Bairrada	"Clássico"
	Mean	Mean	Mean
TASTE_bubbly	0,30	0,39	0,39
TASTE_sweet	2,49	2,09	2,45
TASTE_acid	4,32	4,54	4,51
TASTE_salt	1,26	1,28	1,32
TASTE_bitter	2,17	2,35	2,33
TASTE_dryness (tactile)	3,92	4,19	4,68*(r)
TASTE_smooth texture	4,40	4,15	4,46
TASTE_rough texture	3,08	3,26	3,75*(r)
TASTE_grain texture	2,13	2,24	2,84*
TASTE_astringent	4,66	5,08	5,74**
TASTE_full_body	5,12	5,31	6,43**
TASTE_alcohol	4,52	4,61	5,23*
TASTE_oily	4,78	4,91	5,84**
TASTE_length	5,31	5,61	6,64**

* statistical significance p-value<0,05

** statistical significance p-value<0,01

A Clusters Analysis[3] was performed in order to better understand the interrelationships between the wines that comprise the 3 types of wines. This methodology is useful to confirm if the types are consistent in terms of colour, nose, taste and typicality. It would be expected that each single wine group with the others of its type first.

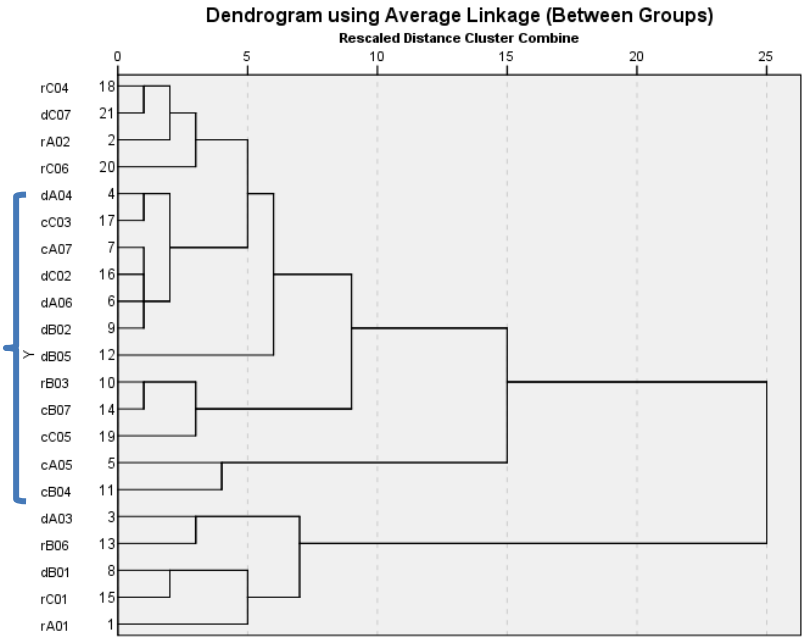

Figure 1: Cluster analysis for Colour Intensity considering all wines and types

[3] Cluster analysis is a technique to classify a large quantity of information. It is a data reduction tool that creates subgroups based on proximities (or distances) of data and inter-relationships of variables. Agglomerative hierarchical clustering begins with every case being a cluster unto itself. At successive steps, similar clusters are merged.

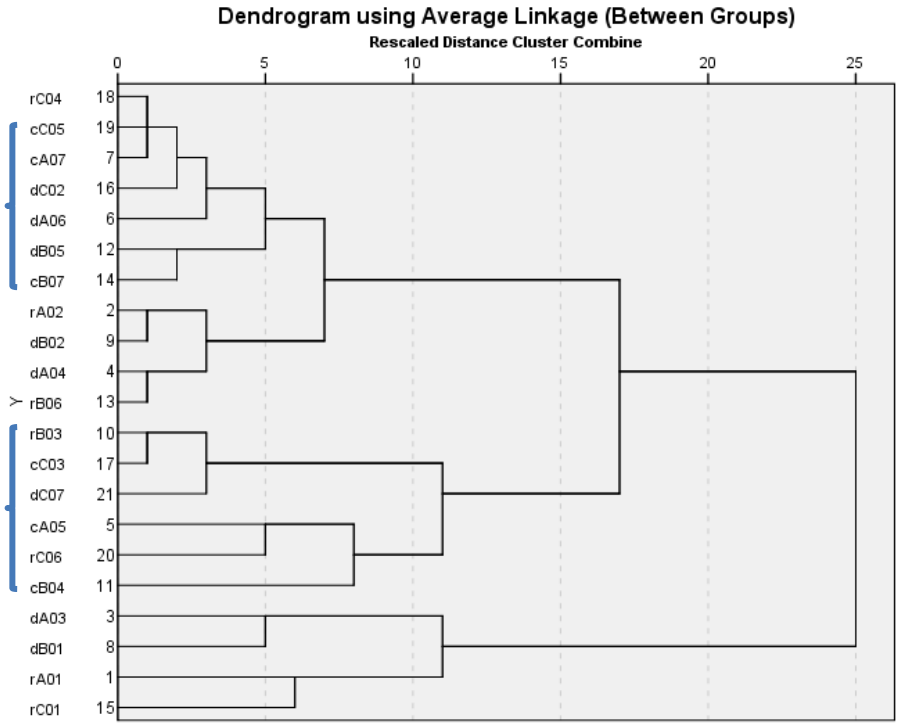

Figure 2: Cluster analysis for Nose Intensity considering all wines and types.

