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Insights on Wine Astringency Mouthfeel Estimations

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Abstract

The sensory properties of food and beverages are key factors that determine consumer preference. Astringency, described as a sensation of dryness and puckering in mouth, is an important quality factor. In fact, great part of the economic efforts within the wine production chain are related to its management. This perception is based on the interaction of wine tannins with saliva proteins, causing a loss of oral lubrication. The quantitative determination of tannins in grapes and wine is crucial for wine producers, since a mismanagement on productive processes or a natural imbalance in the abundance of certain kind of tannins could lead to an unwanted astringency mouthfeel for wine consumers. Here we summarize the main methodologies for astringency intensity and sub-qualities estimations focused on classical and latest advances in methodologies, along with their main advantages and disadvantages.

Keywords: Astringency, Astringency Sub-Qualities; Sensory Panels; Analytical Methods; Tribology

Abbrevations: PA: Proanthocyanidins; HPLC: High-Performance Liquid Chromatography; BSA: Bovine Serum Albumin; MC: Methylcellulose

Introduction

Astringency perception is a highly complex and variable process that involves, mainly, the interaction of condensed tannins and salivary proteins in the oral cavity [1]. Wine condensed tannins (or PAs) are polyphenolic compounds found naturally in the seed and skin of the grape berry [2]. During the first stages of fruit development there is an active biosynthesis of tannin monomers and after veraison, the formation of polymeric structures is favored [3]. Astringency is one of the main sensorial attributes in red wines. A good wine is identified as one that has an adequate level of astringency [4,5]. The excess of astringency may mask other attributes, and a lack of astringency is related to a flat mouthfeel and poor aftertaste [5]. Because of this, understanding the astringency mouthfeel would lead to the development of techniques and mechanisms that would allow researchers and the wine-making industry to control astringency intensity and ultimately, wine quality. There are multiple variables that contribute to the complexity of the astringency phenomenon related to wine tannins. For instance, the chemical structure of the monomers, degree of polymerization, interaction with other components in the wine matrix and their specific interaction with different components of the oral cavity [4,6-8]. It has been suggested that the astringency mouthfeel, particularly the one related to condensed tannins-salivary protein interaction, have a better correlation with the strength of the interaction and the modulating components rather than solely condensed tannin concentration [1]. Furthermore, astringency can be divided into multiple sub-qualities and few studies have address this matter to date [9-12]. A better understanding of the molecular implications of these sub-qualities is required, since they regulate the perception of astringency. Because of this, analytical approaches should not be based solely on the overall intensity of astringency but should also consider the sub-quality spectrum of the studied wines.

The knowledge of tannins levels and also their structural differences among wine varieties are essential during wine production, to be able to follow and estimate the sensory astringency reached at each stage of elaboration and to set measurements related to quality control of the final product.

Currently, there are several methodologies that vary in complexity, time and cost to perform both qualitative and quantitative determinations of condensed tannins and their nature. Sensory panels composed of wine experts have been a common alternative used in several studies related to astringency because they potentially describe sensory astringency perceived, in terms of what customers would like [13-16]. However, this methodology presents some disadvantages such as low objectivity and poor reproducibility. In fact, it has been shown that results are highly variable depending on the kind of study, wine varieties, number of participants, among others [1]. Moreover, this type of studies is cost and time dependent due to the need to create a properly trained panel to ensure that the variability between individuals is minimized. Analytical methods have contributed to reduce subjectivity in astringency studies. Quantitative studies rely on the previously characterized ability of PAs to precipitate proteins and other biomolecules in a fairly linear trend along with tannin concentration [1]. Colorimetric studies employing standard biomolecules such as BSA or Methylcellulose, have been widely used as a complementation of astringency intensity measurements in sensory panels. In general, these techniques stand out due to their simplicity and relatively reduced time to achieve results [17-20]. The main advantages and disadvantages of different colorimetric methods have been recently revised [17]. Although, the use of these techniques is highly common, they show several difficulties in terms of variability. This is because the interaction between tannins and these molecules is not uniform and varies depending on external and internal conditions, such as previous treatment of the sample [21].

