FINGERPRINTING AS AN APPROACH TO UNLOCK THE BLACK BOX OF TASTE

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Taste is not personal

For many people taste is something personal, a subjective concept. That seems to be the most logical perspective: a person tastes. Consequently, taste must be personal, right? This seemingly logical way of thinking becomes less logical if taste and tasting are distinguished, similar to how colour and vision are separated. If you open a bottle of wine and serve a number of people from it, it is likely that different perceptions of the characteristics of the wine are reported. Some may even dislike the wine, whilst others appreciate it. Yet all the glasses come from the same bottle. Taste can therefore be best defined as a product characteristic, and thus as an inherent quality or descriptive factor of the product. Tasting is the perception of taste by humans. Upon separation of these concepts, the door is open to a more objective approach to taste, based on measurable characteristics of products.

Instrumental techniques that are able to analyse and classify wines based on quantifiable properties, will allow the wine industry to have fast, repeatable and cheap characterization of wine compared to the use of a panel (Laguna et al., 2017). The T.A.S.T.E. foundation developed an innovative and advanced approach to analyse and evaluate taste based on the molecular composition of products. An elaborate chemical fingerprint is correlated to a new model by means of an algorithm. A three-dimensional space is constructed using individual coordinates, allowing for comparison between products. Although the analyses and algorithm are still in development, we present the first experiences and insights. Deeper insights in the intrinsic qualities of products open the black box of taste. Potentially this will enable producers to match taste to consumer preferences. That is what defines 'tasty': the right match between what products have and what consumers want (figure 1).

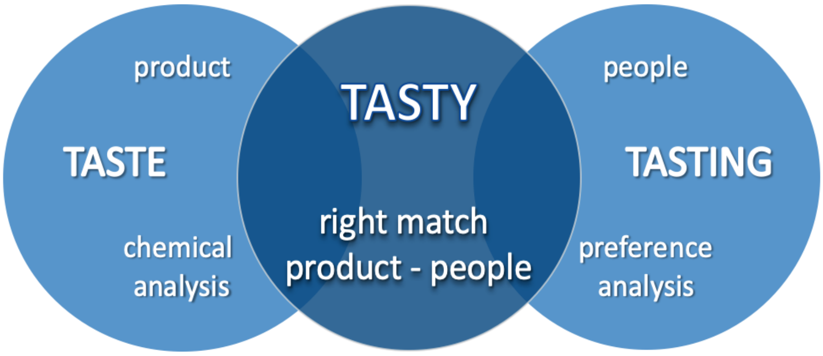

Figure 1: Tasty: a combination of taste and tasting

Mouthfeel as taste descriptor

In describing the taste of foods and beverages the so-called ‘basic tastes’: sweet, sour, bitter, salty and umami are often used. Yet, clearly, what we eat and drink does not simply consist of these basic tastes. All foods and beverages, wines included, are a certain composition of water and a number or all of the so-called macromolecules: proteins, fats, nucleic acids and carbohydrates (Privalov & Crane-Robinson, 2017). To make sense of taste, all elements that contribute to taste perception need to be taken into account. The question is how.

In a recent review about mouthfeel classification, Agorastos et al. (2020) suggested a new perspective for flavour classification based on the mouthfeel model. In this model, the gustatory (the ‘basic tastes’) and trigeminal (pain, touch and irritation) elements are integrated. In this perspective, mouthfeel comprises the chemosensory and somatosensory elements of taste. Three different categories are distinguished: ‘contracting’, ‘coating’ and ‘drying’, which can be individually scaled for intensity. These mouthfeel categories are umbrellas of different sensory attributes. Ingredients contributing to the same group are likely to magnify intensity, whereas different groups can likely show suppression or masking effects. Figure 2 shows the structure of the mouthfeel model (Klosse, 2013).

From this structure, a three-dimensional product space can be derived (figure 3). Contacting, coating and drying form the ribs of a cube. The classification of products based on their mouthfeel profile visualizes the differences in the mouthfeel profile of products. This increases the understanding of the perception of flavour, as it is considered to be the combination of mouthfeel (all non-volatiles) and aroma (all volatiles). For the application of the mouthfeel model to the wine matrix, the essential components need to be related to the dimensions contracting, coating and drying to determine the coordinate in the product space.