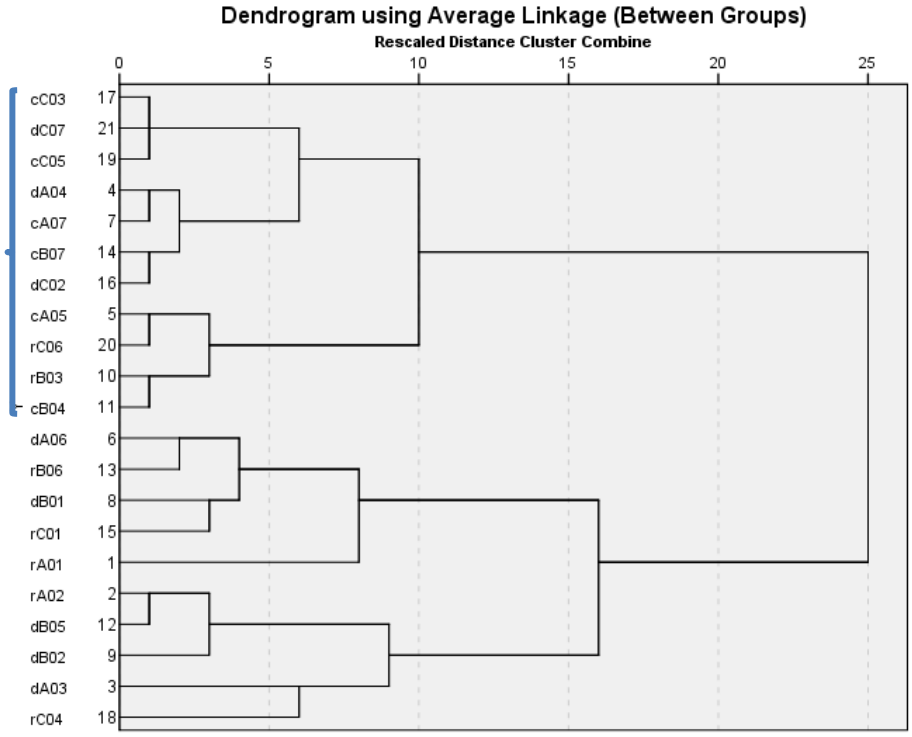

Figure 3: Cluster analysis for Typicality considering all wines and types.

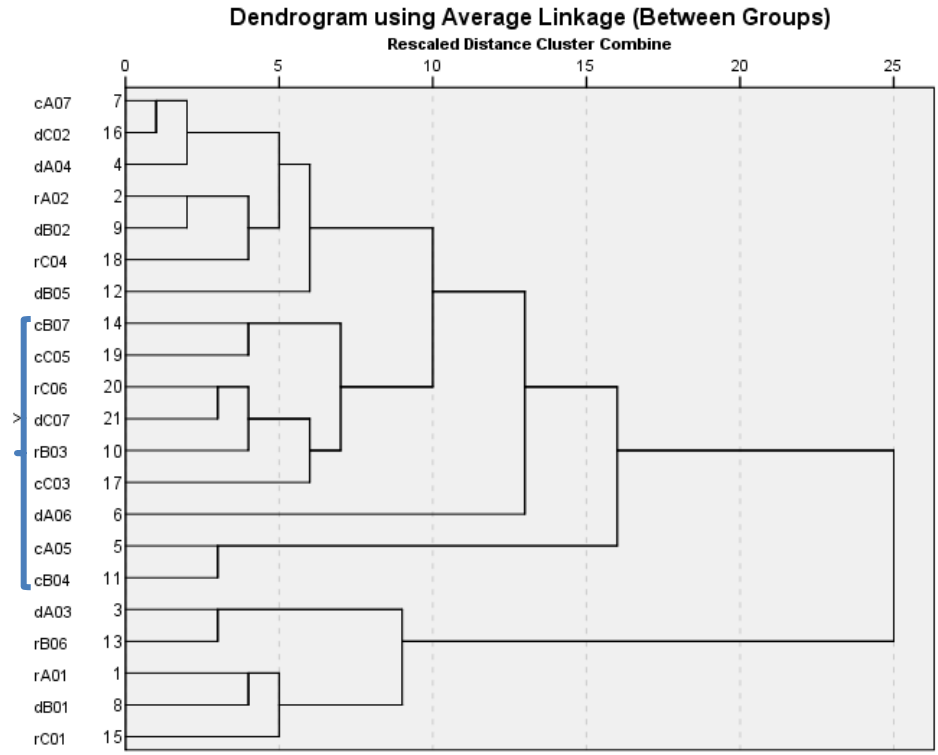

Figure 4: Cluster analysis for Colour and Nose Intensity and Typicality considering all wines and types.

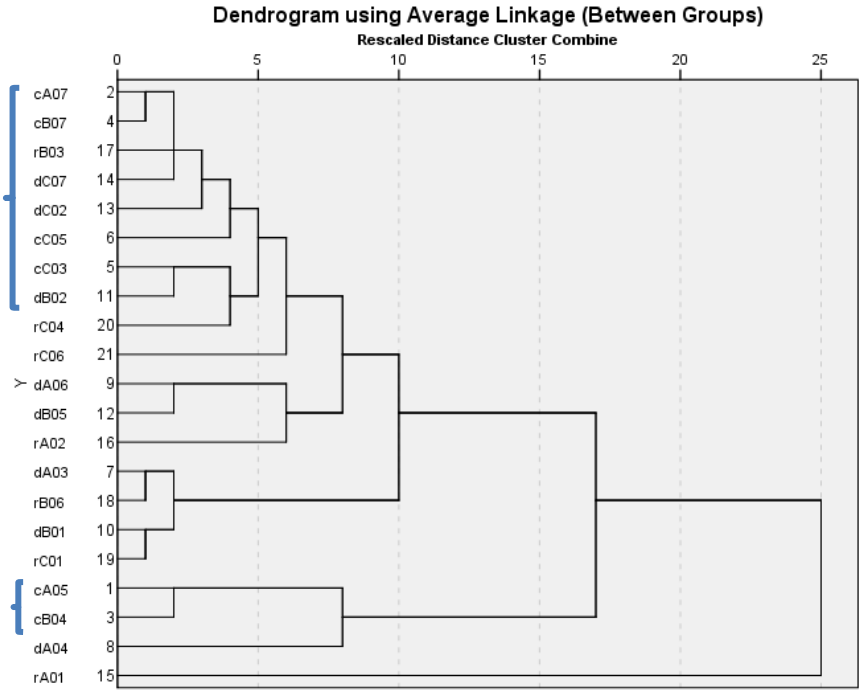

Figure 5: Cluster analysis for All Items considering all wines and types

Figures 1 to 5 show the similarities between wines (and types). Lowercase letters “r”, “d” and “c” before each alphanumeric wine code, refers to wine type and means Regional, DO and “Clássico”, respectively.

It can be seen after applying a cluster analysis that with respect to wine types, the dendograms show clearly a tendency to aggregate wines from “Clássico” group,

although with some wines from regional and DO groups being mixed. This suggests that all wines from "Clássico" group have contributed to discriminating from others by the panelists, especially in what respects to typicality.

3.2 Typicality assessment

Typicality is the set of sensory characteristics that identify a distinctive type of wine. Spearman Correlation analysis was performed to find out which sensory characteristics (for aroma, taste and color), are closely related to typicality judgment. This information helps to better understand why tasters considered the wine type "Clássico" more typical than the others, as typicality scores were higher for "Clássico" group and clusters analysis confirms that the 6 wines belonging to this group were close to each other in what concerns to typicality judgment.

