35

Perception of sparkling wines of varying carbonation levels using descriptive analysis (DA) and temporal check-all-that-apply (TCATA)

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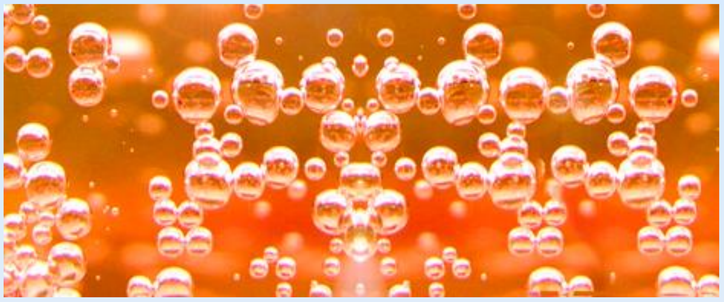
INTRODUCTION

In sparkling wine, the perception of effervescence is elicited by the presence of carbon dioxide (CO_2) bubbles. Previous studies in the area of sparkling wine carbonation have evaluated sparkling wine components. However, few studies have profiled the dynamics of carbonation perception.

A recent descriptive method, Temporal Check-All-That-Apply (TCATA), allows for the simultaneous identification of both non-dominant and dominant attributes to characterize the product[1]. Using this method, panelists are instructed to evaluate the product over time and constantly check and uncheck the attributes as they are or are not perceived, respectively. Researchers have applied TCATA to evaluate a wide range of products, including orange juice and yogurt[1], cosmetic creams[2], chocolate milk[3], salami, cheese, French bread, and marinated mussels[4], and red wine finish[5].

The overall objective of the present study was to describe the sensory aspects of sparkling wines containing different concentrations of CO_2 (0.0–7.5 g CO_2/L). Specifically, we sought to describe the sensory properties of the finished wine using both static (DA) and dynamic (TCATA) methods. Ultimately, this study will provide further insight into the complexity of CO_2 perception over time and allow for the comparison of results collected using static and dynamic sensory methods.



MATERIALS AND METHODS

Wines were produced and processed at a commercial winery by varying the concentration of dextrose added prior to second fermentation to achieve CO_2 levels (0, 1.2, 2.0, 2.8, 3.1, 4.0, 4.6, 4.9, 5.8, 6.7, and 7.5 g CO_2/L).

Sparkling wines were evaluated by a trained DA sensory panel (n=11) for mouthfeel, aroma, flavor, and taste attributes. Canonical variates analysis (CVA) was used to determine the attributes driving the most variation among the sparkling wine treatments.

Sparkling wines were evaluated by a trained sensory panel (n=13) using TCATA methodology for mouthfeel and taste attributes. Temporal curves, average attribute citation, and duration of perception were calculated.

Multiple factor analysis (MFA) was used to assess relationship between two descriptive methods.

RESULTS AND DISCUSSION

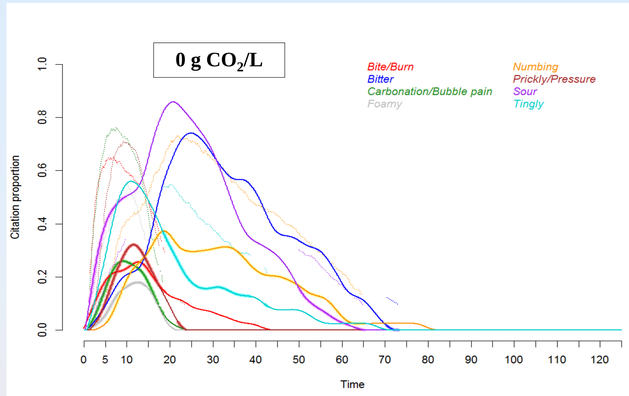
Descriptive Analysis (DA)

Table 1. Mean intensity of mouthfeel attributes (along a 15-cm line scale) of 11 sparkling wine treatments as evaluated by trained DA panel. Low-level plateaus shown in red and high-level plateaus in green.

