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Understanding the meaning and structure of tannin descriptors employed by wine experts

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ABSTRACT

Understanding how wine experts conceptualise and verbalise tannins is essential for improving the clarity, precision, and communicability of sensory vocabulary. Although tannin descriptors are extensively used in professional, pedagogical, and technical contexts, many remain ill-defined, inconsistently applied, and semantically overlapping, creating difficulties for both scientific interpretation and communication with consumers. This study aimed to (1) identify the terms employed by winemakers to characterise red wine tannins, (2) analyse the perceptual and conceptual dimensions underlying these terms, and (3) model their internal organisation through a semantic network.

A two-stage design was implemented. Free descriptions from wine professionals generated an initial lexicon, which was subsequently examined through in-depth interviews (n = 29). Definitions, perceived valence, and conceptual associations were analysed via thematic coding and structured into seven dimensions: Texture, Integration, Intensity, Maturity, Physiological reaction, Hedonic evaluation, and Origin. A graph-theory–based semantic network was constructed from an adjacency matrix reflecting intra- and inter-dimensional proximities.

Fifty-five descriptors were retained. Citation frequency revealed a restricted shared lexical core (six terms cited by > 80 % of participants) and a broad, variable semantic periphery. Network topology identified Texture, Intensity, and Maturity as central organising axes, with remaining dimensions acting as modulatory domains.

This research provides the first structured semantic framework for expert tannin vocabulary. It offers consensus definitions and a multidimensional model that could serve as a tool to improve sensory education, enhance communication, and support future standardisation efforts within the wine sector.

KEYWORDS: semantic network modelling, astringency perception, expert cognition, tannin perception, sensory conceptualisation, semantic organisation

INTRODUCTION

The sensory characterisation of tannins is central to evaluating the mouthfeel of red wines, as these phenolic compounds substantially shape the tactile, structural, and temporal dimensions of wine quality. Recent literature indicates that tannins not only modulate the intensity of astringency but also give rise to a broad and complex set of sensations described through a heterogeneous vocabulary, including terms such as smooth, silky, velvety, firm, grainy, drying, harsh, or green (Paissoni *et al.*, 2023). These descriptors act as multidimensional constructs that integrate aroma, taste, tactile, temporal, chemical, and affective perceptions, which partly explains their ambiguity and lack of operational definitions (Sáenz-Navajas *et al.*, 2016). Although tannins are widely recognised as primary contributors to astringency and several mouthfeel attributes, wine texture is a multidimensional perception influenced by multiple matrix components, including ethanol, polysaccharides, colloidal structure, and dissolved CO_2 (Paissoni *et al.*, 2023). In the present study, for conceptual coherence, we focus on descriptors explicitly attributed to tannins by experts, without implying that tannins are the exclusive drivers of textural perception.

The sensory expression of tannins emerges from a complex interplay between their chemical composition—including degree of polymerisation, molecular size, and subunit proportion—and their interactions with salivary proteins (Soares *et al.*, 2017). Moreover, multiple viticultural and oenological factors, such as grape ripeness, maceration duration, and the addition of oenological tannins, further modulate tannin composition (Feifel *et al.*, 2025; Medel-Marabolí *et al.*, 2017). These structural variations influence not only the intensity of astringency but also its temporal kinetics and its integration with other dimensions of mouthfeel—such as density, volume, and body sensation (Paissoni *et al.*, 2023; Medel-Marabolí *et al.*, 2017). Conversely, studies that focus on the quantification and characterisation of tannins show that many terms commonly used by professionals, including "silky", "grippy", "coarse", or "unripe", reflect complex combinations of chemical and sensory properties. However, these terms rarely possess agreed-upon definitions, contributing to inconsistent interpretations (Watrelot, 2021).

Beyond scientific research, educational and technical texts (Bullipedia, 2022; WSET, 2022; Robinson, 2015) frequently link both the quantity (low, medium, high) and quality (positive or negative) of tannins to overall wine quality. In this context, the notion of wine quality refers to perceived sensory quality as constructed within professional wine evaluation settings, rather than to intrinsic chemical composition or objective quality parameters. Table 1 provides examples of tannin-related terminology and its association with perceived wine quality across different expert sources.

The prominence of tannin descriptors in non-scientific educational and informative materials contributes to their widespread use among wine professionals. However, the specific meanings and boundaries of these descriptors remain unclear, resulting in ill-defined terms that hinder effective communication among practitioners. Such descriptors often fail to point to a specific sensory experience, display strong idiosyncratic variation, and lack consensus among tasters. Furthermore, many wine descriptors used by experts not only articulate sensory impressions but also evoke deeper conceptual frameworks that shape the sensory experience (Honoré-Chedozeau *et al.*, 2020).

Ill-defined concepts are marked by indeterminacy and low agreement, making their systematic use as sensory data challenging. Within this context, the use of graph-theory-based semantic networks has emerged as a valuable approach for representing and analysing diffuse sensory vocabularies. Their key advantage is that they model meaning not as an isolated property of words but as a pattern of relationships within a conceptual graph (Grebitus & Bruhn, 2008). A recent systematic review shows consensus that semantic networks facilitate the visualisation, comparison, and structural organisation of complex and polysemic concepts (Pereira *et al.*, 2022). This methodology is particularly relevant in domains such as wine, where many descriptors lack stable definitions. Computational analyses of expert language further reveal that, even within a creative and heterogeneous lexicon, term co-occurrence patterns allow the identification of stable structures and distinctive terminology (Croijmans *et al.*, 2020). In addition, research on open-ended sensory data demonstrates that the semantic structuring of spontaneously generated terms enhances the robustness and reproducibility of sensory analyses by transforming idiosyncratic vocabulary into interpretable relational structures (Piqueras-Fiszman, 2023). Collectively, this evidence underscores the capacity of semantic-network approaches to elucidate, organise, and operationalise sensory descriptors that are inherently vague, context-dependent, and challenging to standardise.