Table 5: Spearman Correlation[4] with respect to Typicality (Aroma)

NOSE_ intens	NOSE_ vegetal	NOSE_ mineral	NOSE_ citrus fruit	NOSE_ black fruit	NOSE_ stone fruit	NOSE_ raisin	NOSE_ dried fruit	NOSE_ jam	NOSE_ pastry	NOSE_ spice	NOSE_ caramel	NOSE_ woody
,430**	-,138**	,130**	,101*	,232**	,273**	,160**	,161**	,329**	,133**	,313**	,150**	,237**

* statistical significance p-value<0,05

** statistical significance p-value<0,01

Table 6: Spearman Correlation with respect to Typicality (Taste)

TASTE_ bubbly	TASTE_ salt	TASTE_ bitter	TASTE_ astringent	TASTE_ full_body	TASTE_ alcohol	TASTE_ oily	TASTE_ length
,100*	,113*	-,126*	,211**	,642**	,305**	,509**	,705**

* statistical significance p-value<0,05

** statistical significance p-value<0,01

Table 7: Spearman Correlation with respect to Typicality (Colour)

COL_ intens
,468**

* statistical significance p-value<0,05

** statistical significance p-value<0,01

[4] Spearman's correlation (Spearman's rank-order correlation) coefficient measures the strength of association between two ranked variables. The Spearman correlation can be used with the assumptions of presence of a monotonic relationship between your variables and variables are either ordinal, interval or ratio. For more detail see, eg, Pestana, Maria Helena; Gageiro, João Nunes (2003); Data Analysis for Social Science - The Complementarity of SPSS; 3rd Edition, Ed Silabo.

Table 5, 6 and 7 show the significant correlations between typicality and color, aroma and taste items. The items not shown have no statistical significance.
The relationship between typicality and items from descriptive analysis showed that full body, oily and length are taste descriptors highly correlated with evaluation of wine typicality by the expert panel.
We also can assume that nose and color intensity are important items correlated with typicality judgment by the expert panel and that a more driven ripe fruit (black fruit, stone fruit, jam), woody and spice were also the aroma descriptors more correlated with typicality.
We could find that, these descriptors identified as being tightly connected with typicality judgment, strongly match with the items identified on tables 2, 3 and 4 that had showed "Clássico" type being statistical different from Regional and DO types.

3.3 Evaluating aroma and taste distinctive descriptors of GI Beira Atlântico and DO Bairrada wines

On table 8 the results of the 18 aroma items are presented for the 21 wines and figure 6 represents the centered means[5] in descending order. It can be seen that woody, spice, herbal, black fruit, stone fruit, mineral, red fruit and jam are the aromas considered more distinctive of these wines.

[5] Centered Mean Analysis - It is recommended to center the variables so that the predictors have mean 0 (zero) and it is easy to interpret results of different variables and their impact. Also it becomes useful for composite scores like components.

Table 8: Beira Atlântico and Bairrada wine aroma items

	Mean	Standard Deviation
NOSE_floral	2,08	1,92
NOSE_dried flowers	2,21	1,85
NOSE_herbal	3,08	1,98
NOSE_vegetal	2,23	2,21
NOSE_mineral	2,70	1,86
NOSE_citrus fruit	0,92	1,43
NOSE_red fruit	2,68	2,17
NOSE_black fruit	2,94	2,05
NOSE_stone fruit	2,83	2,10
NOSE_raisin	2,45	1,97
NOSE_dried fruit	1,75	1,71
NOSE_jam	2,67	2,02
NOSE_pastry	1,84	1,92
NOSE_spice	3,35	1,93
NOSE_caramel	2,01	1,89
NOSE_woody	3,85	2,13
NOSE_chemical	2,03	1,98
NOSE_animal	1,95	1,90

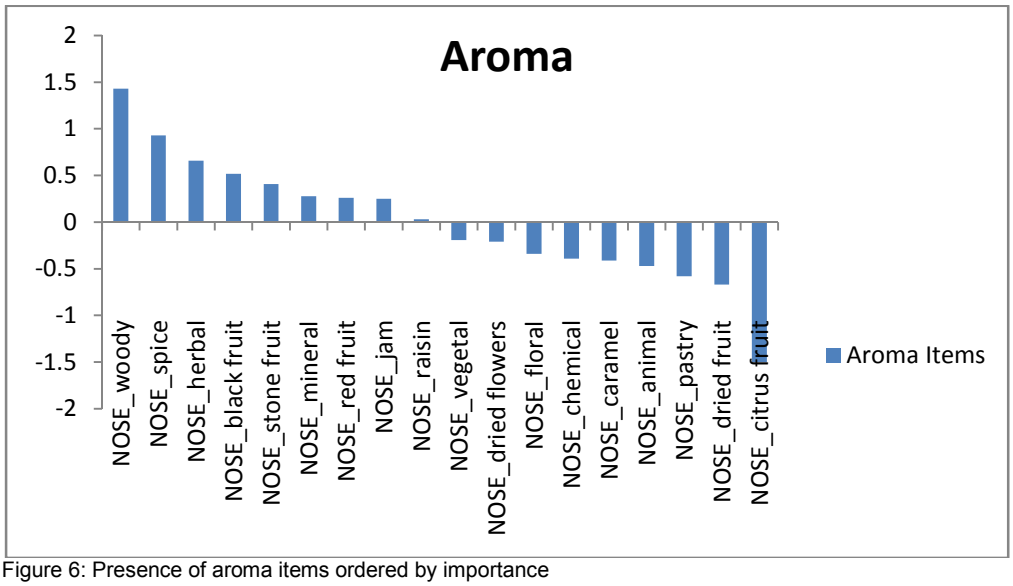

Figure 6: Presence of aroma items ordered by importance

Table 9 shows the results of the 14 taste items for the 21 wines and figure 7 represents the centered means in descending order. It can be seen that length, full body,

astringent, oily, alcohol, acid, smooth texture and tactile dryness are the taste items considered more distinctive of these wines.

Table 9: Beira Atlântico and Bairrada wine taste items

	Mean	Standard Deviation
TASTE_bubbly	0,36	0,80
TASTE_sweet	2,32	1,71
TASTE_acid	4,46	1,70
TASTE_salt	1,29	1,35
TASTE_bitter	2,29	1,89
TASTE_dryness (tactile)	4,24	1,89
TASTE_smooth texture	4,32	2,10
TASTE_rough texture	3,34	1,84
TASTE_grain texture	2,37	2,02
TASTE_astringent	5,13	1,72
TASTE_full_body	5,57	1,86
TASTE_alcohol	4,76	1,98
TASTE_oily	5,13	1,92
TASTE_length	5,80	1,78