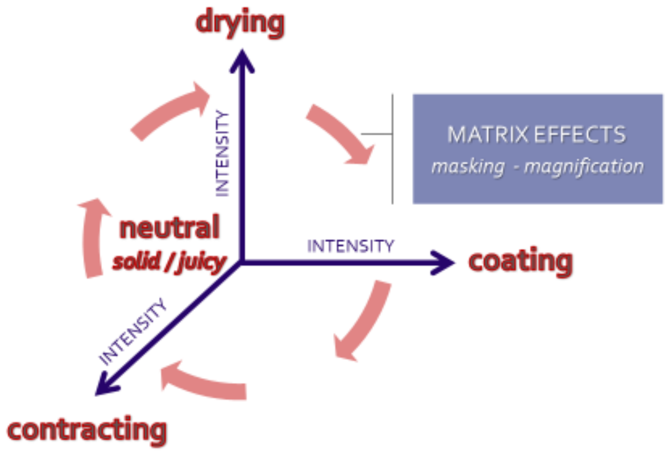

Figure 2: classification of mouthfeel in contracting, coating and drying

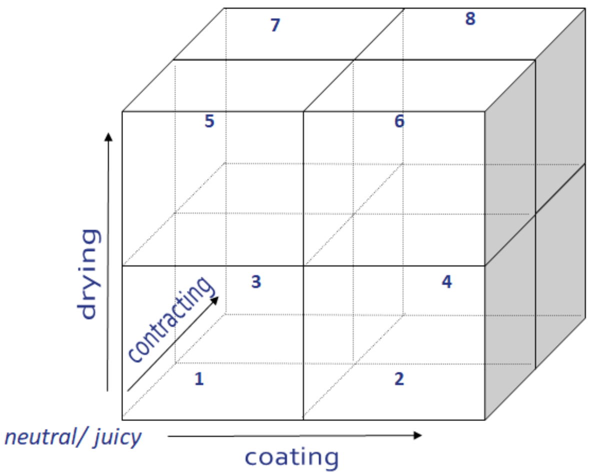

Figure 3: The three-dimensional product space based on the mouthfeel model (Klosse, 2013)

Mouthfeel of wine

Wine is a unique and complex alcoholic beverage that creates numerous sensations. The wine flavour is a combination of sensory modalities including perceptions of aroma, taste and mouthfeel (Prescott, 2012). Although mouthfeel is important for flavour perception, it is still the least understood. This especially applies in complex beverages as wine (Saenz-Navajas, et al., 2020). Gawel et al. reported that mouthfeel refers to tactile, irritant and thermal sensations after the activation of receptors within the oral cavity (Gawel et al., 2018). In literature, there are few scientific papers that relate oral sensations (e.g. ('fullness') to what consumers often associate with the quality of wine (Hopfer & Heymann, 2014; Saenz-Navajas et al., 2016; Varela & Gambaro, 2006; Saenz-Navajas, et al., 2020). Mouthfeel sensations are usually described by various terms such as astringency, hot, viscous, body, warm, acidic, etc. These sensory attributes are often described by expert wine tasters and they are considered as general and subjective terms.

Organic acids such as malic, lactic and tartaric acids are mainly responsible for the sour or acidity sensations (Lee et al., 2013). These are contracting forces, just as mineral salts and CO_2. However, the contribution of these forces is not equal. The intensity of tartaric acid is for instance higher than lactic acid (Ganzevles & Kroeze, 1987). Residual sugar, polysaccharides and alcohol contribute to the coating dimension as they are reported to increase viscosity and provide "fullness" (Vidal et al., 2004; Nurgel & Pickering, 2005). Phenolic compounds and especially tannins have been shown to elicit sensations that can be classified as drying, with astringency being the most well-known of the drying element in mouthfeel (Kennedy et al., 2006; Brossaud et al., 2001; Preys et al., 2006).

Measuring the individual components in the wine matrix provides a first indication of the mouthfeel properties. Next, there are interactions between components to be considered. These interactions can lead to synergistic and antagonistic effects. Intensities of elements can be enhanced or magnified while other components have a masking effect (mixture suppression). In general, a combination of compounds within the same category seem to have a magnifying effect, whilst a mix with elements of another category often appear to have a masking effect.