TABLE 1. Examples of tannin-related terms employed by different sources to convey positive or negative wine quality.

Expert source	Positive to quality	Negative to quality
Winemakers (Sáenz-Navajas *et al.*, 2016)	Round, smooth	Green, coarse
Educational course (WSET, 2022)	Ripe, smooth, fine-grained tannins	Unripe, stalky, chalky
Technical text (Robinson, 2015)	Soft, supple	Hard, green, resinous, leathery, gripping, aggressive
Technical text (Bullipedia, 2022)	Soft, smooth, fine-grained, velvety texture, ripe, enveloping, firm, grainy texture, earthy, sultry sensation, and juiciness	Green, unripe, drying, chunky, coarse, hard, austere

Given this background, further research is needed to understand how sensory properties are conceptualised and verbalised. Whereas consumers tend to use simpler and more stable lexical frameworks, experts rely on technical-metaphorical descriptors whose interpretation is not always shared (Bianchi *et al.*, 2021; Rodrigues *et al.*, 2025). For this reason, the present study focuses on wine experts. The participants were drawn from a single wine-producing region, sharing a common professional and cultural background. While this contextual coherence facilitates the exploration of internally structured terminology, sensory language may nonetheless reflect local winemaking traditions and conventions (Temmerman, 2017; Sáenz-Navajas *et al.*, 2021). Accordingly, the semantic structure identified here should be interpreted within this framework, and cross-regional validation will be necessary to assess its broader generalisability. Based on in-depth interviews with wine experts from Rioja area, this research aims to (1) identify the sensory descriptors commonly used to describe tannins (Studies 1 and 2), (2) analyse their associated perceptual dimensions and internal structure (Study 2), and (3) construct a semantic network of tannin-related terms to assess their semantic coherence within professional discourse (Study 2).

STUDY 1. GENERATION OF TERMS DESCRIBING TANNINS BY WINE FREE DESCRIPTION

MATERIALS AND METHODS

1. Participants

Fourteen winemakers (28–55 years of age, average = 42 years old; 21 % women) participated in the study. They were all active winemakers in the DOCa Rioja (Spain) with an average of 14 years of experience in the field (4–30 years of experience).

2. Wines

The selection was carried out in consultation with Spanish winemakers, and it was also based on previous experiments carried out in our research team. From an initial list of 25 red wines showing different tannin-related characteristics, nine were selected on a bench-test (Table 2). Five experimenters involved in the project carried out a labelled sorting task with the initial 25 wines. The wines that were put together twice or fewer times by the experimenters were assumed to be the most different in terms of sensory perception and were therefore selected.

3. Procedure

The 14 participants attended one session, which lasted a maximum of 45 minutes. During this session, the nine selected wines were tasted, with a 15-minute break between the fifth and sixth wines. The testing was conducted at the Universidad de La Rioja at ambient temperature (22–23 °C) in individual sensory booths under white, fluorescent lighting.

The nine samples of 30 mL were served in clear ISO glasses coded with three-digit numbers covered with plastic Petri dishes. To limit carryover and priming effects, wine samples were monadically presented to each participant in a different order according to a Williams Latin square arrangement. Water and pectin (1 gL^{-1}) were used in the rinsing protocol. Participants were instructed to taste the wines and freely describe the sensory properties elicited by the tannins present in each sample. They were advised to evaluate the wines in the order in which they were presented and to expectorate after tasting.

4. Data analysis

The descriptions were digitised, and a preliminary list of terms was extracted by isolating all unique entries related to the description of tannins. Non-informative words or expressions were removed, as were other aspects of the wine that were not related to the description of tannins. A lemmatisation was then conducted on this initial list, whereby terms sharing the same root were identified and substituted with one selected term. For example, the terms "tannin with high reactivity", "reactive tannin", and "reactive tannins" were fused into "reactive".

TABLE 2. List of wines employed in Study 1.

Code	Origin	Variety	Vintage	Oak	Description*
W1	DOCa Rioja	Graciano	2015	12 months in oak barrels	Persistent, mature tannins
W2	Albacete	Bobal	2020	No	Dry tannin
W3	Albacete	Bobal	2020	No	Green tannin
W4	DOCa Rioja	Tempranillo Tinto	2011	24 months in oak barrels	Ripe, woody tannin
W5	DOCa Rioja	Tempranillo Tinto	2017	No	Overwhelming tannin
W6	DOCa Rioja	Garnacha Tinta	2019	No	Green and ripe tannin
W7	DOCa Rioja	Tempranillo Tinto	2020	6 months in oak barrels	Very ripe tannin
W8	DOCa Rioja	Tempranillo Tinto	2020	No	Green tannin
W9	DOCa Rioja	Bobal	2018	No	Ripe tannin

* Based on the description carried out by the five experimenters after the sorting task.

RESULTS

A list of 64 terms employed to describe tannin sensory characteristics was compiled. The terms in the list were grouped in the 11 categories shown in Table 3. Each category was formed by terms with a close meaning, as well as terms that were considered to be antonyms.

Each of these 11 groups of terms was presented in one slide, including five–six tannin-related terms as support material to conduct the structured interviews reported in the next section.