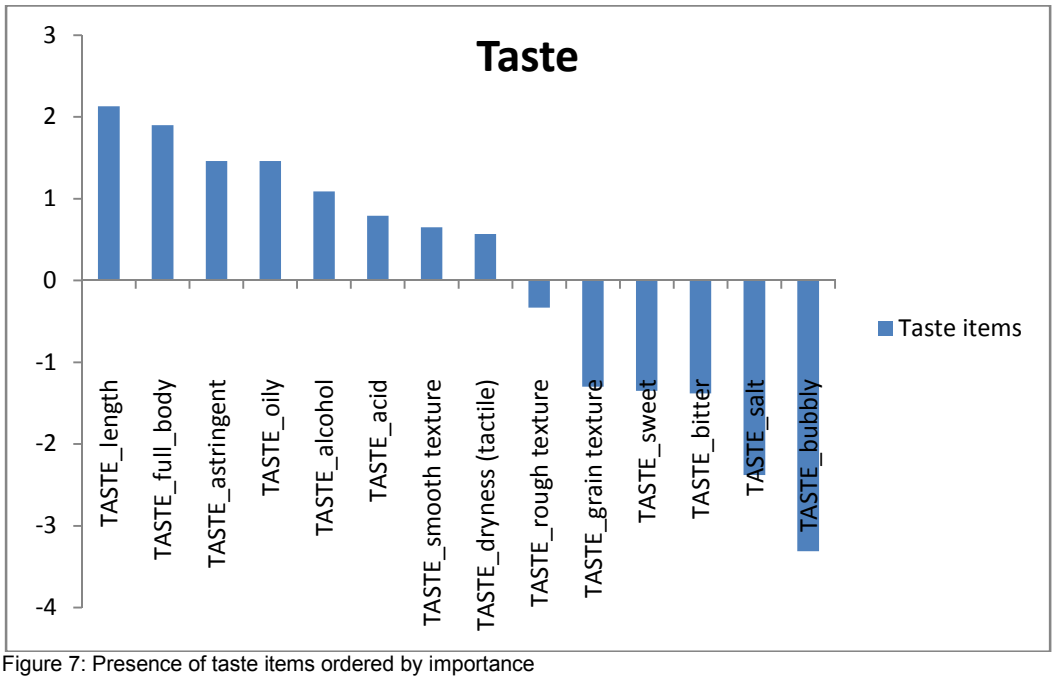

Figure 7: Presence of taste items ordered by importance

Both means values for aroma and taste items presented high values of standard deviation which indicates that the data points are spread out over a large range of values, remembering how difficult is for the panelists to evaluate single sensory

descriptors in a disaggregated form, leading us to perform principal component analysis (PCA), further analyzed in this present work.

Table 10 and 11 shows the results for aroma and taste items considering data collected from a sample of 20 questionnaires from Coutinho (2012), based on cognitive knowledge of 20 wine experts interviewed over the same 18 aroma variables and 14 taste variables. Figure 8 and 9 show the presence of those items ordered by importance with centered means.

Table 10: Wine aroma items collected from Coutinho (2012)

	Mean	Standard Deviation
NOSE_floral	3,95	1,57
NOSE_dried flowers	4,00	1,86
NOSE_herbal	5,95	1,90
NOSE_vegetal	6,25	1,33
NOSE_mineral	5,15	1,76
NOSE_citrus fruit	2,30	1,53
NOSE_red fruit	5,55	1,64
NOSE_black fruit	4,25	1,52
NOSE_stone fruit	3,50	1,57
NOSE_raisin	2,40	1,31
NOSE_dried fruit	3,45	2,16
NOSE_jam	2,95	1,70
NOSE_pastry	2,45	1,43
NOSE_spice	5,10	2,10
NOSE_caramel	2,40	1,31
NOSE_woody	4,85	1,76
NOSE_chemical	3,25	2,27
NOSE_animal	4,25	2,00

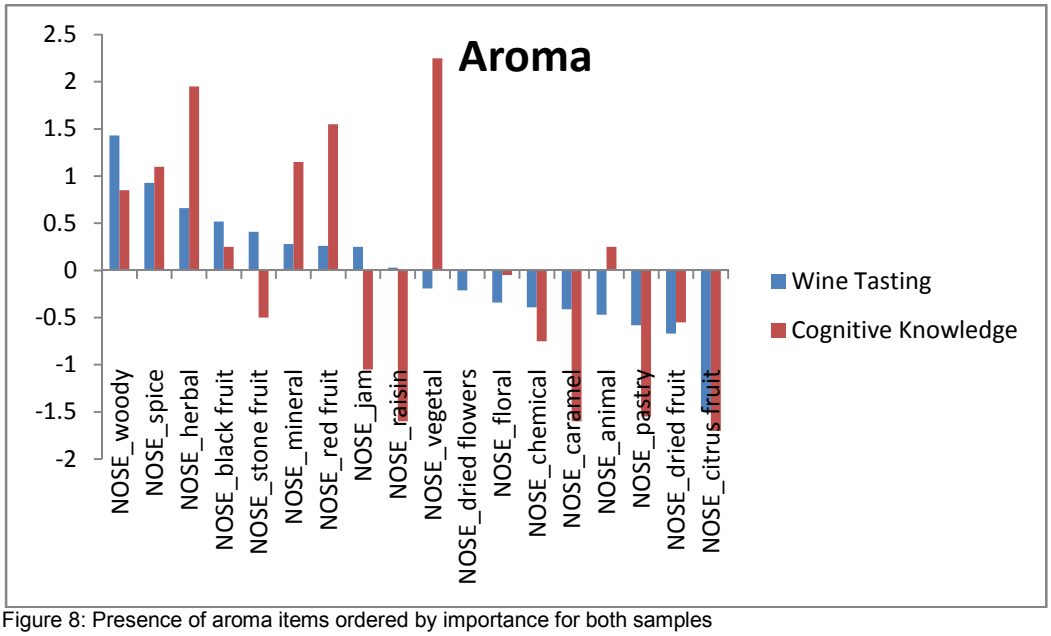

Figure 8: Presence of aroma items ordered by importance for both samples

Table 11: Wine taste items collected from Coutinho (2012)

	Mean	Standard Deviation
TASTE_bubbly	1,10	1,29
TASTE_sweet	2,00	1,62
TASTE_acid	7,00	1,08
TASTE_salt	3,65	2,18
TASTE_bitter	4,60	1,96
TASTE_dryness (tactile)	5,75	1,65
TASTE_smooth texture	3,20	1,44
TASTE_rough texture	5,60	1,47
TASTE_grain texture	5,00	1,81
TASTE_astringent	6,55	1,39
TASTE_full_body	4,45	1,50
TASTE_alcohol	3,70	,86
TASTE_oily	4,30	1,22
TASTE_length	6,75	,97

