Quality of Pinot Noir Wine

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Wine quality is an important concept for each of these disciplines, as well as for both wine producers and consumers. Any technique that could help producers to understand the nature of wine quality and how consumers perceive it, will help them to design even more effective marketing strategies.

Pinot noir wine quality Buckingham Pi theorem

1. Introduction

Wine tasting involves an interaction between an individual and a sample of wine. Everyone has a unique wine tasting experience, due to both physiological (e.g., sensitivity to a particular taste stimulus) and psychological processes, the latter including the individual's unique, domain-specific experiential history [1]. Despite these established inter-individual differences, sufficient consensus exists amongst wine professionals and to a lesser degree, the consumer [2] for wine tasting studies to offer a reasonable degree of validity and reliability when investigating abstract wine attributes such as quality. For example, a Pinot noir wine that is perceived as being balanced and harmonious requires certain proportions of basic flavour and textural components [3]. Pinot noir is quite a costly wine, due to the high demand and challenging growing conditions for the grapes. In the world of wine, the complex flavour palette is unmatched, and it has a silky body and excellent ageing. Nonetheless, wine is a mixture of serendipity, culture and science, such that any innovative scientific approach that can integrate and model the relevant phenomena has the potential to pave the way to identify characteristics that individuals find pleasing (or dis-pleasing) to inform producers to both produce a more pleasing diversity of wines with appropriate characteristics for diverse consumers. Since the Second World War, the use of humans to assess the quality of food and beverage products has increasingly become the domain of science rather than industry [4]. An outcome of this is that nowadays, many food production companies make important decisions based on the scientific data produced by a panel of human assessors, rather than relying on the traditional model of an in-house taster [5]. Despite recent scientific interest, much of how people go about making sensory-based judgments of food products, i.e., the precise sensory and cognitive processes implicated, remains elusive. This is especially so with respect to complex food products such as wine.

2. Perception of Quality in Pinot Noir Wines

Recent years have seen the more abstract and elusive attributes of wine, including perceived quality, come under scientific scrutiny [3][6][7][8][9]. Both the perceived quality [3] and conceptualised quality [8] have been demonstrated to constitute multi-dimensional concepts involving intrinsic factors such as perceived balance and harmony, as well as

extrinsic factors including wine price and the knowledge of the producer [3][10]. Further, overall quality appears to be a positive aspect of a wine for both wine professionals and wine consumers [8], with wine professionals also associating quality with the important, somewhat abstract wine attributes of complexity and varietal typicality [6].

In terms of the specific, intrinsic wine characteristics that drive perceived quality, some commonalities occur across wine types (e.g., in all red wines) and across grape varieties. For example, perceived bitterness has been shown to be associated with less preferred or lower quality wines across several red wine varieties, including New Zealand (NZ) Pinot noir [7] and Australian Cabernet Sauvignon and Shiraz/Syrah [11]. Such commonalities across wine varieties in terms of what constitutes quality appear rare, however, and the overall picture provided from the limited literature published to date suggests that the intrinsic characteristics important to wine quality differ across individual products, i.e., wine varieties. In the present research, the focus is limited to the fine red table wine Pinot noir.

Vitis vinifera L cv. Pinot noir produces table wines commanding amongst the highest prices paid for bottled wine anywhere in the world. The fine wines produced from this red grape express a combination of delicate [12], aromatic qualities and revered in-mouth attributes, the latter comprising a firmness or strength alongside a softness or silkiness [13][14][15][16]. These intrinsic qualities are assumed to have their source in the particular phenolic profile of the grape variety [3]. That is, Pinot noir grapes are typically reported as having a lower concentration of anthocyanins and tannins than many other well-known red varieties [17][18], this aspect of wine chemical composition giving rise to Pinot noir's varietal typicality [6]. Inherent in the varietal nature of Pinot noir wine is a wine at the lighter end of the red wine colour spectrum, and a wine with a combination of specific floral and fruity aromas [6], along with tactile qualities, providing a power or strength combined with a soft, silky texture in the taster's mouth [7].

In two previous studies, Parr and colleagues [6][7] investigated the specific wine characteristics perceived as being important to wine professionals' judgments of Pinot noir overall quality. The studies employed the same 18 NZ Pinot noir wines and similar sensory methodologies, namely, a descriptive rating of experimenter-provided wine characteristics and sorting (classification) procedures (see [19] for the methodological and theoretical elaborations of these procedures). Experiment 1 [6] had as its focus predominantly aromatic attributes of the wines, whilst the second experiment's focus was in-mouth wine attributes and in particular, wine texture. That is, the second research focused on wine attributes pertaining to taste (bitterness, sourness, and sweetness) and trigeminal stimulation, the latter being known as the mouthfeel of a wine [7]. Further, each study reported upon selected physicochemical aspects of the wines, with instrumental colour measuring being a focus in Experiment 1 and wine phenolic composition being the focus in Experiment 2. These studies were consistent in showing that the perceived quality differed significantly across the 18-wine sample set, an important prerequisite factor for differences in wine quality to be modelled via machine learning algorithms. The data from both experiments were consistent in showing that when a wine was perceived as being true to its variety, i.e., demonstrating high varietal typicality, it was also rated higher in perceived quality. Each study further demonstrated the specific sensory wine attributes, aromatic and textural, driving professional wine judgments of Pinot noir wine's overall quality, along with several

physicochemical correlates of the key sensory phenomena demonstrated. The data from these two studies have been employed as the sensory data in developing data driven and mathematical approaches to model wine quality.