STUDY 2. FREQUENCY OF CITATION, DEFINITION, AND SEMANTIC NETWORK

MATERIALS AND METHODS

1. Participants

Twenty-nine winemakers (45 % women, 55 % men) aged between 30 and 64 years old (17 % in the 26–35 age range; 14 % in the 36–40; 34 % in the 41–45 age range; 10 % in the 46–50; 14 % in the 51–55; 3 % in the 56–60; 7 % with > 60 years old) participated in the study. They worked in different regions of Spain, including DOCa Rioja, AOC Txakoli, DO La Mancha, DO Campo de Borja, DO Calatayud, as well as in other regions such as Galicia and Cantabria.

2. Procedure

All interviews were conducted individually in Spanish by three experimenters using a consistent protocol. Each interview was conducted online by one experimenter and was recorded. It was stipulated that the interviews would be audio-recorded and that the tapes would be used exclusively for academic research, with the guarantee of anonymity for the participants.

The participants were informed that the interview would encompass questions pertaining to red wine tannins and that there were no correct or incorrect responses. Throughout the course of the interview, the experimenter employed a series of clarification and reformulation questions with the objective of encouraging participants to express themselves freely and to elicit information of a more profound nature.

To start the interview, participants were asked to provide information pertaining to their sociodemographic characteristics, including their age range, gender, years of experience in winemaking, and region of production. Then, they were asked to recall their last wine tasting. This was done to facilitate their comfort and ease of participation. However, this information was not analysed; it was used merely as a warm-up. Subsequently, the participants were presented with slides containing the terms derived from Study 1, organised into 11 groups as shown in Table 2. Each group of terms was presented in different slides.

TABLE 3. List of the 64 tannin-related terms elicited in Study 1 in Spanish language (English) and presented in 11 slides in Study 2.

Slide	Terms						
1	*duro* (hard)	*agresivo* (agressive)	*reactivo* (reactive)	*pungente* (pungent)	*mordiente* (mordant)	*punzante* (sharp)	
2	*secante* (drying)	*astringente* (astringent)	*áspero* (rough)	*rasposo* (scratchy)	*elegante* (elegant)	*sutil* (subtle)	*fino* (fine)
3	*untuoso* (unctuous)	*graso* (fatty)	*meloso* (honeyed)	*sedoso* (silky)	*suave* (soft)	*dulce* (sweet)	
4	*rugoso* (coarse)	*arenoso* (sandy)	*pulido* (polished)	*terroso* (earthy)	*polvoriento* (dusty)	*granoso* (grainy)	
5	*verde* (green)	*vegetal* (vegetal)	*herbáceo* (herbaceous)	*maduro* (ripe)	*de madera* (woody)	*de roble* (oaky)	
6	*ardiente* (burning)	*picante* (spicy)	*caliente* (warm)	*fresco* (fresh)	*balsámico* (balsamic)		
7	*estrecho* (tight)	*redondo* (round)	*con volumen* (with volume)	*desabrido* (bland)	*intenso* (intense)	*apretado* (cramped)	
8	*pesado* (heavy)	*ligero* (light)	*contundente* (overwhelming)	*firme* (firm)	*sabroso* (tasty)		
9	*armado* (reinforced)	*estrucurado* (structured)	*envolvente* (enveloping)	*ensamblado* (assembled)	*equilibrado* (balanced)	*armónico* (harmonious)	
10	*despuntado* (blunt)	*desorganizado* (disorganized)	*integrado* (integrated)	*con aristas* (angular)	*descarnado* (gritty)		
11	*medio* (medium)	*potente* (powerful)	*presente* (present)	*persistente* (persistent)	*corto* (short)	*permanente* (permanent)	

For each slide, the participants were asked the following questions:

- *Please indicate whether you use or do not use the terms in the slide to describe red wine tannins.*
- *Please also indicate whether you consider any of the terms to be synonymous.*
- *Do you think that any of them have the same meaning as those we have seen before or others not yet mentioned?*
- *If possible, could you provide a word that summarises the meaning of these words?*
- *Which role do you think they have on wine quality?*
- *For those that you use, could you please provide a definition?*

3. Data Analysis

The audio-recorded interviews were fully transcribed manually and then analysed using a four-step procedure.

3.1. Frequency of citation

The number of participants who declared using any of the 64 terms was counted. Nine terms out of the sixty-four were not cited by the participants.

3.2. Valence

The number of participants who considered each term as positive, negative, or ambivalent in red wine quality was counted. If a minimum of 60 % of the participants allocated the term to one of the three categories, it was assigned to that category; otherwise, it was deemed to be ambivalent.

3.3. Dimensions and definitions

A corpus was generated for each term (n = 55) by gathering all the definitions provided by the experts. Then, two analyses were performed in parallel, one by two independent experimenters and the other by an AI tool (ChapGPT OpenAI).

The two experimenters performed a thematic analysis of the corpora to extract the sensory–conceptual dimensions underlying the terms. Seven dimensions emerged from this analysis (D1–D7: Texture, Integration, Intensity, Maturity, Physiological reaction, Hedonic evaluation, and Origin) based on consensus coding and prior theoretical categories. Finally, a consensus definition was established for each term.

The terms corresponding to each dimension and the definitions obtained by the investigators were then compared with those generated using an AI-assisted analysis. ChatGPT (OpenAI) was provided with the corpus generated for each term, with the following prompt: 'First, based on these texts, identify the different dimensions or axes linked to tannins, and then provide synthesised definitions for each of the 55 terms provided'.

The classifications proposed by the AI system were then compared with those obtained through human thematic coding. Agreement between the two approaches was observed for 44 of the 55 terms, while discrepancies occurred for 11 terms. These differences mainly involved dual-dimensional allocations, boundary ambiguities between adjacent conceptual dimensions, or cases where the AI system did not assign a dimension. All discrepancies were resolved by the experimenters through re-examination of the original interview corpus and consensus discussion.