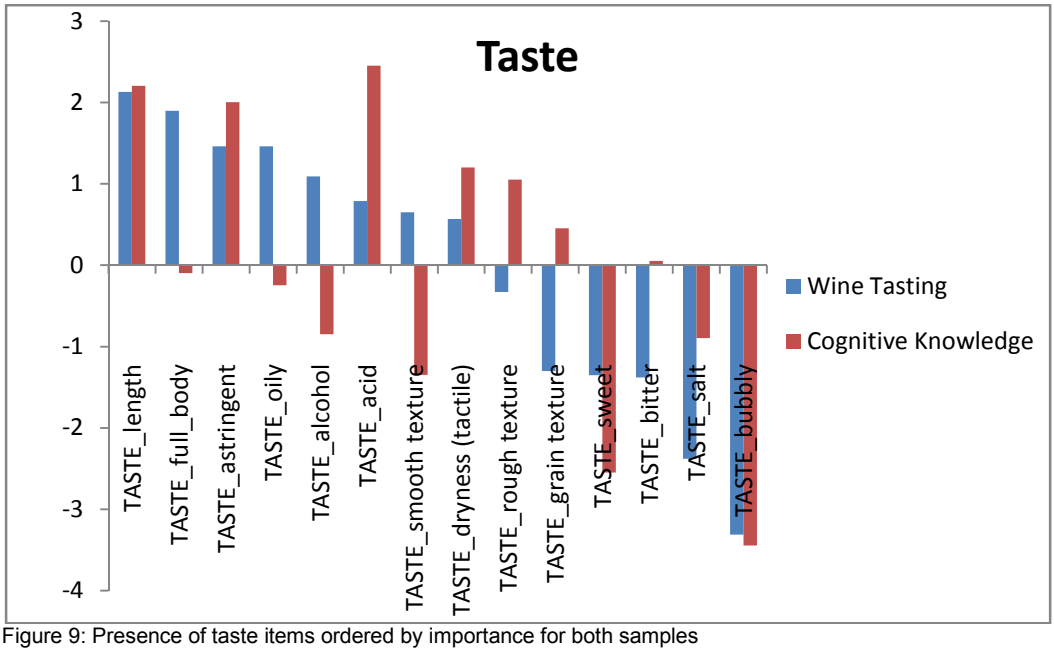

Figure 9: Presence of taste items ordered by importance for both samples

Match was found as most descriptors have the same importance level in both methods, although some differences exists, which can be partially explained due to 1) the gap between conceptual and perceptual representations (Cadot et al., 2012); 2) different previous knowledge of Beira Atlântico region by the two distinct panels; 3) differences in questionnaire interpretation by the two distinct panels. During wine tasting session was opportunity to clarify doubts related to questionnaire interpretation while it hasn't happened in Coutinho (2012) research. Some studies indicate that wine language differs widely from person to person, due to genetics or diversity of experience (Buck, 1993), and that the variability of prototypes between professionals could be important (Zamora and Guirao, 2004). Keep the same panelists, when possible, or simply make some monitoring adjustments to guarantee the same questionnaire interpretation by distinct panels could facilitate methodology comparison.

3.4 Defining vectors which aggregate aroma and taste descriptors

An exploratory factorial analysis[6] (EFA) was conducted, with the principal component method, separately to the aroma and taste items.

Table 12: EFA for aroma items

Component	Eigen values		
	Total	% of Variance	Cumulative %
1	4,602	25,564	25,564
2	2,314	12,853	38,418
3	1,566	8,699	47,116
4	1,379	7,662	54,778
5	1,079	5,992	60,770
6	,962	5,344	66,115
7	,791	4,393	70,508
8	,713	3,959	74,466
9	,691	3,841	78,307
10	,550	3,056	81,364
11	,527	2,931	84,294
12	,508	2,822	87,116
13	,494	2,746	89,861
14	,420	2,333	92,194
15	,413	2,292	94,486
16	,354	1,966	96,452
17	,337	1,875	98,327
18	,301	1,673	100,000

Principal components factor analysis was carried out for the various sensory parameters that constituted the aroma characterization survey of red wines, in accordance with the most up-to-date bibliography. It was obtained, illustrated on table 12, with a KMO of 0,795 and a Bartlett's Test (153) p-value<0,001, five components explaining 60,77% of the variance.

The results of this analysis suggest that several parameters can be grouped, since their variation is directly (or inversely) proportional, among them.

Group 1 includes the following aromatic descriptors: mineral; raisin; dried fruits; jam and pastry, which may be grouped under the so called OVERRIPE aroma profile. In a first glance it could appear strange the presence of the minerality item on this group, however this overripe aroma on wines, which means high levels of grape maturation,

[6]Factor analysis is a set of statistical methods that, in certain situations, helps explain the behavior of a relatively large number of observed variables in terms of a relatively small number of latent variables or factors. This analysis can be seen as an exploratory statistical technique. KMO> 0.6 (indicating the adequacy of the sample size) and significant Bartlett test (tests the null hypothesis that the original correlation matrix is an identity matrix).

might be connected with deeper rooting systems which could confer simultaneously this minerality character.

The 2nd group joins the descriptors red fruit, black fruit and stone fruit, assigned to the RIPE FRUIT profile. Group 3 gathers spice, caramel and woody easily recognized as members of the WOODY & SPICE profile.

Group 4 joins floral, dried flowers, herbal and citrus fruit, all included in the FLORAL & FRESH profile. The 5th aggregate GREEN & OFF FLAVOR profile includes chemical, vegetal (or green) and animal. Intensity descriptor (NOSE intense) was treated separately at this stage of the experimental design. The factor loadings are presented on table 13.

Table 13: Aroma rotated component matrix

	Component				
	1	2	3	4	5
	OVERRIPE	RIPE FRUIT	WOODY & SPICE	FLORAL & FRESH	GREEN & OFF FLAVOR
NOSE_floral				,604	
NOSE_dried flowers				,734	
NOSE_herbal				,548	
NOSE_vegetal					,555
NOSE_mineral	,464				
NOSE_citrus fruit				,646	
NOSE_red fruit		,833			
NOSE_black fruit		,616			
NOSE_stone fruit		,726			
NOSE_raisin	,695				
NOSE_dried fruit	,586				
NOSE_jam	,664				
NOSE_pastry	,576				
NOSE_spice			,644		
NOSE_caramel			,742		
NOSE_woody			,806		
NOSE_chemical					,735
NOSE_animal					,758

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax

Table 14 shows the EFA for taste, with a KMO of 0,702 and a Bartlett's Test (91) p-value<0,001, four components explaining 62,87% of the variance.