Many people are familiar with the masking effect of sugars and acids (Zamora et al., 2006). Polysaccharides potentially mask the dryness of astringency (Gawel et al., 2016). Generally, ethanol is considered to have a coating effect. However, it is also associated with heat/irritation (Gawel et al., 2007). Furthermore, it is suggested that ethanol modulates astringency due to its interference with the saliva protein and polyphenol interactions (which cause dryness) (Fontoin et al., 2008; Pascal et al., 2008). Knowledge of such matrix effects show the importance of looking at the whole matrix, and not only individual components.

Materials and methods

In this experiment 31 sample wines were analysed of a classified growth from the appellation Margaux in the Haut-Médoc region of Bordeaux. These wines originated from specific plots. Every plot represented a specific grape variety, planted in different years and grown on plots with slightly different soil compositions and/or exposition. The grapes of these plots were all vinified separately. The resulting wines had markedly different characteristics. These samples were analysed in the first quarter of the year, following the harvest, after malolactic fermentation.

The wines were analysed both chemically and organoleptically. For the chemical analysis a custom-made flow analyser was used. This instrument was designed to measure the essential contracting, coating and drying components. It was a configuration of different modules, which enabled the measurement of several components in one flow. Different analysis instruments and methods were used: UV/VIS system (Ultrospec 2000, Pharmacia), selective ion electrodes, nomascan (NomaSense Polyscan C200, Vinventions) and continuous flow analyser (Flow Analyzer San++, Skalar).

The samples were also tasted by a trained sensory panel. Panel members rated the perceived intensities of the dimensions of the mouthfeel model and noted specific characteristics if applicable. The results of the sensory panel were compared to the chemical results. By combination of data from sensory research, literature and chemical analyses, the basis has been laid for an algorithm which is the basis for the translation of the absolute and relative measurement data in relation to the mouthfeel. In this translation, it ultimately revolves around magnifying and masking effects. In essence, it is a learning system as threshold values and weighting factors are continuously examined.

The T.A.S.T.E. algorithm enables scaling the resulting fingerprint on the contracting, coating and drying axis. The resulting coordinate was plotted in the three-dimensional product space, visualising the differences in the samples.

Results

The different cuvées are ultimately used to compose the first, second and other wines of the estate. Clearly, the objective for the first wine of a classified growth is to make the best possible composition of the cuvées. It is up to the wine producer to define the desired flavour profile, within the limits of the quality of the harvest. Having a large selection of different cuvées enables making choices. The TASTE approach gives useful insights in the taste profile of wines. To illustrate, the results are presented of six of the 31 cuvées: two merlots (M61 and M65), two petits verdots (PV41 and PV42), a cabernet franc (CF54) and a vin de presse (PC). Figure 4 shows the fingerprint of the six selected cuvées.