Following this validation process, each of the 55 descriptors was assigned to one of the seven dimensions identified in the thematic analysis. It should be noted that the AI tool was used only as an analytical aid, and all final classification decisions were made by the researchers. A detailed comparison between human coding and AI-generated classifications, including the terms for which discrepancies occurred and the rationale for the final allocation, is provided in Table S1.

3.4. Semantic network

A semantic network is a structured representation of knowledge that illustrates relationships between concepts. It consists of nodes and edges that connect these nodes, representing semantic relations. Here, the nodes corresponded to the 55 lexicon terms. Each term was annotated with its assigned dimension (D1–D7) and valence (positive, negative, or ambivalent). Edges were defined using an adjacency matrix based on conceptual proximity within each dimension.

3.4.1. Adjacency matrix

The first step was to construct the adjacency matrix. This matrix is a binary matrix (1/0) encoding the semantic proximity between the 55 terms within each dimension. First, each term was classified into one of the seven dimensions identified in the previous step. Then, semantic paths were established within each dimension. For example, the path: Rough → Coarse → Sandy → Dusty → Earthy → Scratchy → Gritty → Grainy → Soft → Silky → Fine → Polished was obtained for the texture dimension (D1). These paths were initially created by ChatGPT based on the original discourse of the 29 experts and then validated by the experimenters. To create the semantic paths, ChatGPT identified ranking markers such as 1) terms comparisons ("coarser than…", "riper than…"), 2) progressions ("when it gets ripe it goes from green to sweet"), 3) polarities ("silky *vs* rough", "sweet *vs* vegetal"), and 4) scales ("light → medium → powerful"). During the validation phase, the experimenters noted inconsistencies for at least two terms by dimension. To obtain the final semantic paths, the experimenters had to determine the most appropriate sequence for each dimension. This was done in interactions with ChatGPT. Once the final semantic paths were obtained the term-by-term binary adjacency matrix (1 = connection, 0 = no connection) was constructed using the following rule:

- 1 = the two terms represent a consecutive step within a semantic path.
- 0 = there is no immediate semantic proximity between the two terms.

For example, for D1 (Rough → Coarse → Sandy → Dusty → Earthy → Scratchy → Gritty → Grainy → Soft → Silky → Fine → Polished), the adjacency between the terms rough and coarse is 1, whereas the adjacency between the terms rough and sandy is 0.

3.4.2. Dimension proximity matrix

The next step was to compute the proximity between the seven dimensions. ChatGPT was given the adjacency matrix and the original interviews. The relationships between the dimensions were based on discourse co-occurrences and semantic affinities. Co-occurrences refer to instances where terms from different dimensions appear in the same sentence. For example: "green tannins tend to feel angular and drying" creates links between D4 Green, D2 Angular, and D5 Drying. Semantic affinity is based on similarity in sensory function (*i.e.*, D1-Texture and D2-Integration are sensory close because both are *tactile-structural*), oenological mechanism (*i.e.*, D1-Texture and D4-Maturity are both related to phenolic polymerisation), and expert cognitive association (*i.e.*, "silky tannins tend to be more integrated and elegant" → D1 ↔ D2 ↔ D6).

3.4.3. Semantic network

The final step was to represent the tannin lexicon as a semantic network using the NetworkX Python package (v. 3.2). The graph layout was computed using a force-directed spring algorithm (k = 1.8, 300 iterations), which distributes nodes as a function of semantic affinity and dimension co-occurrence, generating an emergent topology in which conceptually related terms converge spatially. Inter-dimensional relationships in the semantic network emerged from the force-directed layout applied to the adjacency matrix. Node size was scaled proportionally to citation frequency, node border colour encoded valence (green = positive; red = negative; orange = ambivalent), and node fill colour represented the corresponding dimension.

4. Ethical approval

Ethical approval for the involvement of human subjects in this study was granted by CSIC Research Ethics Committee on 23/07/2021 with Reference number 134/2021. Prior to the commencement of both Study 1 and Study 2, the participants were furnished with information pertaining to the ethical requirements of the experiment and provided written (Study 1) or oral (Study 2) informed consent.

RESULTS

1. Frequency of citation and valence

Nine out of the sixty-four terms generated in Study 1 were not mentioned by any of the experts during the interviews (pungent, honeyed, spicy, tight, bland, cramped, reinforced, blunt, and disorganised tannins). Figure 1 shows the word cloud of the 55 terms cited by the participants. The larger the size of the words, the higher the citation. The valence of the terms (*i.e.*, their relationship with wine quality) is illustrated in black for negative, in light grey for positive, and in medium grey and underlined for ambivalent perception.