3. Modelling Human Responses to Sensory Stimuli

Advances in technology over recent decades have permitted developments aimed at either replacing or modelling human responses to sensory stimuli. The purpose of such developments is to improve the reliability and/or validity of the data gathered in response to sensory stimulation, the desire for increased accuracy being driven by the known idiosyncratic nature of human perception, in particular with respect to the process of olfaction [4], olfaction being a process that is extremely important in wine sensory assessment. For example, electronic noses (E-noses), with their array of sensors, have been employed to detect a range of volatile qualities in a wine, in particular, those gases producing what typically are considered as the wine faults or off-notes [20][21].

In terms of attempts to model how the human sensory system interprets and appreciates a complex product such as wine, various technologies associated with neuroscience (e.g., EEG to measure cerebral electrical activity and cerebral imaging techniques) have been employed. In the limited research endeavours published to date [22], this approach has been aimed at providing more objective data and outcomes relative to those provided using a cognitive analysis of wine tasting phenomena [1]. That is, a cognitive analysis of wine-tasting data requires the use of intervening variables to define constructs such as expectations, cerebral representations, memories, and so forth, to interpret data from sensory-based judgments. Such neuroscience-based studies have been limited in their effectiveness in providing an understanding of the precise processes implicated in sensory judgments of wine. That is, whether a study participant can ‘taste’ a wine with any degree of ecological validity whilst lying prone in a scanning device used for cerebral imaging.

More recently, researchers have begun to develop and apply artificial intelligence and machine learning approaches to take some of the uncertainty out of wine production and wine assessment. Viticultural and oenological phenomena, including weather patterns, soil types, fruit ripeness, and wine classification have been of particular interest [23][24][25][26][27]. In terms of appreciating and judging the finished wine in the glass, limited studies have begun to appear that involve the use of machine learning algorithms. The study reported by [24] investigated an important red wine intrinsic attribute, namely, perceived astringency. Employing both sensory and wine chemical composition data in their machine learning model of wine astringency, the researchers reported various aspects of wine polyphenolic composition that were important to perceived astringency. A recent study relevant to this research investigated the prediction of Pinot noir wine colour and other sensory descriptors from weather events and management practices [25] across nine vintages, although perceived wine quality was not an attribute that was assessed. The researchers reported that the use of weather information and vineyard water-management data advantaged a model’s accuracy in predicting wine sensory profiles, including wine colour [28][29]. In this research, researchers employ computational and machine learning models to combine both sensory and selected physiochemical data on a set of NZ Pinot noir wines to predict wine professionals’ judgments of overall wine quality.

4. Chemical and Physiochemical Correlates of Perceived Quality

Wine descriptions outside the scientific domain can appear quite fanciful. Wine aroma often is given much weight in such descriptions, as it plays a vital role in defining a wine's attributes, including its quality and varietal typicality [30]. In scientific analyses, the perceived aroma is typically defined as resulting from ortho-nasal and retro-nasal olfactory processes. In recent years, however, aroma has been argued as being inherently entwined with taste and trigeminal stimulation. As such, aroma is an integral part of a multi-sensory perceptual process [31] involving interactions with texture and taste. In turn, all these perceived wine qualities result from the viticultural and vinification practices applied to grapes, including fermentation temperatures and maturation processes. What is clear is that the intrinsic quality of an individual wine cannot be judged just by reading the bottle label.

Chemical compounds play a vital role in the composition and sensory expression of wines. This is especially so for wines and red wines, which tend to be more complex, but ultimately the chemical composition of any wine is what the taster perceives [32]. A good understanding of the interlinkage between the perceived wine quality and these chemical compounds can certainly help in the creation of a unique wine style. Modulating the significant characteristics of a wine, while maintaining the best viticultural, oenological, and management practices, is an ongoing challenge for the wine industry [30][33]. Due to their domain-specific experience, and their extensive knowledge of wine production processes and the chemical composition of various wine varieties, wine experts [34] tend to have a consensual perspective when judging wine, including its quality and complexity [2][34][35]. Research suggests that everyday consumers tend to associate wine quality with how much they enjoy a wine, along with extrinsic factors such as the wine's price, its presentation, and the wine's origin [8][10]. Consumers may struggle to judge a wine's quality, due to the sheer number of available wines [36], although have some pre-conceived ideas about the type and nature of a particular wine, due to their prior experience with some wines [2].

A wine's aromatic characteristics are associated with the volatile compounds [37] contained within the bottle. By themselves, volatile compounds cannot provide the wine with an aroma; it is often through their combinations, but not always, along with the human processes of sensation and perception, that one can detect the aromatic characteristics of an individual wine [38]. These compounds can saturate the wine with different kinds of aromas that are recognised as flavours such as fruity, smoky, herbaceous, coconut, green apple, and so forth. In wine, the aromatic compounds are related to diverse groups of chemicals. A few of them act as precursors for other groups. Some of the most important classes of volatile compounds present in wine, along with their subtypes, are aldehydes, higher alcohol, esters, terpenes, pyrazines and norisoprenoids [11][37][39]. The concentration of each of these compounds depends on a multitude of viticultural and oenological factors such as the grape variety, the soil in which the grapes are grown, the nutrients and water present in the grapes, method of grape harvesting, and the precise vinification processes, such as the type of maceration, the fermentation temperature and yeast species.

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