Table 14: EFA for taste items

Component	Eigen values		
	Total	% of Variance	Cumulative %
1	3,587	25,621	25,621
2	2,339	16,710	42,330
3	1,791	12,794	55,124
4	1,084	7,745	62,869
5	,978	6,982	69,852
6	,931	6,651	76,503
7	,724	5,173	81,676
8	,584	4,171	85,847
9	,563	4,019	89,866
10	,387	2,766	92,631
11	,327	2,332	94,964
12	,317	2,264	97,228
13	,251	1,796	99,023
14	,137	,977	100,000

The items are grouped in the following way:

Group 1 is composed by full body, alcohol, oily and length easily recognized as members of the PERSISTENT profile.

The 2nd Group joins the tastes sweet, smooth texture and (the inverted assessment corresponding to) tactile dryness, and may be referred to as SMOOTH & SWEET. The inverse assessment between tactile dryness and the other smooth & sweet profile descriptors should be underlined, meaning that the experts panel sensory discrimination is inversely proportional with regard to (sweet and smooth texture) and dry tastes, i. e. when the panel considers that a wine is characterized by a high level of sweet taste and smooth texture, then the evaluation of the tactile dryness is proportionally lower in that wine. Group 3 includes salt, bitter and bubbly to express the COASTAL & FRESH profile. Bitter taste was unexpectedly assessed differently from astringent sensations as they usually appears correlated and it inclusion in a costal and fresh profile can be related to grape under maturation. Group 4 adds grain and rough textures, astringent and acid taste, encompassing the evaluation of a rough sensations profile designated by ACID & ASTRINGENT. This grouping of acid and astringent sensations can be explained by the well known influence of the acidity in the increasing astringency perception (Fontoin et al., 2008).

The factor loadings are presented on table 15.

Table 15: Taste rotated component matrix

	Component			
	1	2	3	4
	PERSISTENT	SMOOTH & SWEET	COASTAL & FRESH	ACID & ASTRINGENT
TASTE_bubbly			,714	
TASTE_sweet		,756		
TASTE_acid				,717
TASTE_salt			,635	
TASTE_bitter			,725	
TASTE_tactile dryness		-,547		
TASTE_smooth texture		,730		
TASTE_rough texture				,558
TASTE_grain texture				,585
TASTE_astringent				,489
TASTE_full_body	,873			
TASTE_alcohol	,751			
TASTE_oily	,853			
TASTE_length	,794			

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax.

3.5 Aroma and taste radar profiles

Table 16 presents the components and means for the 399 questionnaires resulting from the present research and for a sample of 20 questionnaires from Coutinho (2012) which was analyzed under the same principal components. Both samples are showed however it must be noted that the first sample is based on a real sensory experience (and wine comparative) and the second is based on cognitive memory and expert knowledge (in absolute terms without any comparison). This leads to intensity differences so only presence or absence is analyzed.

Table 16: Aroma and taste components

	Components	Sample			
		Wine Tasting		Cognitive Knowledge	
		Mean	Standard Deviation	Mean	Standard Deviation
Aroma	FLORAL & FRESH	2,04	1,226	3,98	1,259
	OVERRIPE	2,28	1,316	3,17	1,067
	WOODY & SPICE	3,08	1,574	4,09	1,265
	GREEN & OFF FLAVOR	2,05	1,526	4,43	1,598
	RIPE FRUIT	2,80	1,656	4,50	1,200
Taste	ACID & ASTRINGENT	3,81	1,234	6,08	1,088
	SMOOTH & SWEET	3,97	1,387	3,04	,875
	COASTAL & FRESH	1,32	1,011	3,10	1,416
	PERSISTENT	5,33	1,577	4,80	,836

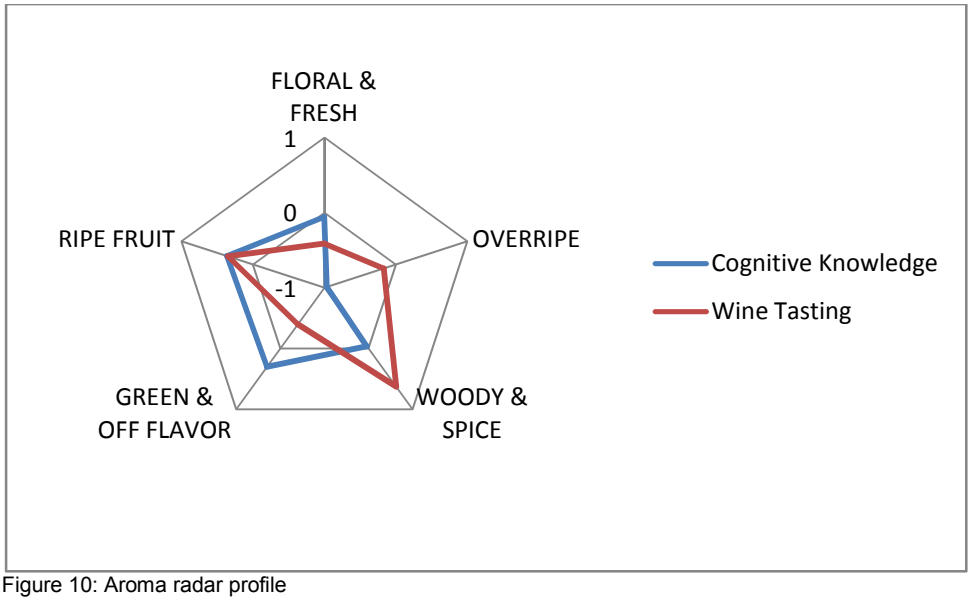

Figure 10: Aroma radar profile

Figure 10 represents the centered mean aroma components for both samples and it can be seen that although both areas do not coincide exactly one can argue that the aroma profile of DO Bairrada and GI Beira Atlântico wines is on the vectors WOODY &

SPICE and RIPE FRUIT. These results corroborate with findings from Coelho et al. (2006) when identified the free varietal and pre-fermentative related volatile compounds in crushed grapes from Baga variety wherein sesquiterpenoids was the group with higher number of constituent varietal compounds and reported has exhibiting a precious spicy and woody aromas that could contribute favorably to the wine aroma characteristics. Rocha et al. (2003) when analyzing the volatile composition of Baga red wine, according to aroma index and odor descriptor for the 9 compounds that seemed to be the most powerful odourants present in the Baga monovarietal wine, conclude that it presents ripe red fruit, cherry, strawberry, vegetable, sweet and smoke/phenolic notes, which are also closely correlated with the aroma profile identified in our present research, suggesting that Baga variety plays an important role on aroma profile of DO Bairrada and IG Beira Atlântico wines.

The GREEN & OFF FLAVOR component in wine tasting is not present at same intensity level as it was in Coutinho (2012) research based on cognitive knowledge. Conversely the OVERRIPE aroma component is now more evident. These facts could be related to improvements on viticultural and winemaking practices and also facilitated by warming climatic changes that have been encouraging grape ripeness, reducing its green character and inducing a shift to a more driven ripe fruit character. The temporal gap between conceptual and perceptual expertise, already mentioned, explains the differences achieved.