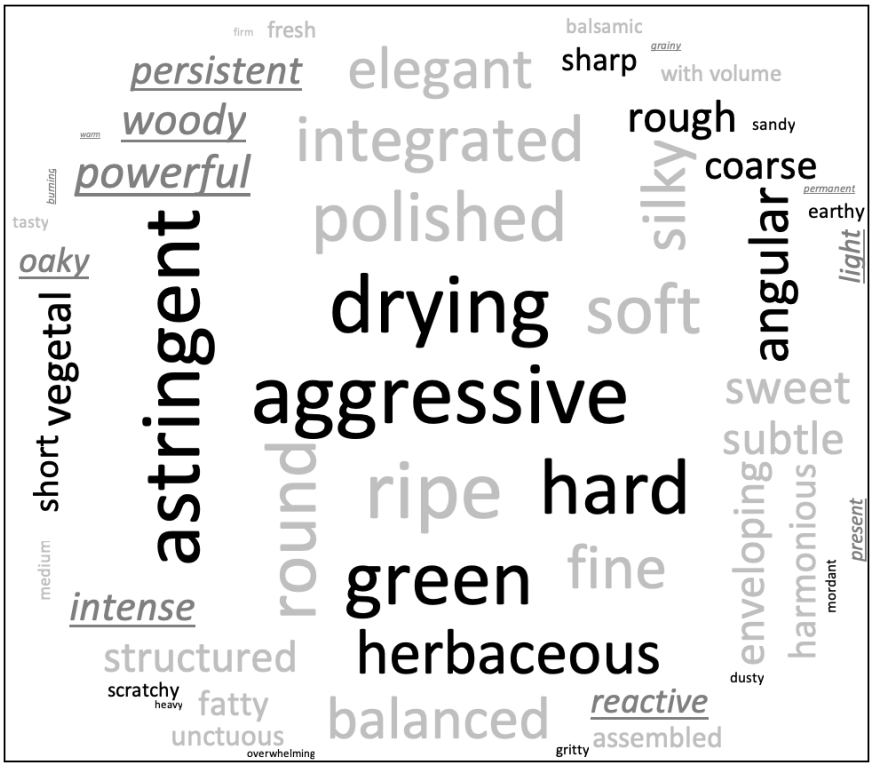


FIGURE 1. Word cloud including the 55 terms mentioned by the 29 experts in the interviews. The size of the words represents the frequency of citation (bigger size, higher citation) and the colour represents the valence of the terms (black = negative, light grey = positive, medium grey and underlined = ambivalent).

The frequency of citation and valence of the 55 terms are detailed in Table S2.

Twelve terms, including powerful, woody, persistent, intense, oaky, reactive, light, present, permanent, burning, grainy, and warm tannins, are ambivalent (underlined). The most frequently cited terms (with citations exceeding 80 %) include five negative terms (aggressive, astringent, drying, green, and hard tannins) and one positive term (ripe tannin). In descending order of frequency, eight positive terms are cited by 60 % to 80 % of participants: soft, polished, round, integrated, fine, silky, balanced, and elegant tannins. The only negative term in this range of citation is herbaceous tannin. Between 30 % and 60 % of citations, positive terms include: sweet, subtle, structured, harmonious, and fatty tannins, while negative terms are angular, rough, vegetal, coarse, short, and sharp tannins. The terms with the lowest citation rate (*i.e.*, those cited by fewer than 30 % of participants) include eight positive terms: balsamic, medium, tasty, firm, assembled, unctuous, fresh, and with volume tannins; and nine negative terms: earthy, scratchy, sandy, gritty, mordant, dusty, heavy, overwhelming, and heavy tannins.

2. Dimensions and consensual definitions

The interviews revealed seven main dimensions underlying the tannin terminology. Agreement between human coding and AI-generated classifications was observed for 44 out of 55 terms (80 %). Discrepancies mainly involved dual-dimensional associations or borderline cases between adjacent conceptual domains (Table S1). Table 4 illustrates these dimensions and the consensual definitions of the 55 tannin-related terms.

The first dimension (D1-Texture) corresponds to a tactile gradation. The second dimension (D2-Integration) represents the degree of structural cohesion between tannins and the other components of the wine (acidity, alcohol, fruity and woody aroma). The third one (D3-Intensity) is related to the quantitative presence of tannins and their structural weight in the wine. The fourth dimension (D4-Maturity) reflects the degree of ripeness of the grapes and the state of evolution of the tannins. The fifth dimension (D5-Physiological reaction) is linked to the mouth's physiological responses to tannins, such as contraction, dryness, and salivary stimulation. The sixth dimension (D6-Hedonic evaluation) corresponds to the affective and evaluative dimension of tannin. It transforms tactile sensations into value judgements. The last dimension (D7-Origin) is related to the origin of the tannins and only includes woody and oaky tannins.

Together, the seven dimensions form an integrated analytical framework linking sensory vocabulary, oenological interpretation, and perceptual polarity as shown in Table 5. D1 (Texture) reflects tactile granularity and relates it oenologically to tannin structure, confronting rough to silky tannins. From an oenological point of view, this dimension relates to structural features of tannins such as degree of polymerisation, subunit composition, galloylation, and conformational behaviour, which influence their interaction with salivary proteins and the resulting perception of astringency (Soares *et al.*, 2017; Watrelot & Norton, 2020). However, these tactile sensations are not solely determined by intrinsic tannin structure: wine matrix components, including polysaccharides, ethanol concentration, and colloidal organisation, modulate protein–tannin interactions and frictional properties, thereby shaping mouthfeel expression (Soares *et al.*, 2017; Paissoni *et al.*, 2023). D2 (Integration) describes the structural cohesion of tannins within the wine matrix and is modulated by ageing processes and macromolecular interactions, being angular and integrated the poles of the dimension. D3 (Intensity) captures the perceived quantitative presence and persistence of tannins, which depend not only on concentration but also on molecular reactivity and matrix-mediated modulation (Paissoni *et al.*, 2023) and ranges from light to powerful tannins. D4 (Maturity) indexes phenolic ripeness and evolutionary state, ranging from green to ripe expressions, and reflects compositional shifts occurring during grape development (Watrelot & Norton, 2020). D5 (Physiological reaction) captures the salivary response elicited by tannins, including drying or salivation-related sensations, linked to protein precipitation dynamics and oral lubrication mechanisms (Soares *et al.*, 2017). D6 (Hedonic evaluation) synthesises the affective judgement of tannin quality, from unpleasant to elegant, while D7 (Origin) incorporates terms linked to wood-derived tannins and their aromatic or drying contributions. This integrated framework enables a coherent description of how experts conceptualise tannin quality.