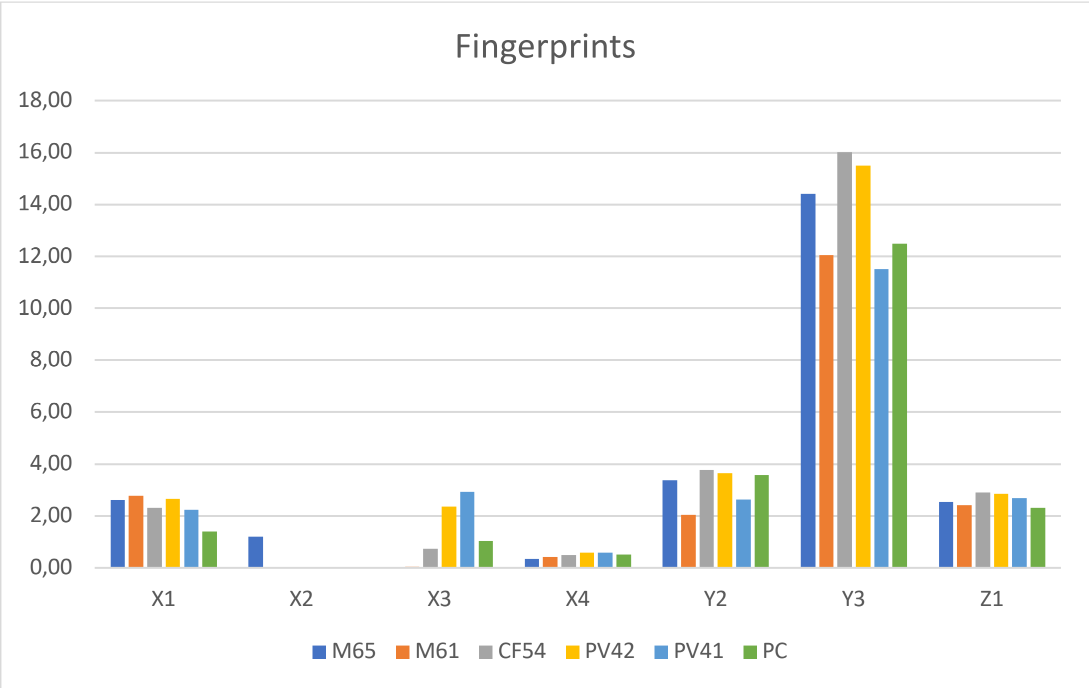

Figure 4: The fingerprint of 6 selected cuvées. X are the most important contracting elements (g/L). Y are the predominantly coating elements (g/L) and Z are the elements contributing to drying (mg/L)

The concept of fingerprinting, the depiction of measurements of the individual components, is not new. The TASTE approach brings this type of analysis to a next level by taking matrix effects into account. Our algorithm enables us to aggregate the measured elements and determine their contribution to contracting. coating and drying. The resulting coordinates of the samples are shown in table 1. In figure 5 these coordinates are placed in the three-dimensional product space, which clearly visualizes the different characteristics of the samples.

CUVÉES	CONTRACTING	COATING	DRYING
M65	10,46	16,60	10,36
M61	5,74	7,60	8,93
CF54	3,12	26,27	14,46
PV42	4,41	22,77	13,82
PV41	3,48	6,51	11,82
PC	1,55	9,35	8,07

Table 1 The coordinates of the six cuvées, after applying the algorithm

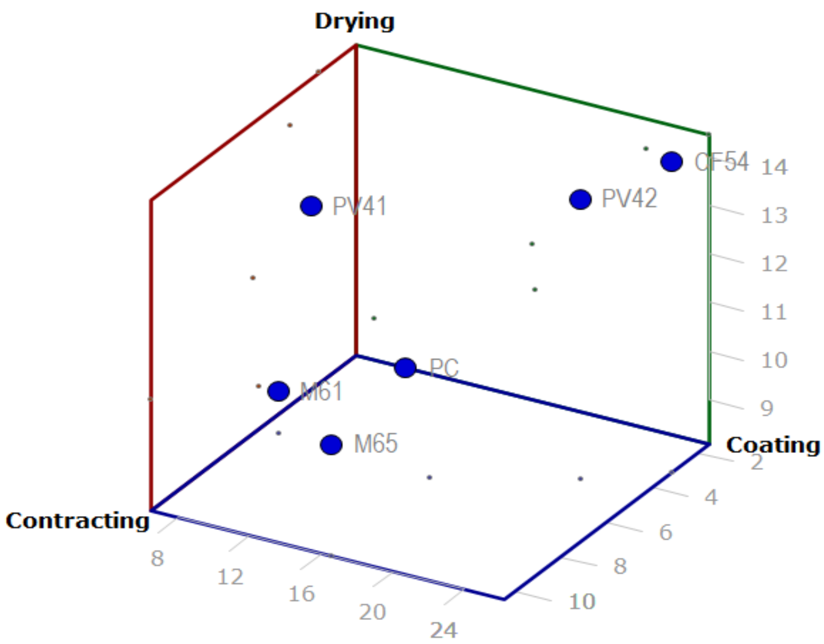

Figure 5 The position of the six cuvées in the three-dimensional product space

Discussion

The presented TASTE approach is a way to open the ‘black box’ of taste in the sense that it is focused on learning how a certain input (wine) leads to an output (a sensory evaluation of the wine). The approach is based on three prerequisites. The first is the distinction between taste and tasting. Taste is defined as a product characteristic which implies the analysis of the molecular composition. The second is the inclusion of all elements that contribute to taste registration. In other words, the analysis should not be limited to the basic tastes. In the case of wine, this implies for instance the inclusion of phenolic compounds and polysaccharides. Thirdly, and most complex of all, is the recognition of matrix effects, especially the masking and magnifying effects. The mouthfeel model provides a useful basis to describe taste.