Thus, based on the information collected from principal component method and also considering the more distinctive aromas resulting from the centered mean analysis, we can argue that DO Bairrada and IG Beira Atlântico wines have a woody & spice, ripe fruit aroma profile with also herbal and mineral aromas.

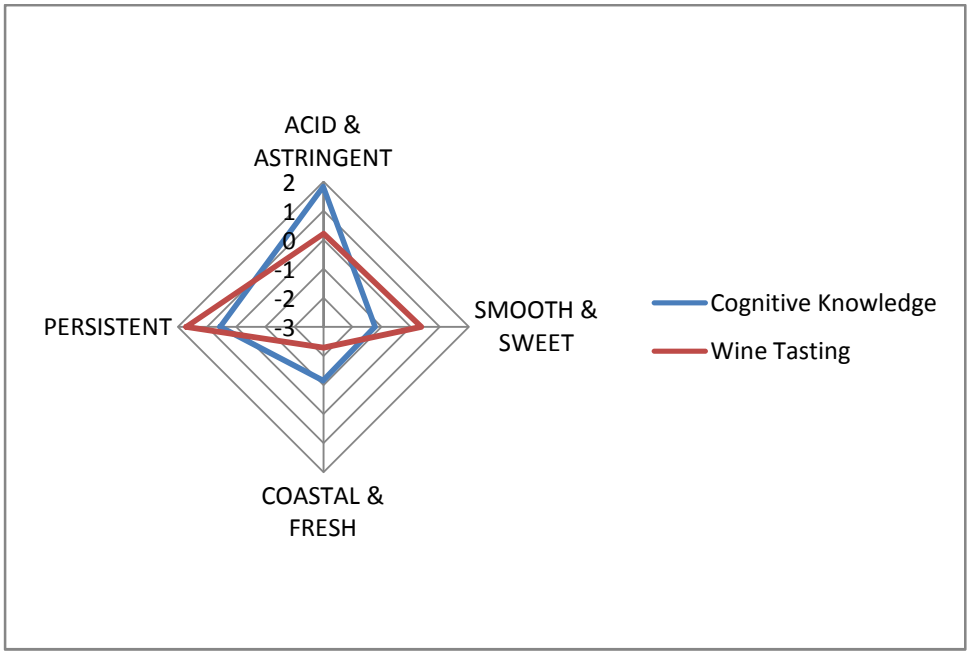

Figure 11: Taste radar profile

Figure 11 represents the centered mean taste components for both samples and it can be seen that the wine profile for taste is mainly on the fourth quadrant PERSISTENT-ACID & ASTRINGENT, but at same time balanced with a SMOOTH & SWEET taste component. The COASTAL & FRESH component wasn't present with a same intensity level.

Based on the information collected from principal component method and also considering the more distinctive taste items resulting from the centered mean analysis, we can argue that DO Bairrada and IG Beira Atlântico wines can be defined as having pronounced acidity & astringency, balanced with a smooth & sweet taste component and being very persistent.

3.6 Analyzing wine type by principal components

Table 17 shows the aroma and taste components per wine type and it can be seen that the "Clássico" type is statistically different from the others on OVERRIPE, WOODY & SPICE, ACID & ASTRINGENT and PERSISTENT, having higher presence in all of them.

A cluster analysis, considering all wines and types, was performed for the 9 principal components of aroma and taste. We can see that the "Clássico" type tends to group together, confirming the distinctiveness of this type of wine and also strength the adequacy of the components as the vectors of the DO Bairrada and GI Beira Atlântico wines.

Table 17: Components per wine type

	Wine type		
	Regional	DO Bairrada	"Clássico"
	Mean	Mean	Mean
FLORAL & FRESH	2,08	1,97	2,08
OVERRIPE	2,06	2,03	2,88**
WOODY & SPICE	2,68	2,89	3,80**
GREEN & OFF FLAVOR	1,95	2,10	2,12
RIPE FRUIT	2,84	2,75	2,83
ACID & ASTRINGENT	3,55	3,78	4,17**
SMOOTH & SWEET	4,14	3,83	3,94
COASTAL & FRESH	1,25	1,35	1,36
PERSISTENT	4,94	5,12	6,05**

** statistical significance p-value<0,01

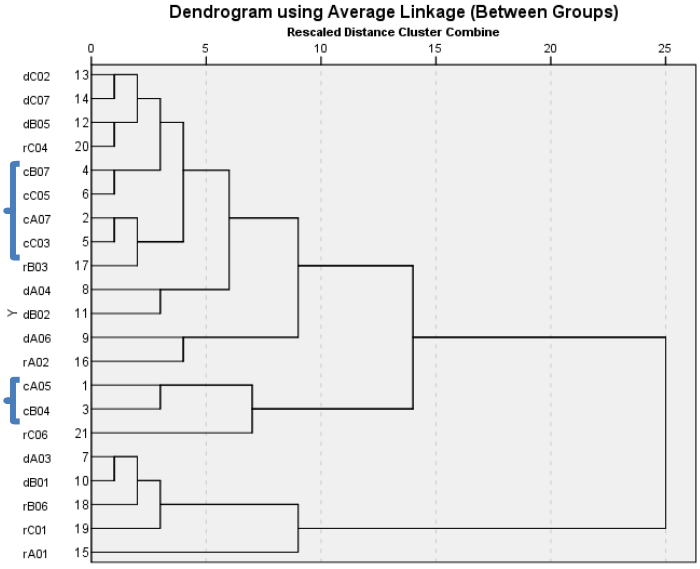

Figure 12: Cluster analysis for the 9 components of aroma and taste considering all wines and types

Table 18: Price per wine type

	Regional		DO		Classic	
	Mean	SD	Mean	SD	Mean	SD
Price	5,39	4,44	2,83	,70	22,50**	4,39

** statistical significance p-value<0,01

Table 18 shows a statistical difference on the price of the classical type.

Conclusions

This is the first time that an extensive study has been attempted to characterize the sensory profile and typicality of GI Beira Atlântico and DO Bairrada wines.

These wines were characterized by having a ruby color, with medium-high intensity. On the nose they've presented a medium to medium-high intensity, with a woody & spice, ripe fruit aroma profile with also herbal and mineral aromas. On taste, these wines can be defined as having pronounced acidity & astringency, balanced with a sweet & smooth mouthfeel component and being very persistent.