3. Semantic network

Figure 2 presents the semantic network constructed from the 55 tannin-related terms used by the 29 wine experts to describe the sensory properties of red wine. Each node corresponds to a term; its area reflects its salience in expert discourse.

The semantic network reveals a structure organised into seven dimensions that interact to form a sensory and oenological continuum. D1-Texture occupies a central position and acts as a bridge between perceptual domains: it connects directly with D6-Hedonic evaluation (*e.g.*, aggressive, elegant), showing that perceptions of graininess and smoothness immediately determine hedonic judgements; in turn, it links to D4-Maturity (via gritty → tasty) and D3-Intensity (*e.g.*, rough → intense), indicating that both phenolic maturity and the structural strength of tannin are sensorially interpreted based on perceived texture. This centrality makes texture a key structural axis from which the other dimensions are organised. D3-Intensity emerges as a transversal axis connecting D1-Texture with D4-Maturity, showing that the perception of intensity (*e.g.*, intense, powerful, firm) depends simultaneously on the graininess and evolutionary state of the tannin.

D4-Maturity, in turn, is closely linked to D2-Integration: mature terms related to integrated perception (ripe, sweet, balanced, harmonious) are grouped in the same region, while unripe terms (green, vegetal, mordant) move towards the pole reflecting the absence of harmony in D2 (angular).

TABLE 4. List of the 55 tannin-related terms cited by experts in Study 2, together with their dimension and consensual definition. (part 1/2)

Term	Dimension	Definition
Rough	D1-Texture	Tannins with rugged, irregular granularity producing a scratchy feel.
Coarse		Tannins with a rough particle size and broad granularity, producing a rustic mouthfeel.
Sandy		Tannins with granular texture reminiscent of fine sand.
Dusty		Tannins that feel powdery and fine, creating a chalky dryness on the palate.
Earthy		Tannins perceived alongside soil-like notes, often contributing to dryness and rusticity.
Scratchy		Tannins that produce a rasping sensation on oral surfaces.
Gritty		Tannins with a harsh, abrasive particle feel, generating a sandpaper-like sensation.
Grainy		Tannins with medium granularity—neither coarse nor fine—producing a subtle grain-like texture.
Soft		Tannins with low astringency, smooth texture, and gentle tactile profile.
Silky		Exceptionally smooth tannins with fluid, delicate tactile sensation.
Fine		Tannins with very small perceived particle size, giving a delicate, polished tactile sensation.
Polished		Smooth, refined, and matured tannins showing high integration and finesse.
Integrated	D2-Integration	Tannins fully merged with other wine components, producing smoothness and unity.
Round		Tannins with smooth, curved sensory contours—soft, full, and lacking edges.
Harmonious		Tannins fully aligned with the wine's structural elements, producing a seamless palate profile.
Balanced		Tannins in equilibrium with acidity, alcohol, fruit, and body.
Assembled		Tannins well-combined within the matrix, contributing to unity.
Structured		Tannins that provide backbone and architecture to the wine.
With volume		Tannins expanding in the mouth, contributing to three-dimensional fullness.
Enveloping		Tannins that coat the palate smoothly and uniformly, giving a sense of volume.
Angular		Tannins with sharp, pronounced edges, lacking roundness.
Light	D3-Intensity	Soft, low-intensity tannins with minimal structural weight.
Medium		Moderately intense tannins providing balanced structure.
Powerful		Dominant, concentrated tannins with strong structural impact.
Intense		Strongly present tannins with clear persistence.
Overwhelming		Tannins so strong they overshadow other sensory elements.
Firm		Strong structural grip supporting the wine without harshness.
Persistent		Tannins that last well into the finish.
Present		Clearly perceptible tannins providing noticeable grip.
Permanent		Tannins continuously perceptible throughout the tasting duration.
Warm		Tannins giving a gentle heating sensation, usually alcohol-related.
Burning		Tannins producing a warm, prickly or heated tactile sensation.
Short		Tannins with brief, quickly disappearing presence.
Green	D4-Maturity	Under-ripe tannins with bitter, vegetal, or harsh sensations.
Herbaceous		Tannins associated with green, leafy aromatic, and tactile notes.
Vegetal		Plant-like, green tannins linked to under-ripeness.
Mordant		Biting tannins that 'grip' with reactive bitterness.
Reactive		Young tannins with high protein-binding capacity and evolution potential.
Ripe		Well-matured tannins with softened reactivity and smooth mouthfeel.
Sweet		Soft, ripe tannins giving a sweet-like tactile impression.
Fatty		Tannins producing a dense, creamy, slightly viscous sensation.
Unctuous		Rich, viscous tannins enhancing mouth-coating roundness.
Balsamic		Tannins softened by balsamic-like aromatic notes.
Tasty		Tannins contributing to a flavourful, pleasant, juicy finish.

TABLE 4. List of the 55 tannin-related terms cited by experts in Study 2, together with their dimension and consensual definition. (part 2/2)

Drying	D5-Physiological reaction	Tannins rapidly inducing dryness by reducing salivation.
Astringent		Tannins strongly precipitating salivary proteins, producing contraction.
Fresh		Tannins that stimulate salivation, giving a juicy, lively finish.
Sharp		Piercing, pointed tannins linked to acidity–tannin synergy.
Elegant	D6-Hedonic evaluation	Refined, subtle tannins contributing to finesse.
Subtle		Tannins contributing discreet complexity without dominance.
Aggressive		Harsh, forceful, unbalanced tannins.
Hard		Firm, angular, resistant tannins lacking softness.
Heavy		Dense, weighty tannins creating a burdensome mouthfeel.
Woody	D7-Origin	Wood-derived tannins giving dryness and oak notes.
Oaky		Oak-driven tannins contributing aromatic and structural wood character.