Approaches using liquid and gas chromatography have been assessed in several studies [18,22-26]. HPLC has been used for the separation and characterization of tannins monomers, due to its high sensitivity and specificity [1,17]. When coupled with other techniques such as mass spectrometry it can give a quantification of tannins in wine samples [1]. The use of these approaches has shown low variability between replicates and high correlation with sensory studies [20]. However, the high costs associated with the standardization processes, the lack of a wide range of available standards for tannin studies, and the need of extensive sample treatment prior to analysis make this technique not a reasonable option, especially in exploratory studies [25]. It needs to be highlighted that none of the analytical methods previously described have been successful to assess astringency sub-qualities. This is due to the unknown molecular and chemical mechanisms that are associated with each different sub-quality. Biosensors have also been recently used in the wine-making industry to estimate polyphenol content during wine-making processes [27]. Enzyme-based biosensors have been developed for this purpose using tyrosinase, peroxidase, quinine-dependent pyrroloquinoline glucose dehydrogenase, among others [28-30]. Although, the developed biosensors have a good detection limit in most cases, it has been shown that some of these reactions show interferences, because these enzymes use more than one type of polyphenol as substrate, which does not necessarily correlate to astringency intensity or its sub-qualities [7]. As stated in a recent study, nanotechnology might contribute to the development of new biosensors with more stability and without the need for enzymes to solve this problem [31].

Oral tribology is based on physical changes that occur during contact of two moving surfaces, such as adhesion, friction, and lubrication [1]. It is a current approach that has been proposed as an effective tool for assessing astringency using some lubrication-based textural features that simulate the oral cavity [32]. The friction coefficient is used for obtaining quantitative information about the nature of the interactions between the different surfaces involved. In the case of saliva studies, this indicates the lubrication status which usually decreases due to the interaction of tannins with salivary proteins [7]. Tribological studies could be an efficient approach to determine and correlate with the astringency perceived in red wines in a rather objective manner. Studies to date have been able to obtain good correlations between the increase in friction detected in tribological studies and the tannin-protein interaction supported by astringency perceived in sensory panels [7]. Furthermore, oral tribology approaches, measuring friction coefficient, have been recently used to assess differences not only in overall astringency intensity but also in astringency sub-qualities, comparing varieties and different harvest periods [9]. Moreover, tribology differences in model wines have also been assessed finding that dry and pucker sub-qualities can be differentiated by this approach [11].

Some disadvantages of this approach have been seen in terms of costs and the use of trained personnel. Additionally, extensive standardization of the instrumental conditions needs to be done prior to use. Finally, to date there are few comparative studies available regarding astringency sub-qualities, which makes it difficult to conclude on the mechanisms and origin of these, and on the other hand, the ideal parameters to assess friction, such as sliding speeds, pressure, sliding rolling ratio (SRR) and others, need to be established. Predictive studies have been recently getting extensive due to the need to manage or estimate the astringency mouthfeel that a grape berry in the field. The establishment of a potential astringency prior and during the wine-making process could contribute to decrease production costs. Some studies have been based on the use of Near Infrared Spectroscopy (NIR) to establish predictive models for grape seeds and skins astringency [33]. In addition, the construction of electric tongues with spectroscopy electrochemical and potentiometric sensors has been assessed to estimate astringency. In general, these have shown promising results in terms of estimations [34,35]. Although these methodologies have shown good correlations with sensory panels, they do not provide any information about the process itself, and it might only be useful in field-related measurements.

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Conclusion

Astringency estimations techniques stated above have shown improvements and promising results in recent years, in terms of reduced variability and correlation with sensory studies. However, there are still certain discrepancies when comparing studies involving, for instance, the same wine varieties or the same tannin content. The complexity of condensed tannins, previously described, is a fundamental part of this. The election of a certain methodology will depend on the goal of the study, the sample material, and the equipment accessible to the research group. A focus on astringency sub-qualities is still needed since it has been shown that these might direct consumer preference.

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