Results from this research, based on wine tasting and sensory experience, were compared with results from Coutinho (2012), based on cognitive memory and expert knowledge. We can argue that methodology proposed by Coutinho (2012) could be a valid alternative to the conventional wine tasting methods when intended to identify wine regions profiles, although further work on other regions might continue.

When comparing wine types, we couldn´t find any difference between Regional and DO Bairrada wines in terms of typicality and sensory profile, as Coutinho (2012) had already achieved on his research. However the small group of "Clássico" wine was clearly identified by the tasters as being more typical, with more color and nose intensity. It´s spice & woody character showed being increased, presenting also more overripe fruit character on the nose. On the taste, "Clássico" wines tends to have a pronounced acidity & astringency component when compared to regional and DO Bairrada wines and are also more persistent. These results, leaving "Clássico" group in a distinct level, suggests that Bairrada region has an opportunity on the "Clássico" meaning to differentiate among others, keeping its own typicity and identity, facilitating it's recognition abroad, which could lead to Bairrada affirmation in the global wine industry. However, when analyzing the mean prices of the 3 types of wines, we can realize that "Clássico" wines tend to be 4 and 8 times more expensive when compared to Regional and DO, respectively, which could have a great impact on consumer choice.

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Annexes

VINHOS TINTOS IGP BEIRA ATLÂNTICO e DOP BAIRRADA

POR FAVOR RESPONDA A TODAS AS PERGUNTAS COLOCANDO UMA CRUZ NA RESPOSTA OU NÍVEL DE INTENSIDADE DESEJADOS.

CARACTERIZAÇÃO GENÉRICA DA **COR** (ESCOLHA APENAS UMA DAS QUATRO CORES DE BASE E AVALIE A RESPECTIVA INTENSIDADE CORANTE)

VIOLETA - PÚRPURA ☐ PÚRPURA - RUBI ☐ RUBI - GRANADA ☐ GRANADA - TIJOLO ☐

COR AGUADA	0	1	2	3	4	5	6	7	8	9	10	COR INTENSA

CARACTERIZAÇÃO GENÉRICA DO **AROMA** (RESPONDA A TODAS AS ESCALAS, AINDA QUE, EM VÁRIOS GRUPOS AROMÁTICOS, TENHA QUE MARCAR O (X) NO INÍCIO DA ESCALA DE INTENSIDADE, POR CONSIDERAR ESTE GRUPO AROMÁTICO AUSENTE DO VINHO EM PROVA.

INTENSIDADE NULA (-)	**INTENSIDADE AROMÁTICA**				**Intensidade Global do Aroma**							FORTE INTENSIDADE (+)
	0	1	2	3	4	5	6	7	8	9	10	
	AROMAS FLORAIS				**rosa, flor de laranjeira, violeta, cravo**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE FLORES SECAS				**feno, rosa velha, camomila**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS HERBAIS				**mentas, tomilho, relva cortada, chás, anisados, mato mediterrânico**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS VEGETAIS				**aromas pungentes de pimentos verde ou vermelho, azeitonas**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS MINERAIS				**xisto seco, terra, fumo mineral, água mineral, apetrolados**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE FRUTOS CÍTRICOS				**laranja, limão, bergamota, toranja**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE FRUTOS VERMELHOS				**morango, framboesa, groselha**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE FRUTOS PRETOS				**amora, arando, mirtilo**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE FRUTA DE CAROÇO				**ameixa preta, abrunho, cereja**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS FRUTOS DESIDRATADOS				**passa de uva, passa de ameixa, figo, banana**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE FRUTOS SECOS				**amendoa, avelã, noz, pinhão**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE FRUTA COMPOTADA				**compotas de frutos vermelhos ou pretos, alicorados**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS ALIMENTARES E PASTELARIA				**manteiga, pão, chocolate de leite, baunilha, ovo**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DE ESPECIARIA				**pimenta, cravinho, noz moscada, canela, cacau, café**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS CARAMELIZADOS				**caramelo, fruto caramelizado, mel, polen, alcaçuz**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS DA MADEIRA				**eucalipto, cedro, resina, madeira verde, queimados e fumados**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)
	AROMAS QUÍMICOS				**dentífrico, cola, metal, redução, fermento, fruta artificial (sem ser defeito)**							
(-)	0	1	2	3	4	5	6	7	8	9	10	(+)

AROMAS ANIMAIS — **couro, carne, bacon, musk/ginete, cão molhado (sem ser defeito)**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

SE ACHAR CONVENIENTE, PODE COMPLETAR A SUA CARACTERIZAÇÃO AROMÁTICA, POR EXTENSO

CARACTERIZAÇÃO GENÉRICA DO **GOSTO** (RESPONDA A TODAS AS ESCALAS, AINDA QUE, EM VÁRIAS SENSAÇÕES GUSTATIVAS, TENHA QUE MARCAR O (X) NO INÍCIO DA ESCALA DE INTENSIDADE, POR CONSIDERAR DETERMINADA SENSAÇÃO AUSENTE DO VINHO EM PROVA.

BORBULHA — **sensação gasosa, carbonatada, na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

DOCE — **doce, sucroso**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

ACIDEZ — **ácido, como sumo de limão, fresco e arrepiante**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

SALGADO — **salgado**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

AMARGO — **não avalie como adstringência. Amargo é o gosto ágrio, como café ou chicória**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

SECURA (TÁCTIL) — **secura na boca, falta de lubrificação ou de humidade na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

TEXTURA SUAVE — **texturas suaves na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

TEXTURA RUGOSA — **texturas rugosas, aguçadas na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

TEXTURA GRANULADA — **texturas granuladas na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

ADSTRINGÊNCIA GLOBAL — **conjunto da secura, textura superficial e das sensações dinâmicas na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

CORPO CHEIO — **volume, extrato seco e viscosidade**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

ÁLCOOL — **sensações resultantes da presença do álcool, quentes e cáusticas**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

COBERTURA DE BOCA — **sensação final oleosa e untuosa na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

PERSISTÊNCIA — **comprimento do vinho na boca**

(-) 0 1 2 3 4 5 6 7 8 9 10 (+)

SE ACHAR CONVENIENTE, PODE COMPLETAR A SUA CARACTERIZAÇÃO GUSTATIVA, POR EXTENSO

AVALIAÇAO GENÉRICA DA **TIPICIDADE** DO VINHO EM PROVA. PONHA UM (X) SOBRE A ESCALA DE INTENSIDADE EM FUNÇÃO DO QUE CONSIDERA SER UM MAU OU BOM EXEMPLO DE UM VINHO TINTO TÍPICO DA BAIRRADA

MAU EXEMPLO 0 1 2 3 4 5 6 7 8 9 10 BOM EXEMPLO

MUITO OBRIGADO PELA SUA COLABORAÇÃO!