TABLE 5. Relationship between tannin dimensions, sensory cues, suggested oenological interpretation, and their polarity.

Dimension	Sensory vocabulary	Oenological interpretation	Polarity
D1-Texture	Tactile granularity	Polymerisation, subunit composition, galloylation, conformation	Rough/silky
D2-Integration	Structural cohesion	Ageing, macromolecular interactions	Angular/integrated
D3-Intensity	Persistence	Concentration, reactivity, matrix modulation	Light/powerful
D4-Maturity	Phenolic	Grape ripeness, phenolic evolution	Green/ripe
D5-Physiological reaction	Physiological	Saliva-tannin interaction	Drying/salivating
D6-Hedonic evaluation	Affective/aesthetic	Overall synthesis	Unpleasant/elegant
D7-Origin	Aroma and dryness	Origin	

D5-Physiological reaction is close to D1-Texture and D6-Hedonic evaluation, indicating that physiological sensations (*e.g.*, drying, astringent, fresh) act as a modulator between texture and hedonic evaluation. Finally, D7-Origin forms a peripheral cluster, but maintains weak connections with D2-Integration and D3-Intensity, reflecting that woody descriptors (woody, oaky) mainly affect the overall harmony of wine and perception of potency, rather than texture or maturity.

Taken together, the network describes a sensory system in which Texture (D1), Intensity (D3), and Maturity (D4) form the integrative core of meaning, while Integration (D2), Physiological reaction (D5), Hedonic evaluation (D6), and Origin (D7) are organised as modulators of this central continuum.

DISCUSSION AND CONCLUSION

This study provides a multidimensional characterisation of the vocabulary used by experts to describe wine tannins, highlighting the profoundly ill-defined nature of many descriptors and the considerable idiosyncrasy in their use. In line with previous reports on terminological inconsistency (Ivanova *et al.*, 2022; Paissoni *et al.*, 2023), our findings show that only six of the fifty-five terms receive more than 80 % of citations (aggressive, astringent, drying, green, hard, ripe), whereas a substantial number are used infrequently. This asymmetric distribution supports the existence of a small shared lexical core accompanied by a broad, variable semantic periphery, even among experts from similar professional contexts.

A major insight is that tannin terms are not based solely on tactile phenomena such as granularity or dryness, nor exclusively on bitterness associated with polyphenolic content (Soares *et al.*, 2017). Instead, experts construct their descriptions through the integration of multiple sensory and conceptual dimensions, including integration, phenolic maturity, persistence, physiological reactivity, and hedonic evaluation. These dimensions extend the meaning of tannin descriptors far beyond astringency and bitterness, reflecting the complexity of expert conceptualisations. The semantic network reveals a structured and interconnected lexicon in which Texture (D1), Intensity (D3), and Maturity (D4) form a central core of meaning. These dimensions show the highest connectivity and contain the most frequently cited descriptors, indicating their cognitive primacy in how experts perceive and articulate tannic behaviour. Surrounding this core, Integration (D2) and Hedonic evaluation (D6) act as interpretative layers that translate textural and maturational cues into assessments of balance, smoothness, or quality, reflecting their dependence on the central sensory axes. In contrast, Physiological reaction (D5) and Origin (D7) occupy more peripheral positions, with lower frequency, yet they still modulate the network by linking tactile dryness to astringency or by introducing wood-derived structural notes.