The TASTE approach is an instrumental technique to classify wines. When applied to the six samples that are reported in this experiment, the differences in taste are made visible. This approach can potentially replace sensory techniques, such as descriptive analysis. Classical sensory analysis techniques where panellists are asked to report taste based on characteristic sensations and their intensities are expensive and time-consuming. Furthermore, differences in the sensory analysis can be found between trained and untrained panellists (Lehrer & Lehrer, 2016). Preference and intrinsic qualities are often confounded (De Mets et al., 2017). This instrumental technique classifies wines based on mouthfeel properties, which enables the wine industry to have fast, repeatable and cheap wine characterization compared to the use of a panel (Laguna et al., 2017).

The classification of wines is useful in several respects. In this experiment, the information on the different taste profiles of the presented samples could be used in blending. To illustrate, have a closer look at the two merlots. Their profiles are quite different. The coating side of the merlots is likely to have a masking influence on the dryness of the PV42 and the CF54. However, contracting forces magnify dryness. Therefore, it is to be expected that the M61 is the better choice in the blend compared to the M65.

Some other predictions can also be derived from figure 4. A blend of the M61, PV41 and PC will give a wine that is more on the contracting side. And the wine that is a blend of the PV42 and the CF54 will be on the drying side and is likely to lack some contracting elements and will therefore be perceived as imbalanced. Evidently, all these assumptions can be tested by actually making the blends and taste them. This is important for the development of the algorithm, making it a learning system that gets better over time. Positive experiences with machine-learning and algorithm development have already been reported to predict astringency (Saenz-Navajas et al., 2019).

Conclusion

The aim of this research was to gain a deeper understanding of the relation between wine compositional factors and mouthfeel sensations. This experiment had three objectives: (i) to apply the mouthfeel model in the context of wine; (ii) to test an innovative instrumental method to classify wines and (iii) to use the results of the classification.

Firstly, the results from this study were found to increase the knowledge of chemical variables related to the perception of wine astringency and provide tools to control and optimise grape and wine production stages to modulate astringency and maximise quality and the consumer appeal of wines.

Secondly, the mouthfeel model allows for a holistic evaluation of wines, which can be directly translated in terms which are comprehensible for consumers. The importance of common mouthfeel terminology, in order to achieve better communication between wine experts and consumers, has been already demonstrated by Gawel et al (1997). In 2000 Gawel et al. developed a wine mouthfeel wheel based on a hierarchical classification. The aim of this mouthfeel wheel was to facilitate communication among wine consumers. However, Vidal et al. (2015) showed that less experienced consumers did not understand most of the terms, which suggested that there is still a lack of understanding among wine audience. The mouthfeel model has been developed for everyone ranging from food professionals to consumers, bridging the communicative gap. It provides efficient communication and wine classification between consumers and wine experts (Klosse, 2013).

Thirdly, the visualization of the results gives better insights in the composition of wines. These insights can be applied to what is known from matrix effects, like masking and magnification. Consumer preferences can also be analysed, which allows for optimizing taste to consumer preferences. As foods can also be classified with the concepts of the mouthfeel model, this classification can also be used for wine and food pairing. We aim to progress in quantifying the model and developing scales to be able to measure mouthfeel as a primary indicator.

To conclude, this approach bridges taste (products) and tasting (people). The mouthfeel model facilitates communication and the marketing of wines. This instrumental, reliable and innovative technique has the potential to develop into a useful tool for the wine industry.

Summary

New insights in taste offer opportunities to wineries. The wines' chemical composition is analysed using innovative and advanced analysis techniques, The resulting data are interpreted by an algorithm which is trained to aggregate the wines' individual characteristics. This allows for placing wines in a three-dimensional space, which facilitates comparison between wines and facilitates communication about taste. Unique to this approach is that matrix effects, like masking and magnification, as well as trigeminal sensations are combined in one model. The TASTE approach has been developed as an instrumental technique to classify wines quickly and reliably. It was tested on the cuvées of a classified growth in Bordeaux. The results are presented. This approach gives useful insights in the taste of wines. The model that is used visualizes the differences between the taste of wines and facilitates communication among consumers and wine experts. Furthermore, using this tool the taste profile of a wine can be tuned to the desired taste profile of a consumer target group. Taste is less of a mysterious 'black box', but starts to become a tool to optimize quality and consumer appeal of wines.

Keywords: fingerprinting, mouthfeel model, classification, chemometrics, consumer preferences, taste

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