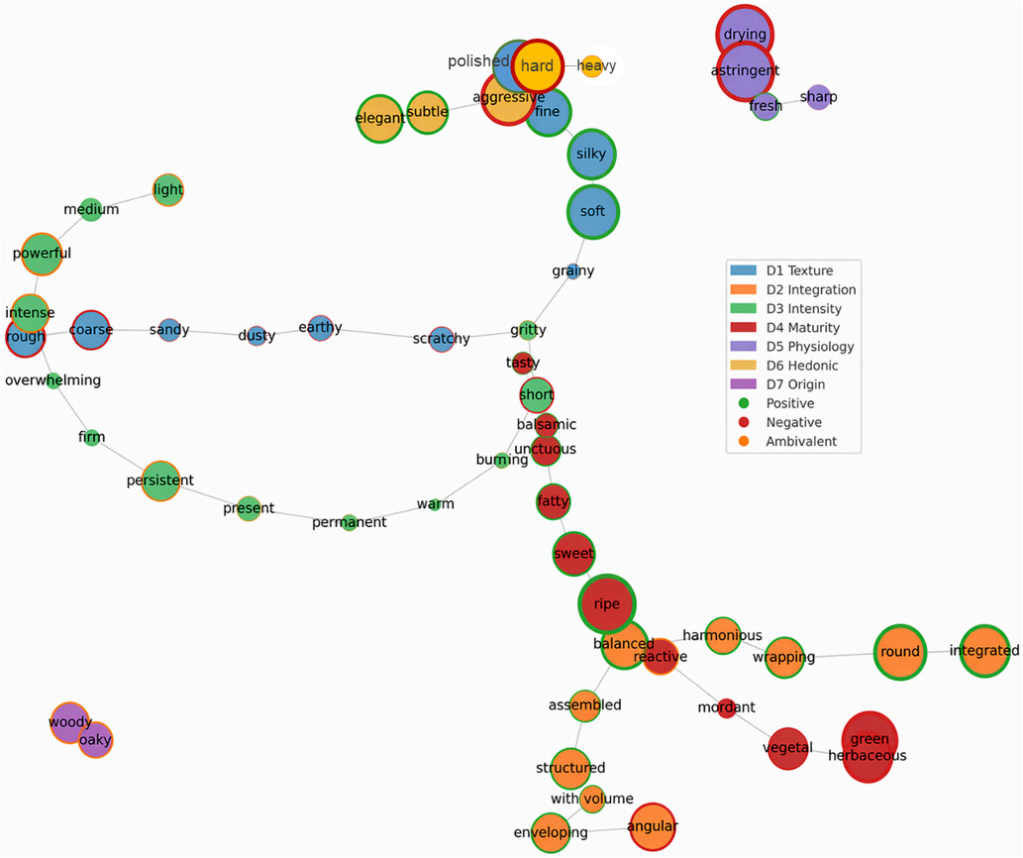


FIGURE 2. Semantic network of the tannin lexicon used by wine experts (55 terms). Nodes represent sensory descriptors and are scaled according to citation frequency. Node fill colours correspond to descriptor categories (D1–D7). Border colours indicate the valence associated with each term (positive, negative, or ambivalent), and thickness is proportional to frequency. The force-directed layout reveals coherent semantic clusters aligned with perceptual domains such as texture, integration, intensity, and phenolic maturity.

The semantic network further illustrates that tactile cues interact with aromatic and gustatory information, particularly within the integration, maturity, and origin dimensions. This aligns with research showing that expert language is inherently multisensory and conceptually organised (Honoré-Chedozeau *et al.*, 2020; Parr *et al.*, 2011). Terms such as "green", "ripe", or "sweet" derive meaning from both tactile impressions and aromatic markers linked to phenolic evolution, whereas descriptors like "balanced" or "round" arise from judgements about the interplay between tannins, acidity, alcohol, body, and aroma. Such findings underscore that experts engage in inferential reasoning based on prior oenological knowledge—vintage conditions, viticultural practices, grape variety, or origin—rather than relying solely on immediate perception.

As reported in earlier studies (Ballester *et al.*, 2008; Bianchi *et al.*, 2021), experts employ a technical and knowledge-based cognitive framework that differs markedly from that of consumers or less experienced tasters. Our results illustrate how expert interpretations depend on tacit knowledge, experience, and the tasting situation. For example, a *grainy* tannin is not used merely to denote a specific tactile granularity, but often to signal an intermediate tannin state that experts recognise from experience with wines at different stages of evolution. Likewise, terms such as *ripe*, *green*, or *reactive* reflect internalised expectations about phenolic maturity rather than direct sensory cues alone. Even ostensibly evaluative terms such as *elegant* or *aggressive* emerge from this interpretative background, their meaning shifting depending on wine style, age, and structural context. Taken together, these patterns highlight that expert tannin vocabulary functions as a context-dependent interpretative system, shaped by exposure and situational judgement rather than by isolated perceptual impressions.

These insights have implications for communication within the wine sector. Consumers frequently misunderstand technical terms or interpret them inconsistently (Ivanova *et al.*, 2022; Croijmans *et al.*, 2020), which contributes to a persistent gap between expert vocabulary and consumer perception. To bridge this gap, several strategies emerge. First, the present work provides a basis for standardised glossaries and consensual definitions, in line with OIV recommendations (OIV, 2015). Second, the use of visual semantic maps—such as the network presented here—can clarify relationships among descriptors. Third, pedagogical tools based on controlled metaphors and validated experiential descriptors (Rodrigues *et al.*, 2025) may improve comprehension in non-expert contexts.

The semantic structure observed in this study suggests that variability in term use does not arise from randomness but from an underlying conceptual organisation. This opens avenues for computational approaches and AI-based training tools capable of detecting inconsistencies and supporting vocabulary standardisation—an aspect explored here through the comparison with IA tools (namely ChatGPT).

Overall, this work demonstrates that understanding the conceptual foundations of expert vocabulary is essential for developing a more precise, communicable, and accessible language of wine. By combining qualitative analyses, semantic structuring, and network modelling, this study offers a framework that can inform future efforts in sensory education, research, and wine communication.

Across the semantic network, the topological configuration highlights hierarchical organisation, cross-dimensional linkages, and transitional zones that reveal how experts cognitively structure tannin-related concepts. The integration of frequency, valence, and sensory dimensions provides a comprehensive model of tannin perception, aligning sensory, chemical, and evaluative components. Importantly, the present study relies on a memory-based, non-tasting approach, which facilitates the generalisation of results beyond specific wine samples and captures stable, experience-derived mental representations. Nevertheless, this approach could be strengthened by incorporating real-time sensory evaluation, which would allow dynamic cues to emerge and potentially reveal context-dependent shifts in descriptor use. A combined non-tasting and tasting strategy may therefore provide deeper insight into the cognitive grounding of tannin terminology.

Despite the notable strengths of the paper, a limitation of the present work is that the expert sample, although diverse in experience and regional origin, was limited to Spanish winemakers, which may restrict the generalisability of the semantic structures identified. Sensory language is shaped not only by perceptual experience but also by professional training, stylistic conventions, and cultural narratives surrounding wine (Parr *et al.*, 2011; Temmerman, 2017; Honoré-Chedozeau *et al.*, 2020). Therefore, the semantic configuration observed in this study may partly reflect regionally shared conceptual frameworks. Cross-cultural and cross-linguistic replications would be necessary to determine the stability of the identified dimensions and to evaluate the feasibility of constructing a broadly harmonised tannin lexicon across wine-producing contexts.

Future research should extend this work by comparing expert and consumer networks to more precisely quantify semantic gaps, investigating how training influences descriptor use over time, and testing whether targeted sensory-lexical interventions improve communication accuracy. Additionally, integrating chemical and sensory kinetic data with semantic modelling could deepen our understanding of how physical wine properties map onto expert conceptualisations. Overall, advancing towards shared, transparent terminology will require interdisciplinary collaboration between sensory science, linguistics, oenology, and data science.

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