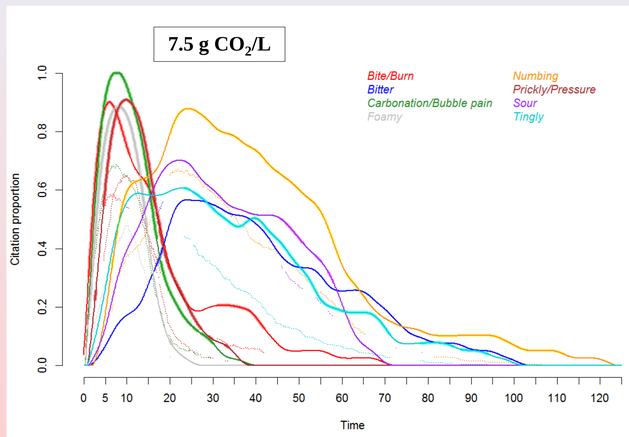
CO_2 concentration (g / L)	Mouthfeel Attributes								
	Bite	Burn	Numbing	After-numbing	Carbonation/ Bubble pain	Prickly	Pressure	Foamy	Tingly
0.0	1.9[a] a	1.6 a	2.1 a	2.9 a	1.2 a	1.3 a	1.0 a	1.2 a	1.9 a
1.2	2.1 a	2.0 ab	2.4 a	3.0 a	1.3 a	1.6 a	1.3 a	1.2 a	2.2 ab
2.0	2.8 a	2.7 b	2.7 a	3.2 a	2.4 b	2.0 ab	1.7 ab	1.8 a	2.9 bc
2.8	4.2 b	4.5 c	3.8 b	4.7 b	3.4 c	3.0 bc	2.4 bc	2.8 b	3.9 de
3.1	4.7 b	4.7 cd	4.1 b	4.6 b	3.5 c	3.5 c	2.3 bc	2.8 b	3.4 cd
4.0	5.1 bc	5.6 de	4.4 bc	4.8 bc	4.1 c	3.8 cd	3.0 c	3.8 c	4.2 def
4.6	6.0 cd	6.5 ef	5.1 cd	5.6 cd	5.7 de	4.8 de	4.0 d	4.6 cd	5.2 fgh
4.9	6.9 de	7.0 f	5.2 cd	6.1 de	5.4 d	5.5 ef	4.2 de	5.1 de	4.7 efg
5.8	7.5 ef	7.4 fg	5.8 de	6.6 e	6.6 ef	6.1 f	5.2 f	5.8 ef	5.4 gh
6.7	7.9 f	8.4 h	5.9 de	6.3 de	6.7 f	5.6 ef	5.0 ef	6.1 f	5.0 fgh
7.5	8.1 f	8.3 gh	6.6 e	6.8 e	7.0 f	6.0 f	5.3 f	6.7 f	5.9 h

- For burn, carbonation/bubble pain, and tingly, the lowest concentration at which there was a significant difference from the control wine was 2.0 g CO_2/L. For bite, numbing, after-numbing, prickly, pressure, and foamy, the lowest concentration was 2.8 g CO_2/L ($p<0.05$).
- Mouthfeel attributes were grouped by the CO_2 concentration at which the intensity plateau was observed. For tingly, after-numbing, and prickly, at concentrations above 4.9 g CO_2/L, few significant differences in intensity were observed. For the other mouthfeel attributes of bite, numbing, carbonation/bubble pain, pressure, and foamy, intensity ratings plateaued at sparkling wine treatments containing ~5.8 g CO_2/L, with no significant intensity differences noted at concentrations above this concentration

Temporal Check-All-That-Apply (TCATA)



- Within the first ~10 s of evaluation, sourness was used more frequently to describe the base wine compared to the average citation frequency of sour to describe the other treatments
- Carbonation/bubble pain was cited less frequently during the first 17 s as compared to the frequency of carbonation/bubble pain citation for the other treatments during this time.



- Proportions for bite/burn (1–10 sec, with a second burst of perception (30–38 sec), carbonation/bubble pain (2–30 sec), and prickly/pressure (5–27 sec) were all higher compared to the other sparkling wine treatments ($p<0.05$).
- There were extended durations of numbing and tingly perception relative to the other wine treatments, which continued beyond 1 min of evaluation.

Figure 1. Smoothed TCATA curves. Each attribute has its own smoothed curve and reference line (thin, non-continuous line of corresponding color). Reference lines (dotted) are non-continuous; only the periods of significant differences in proportion of citations for each treatment as compared to the other ten treatments are indicated. Time is expressed in seconds.

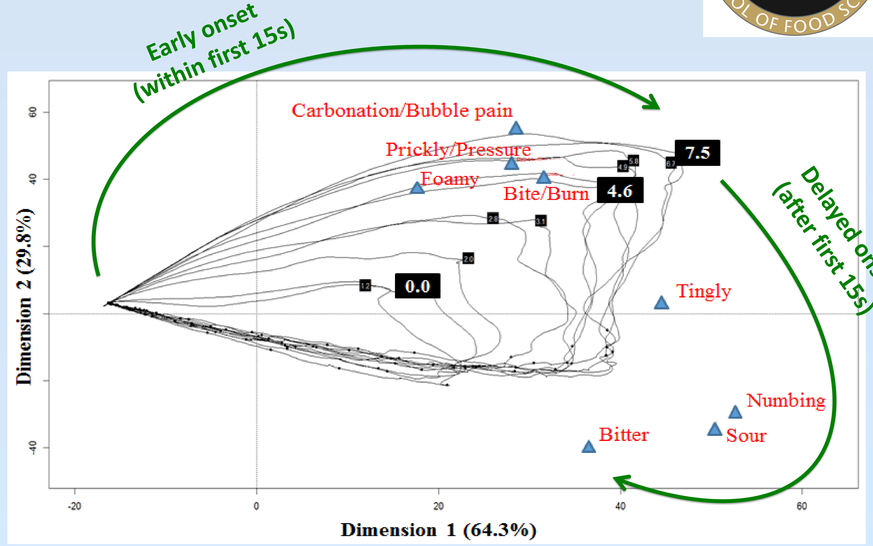


Figure 2. Principal Component Analysis results of the TCATA data of the mouthfeel attributes. Sparkling wine treatments shown in black boxes (0, 4.6, and 7.5 indicate direction of increasing CO_2 level (g/L) among trajectories). Wine treatment trajectories move in a clockwise loop, and are labelled at the first 10 sec of evaluation time.

- Each of the trajectories followed a clockwise loop. Specifically, each of the trajectories started at the far left (t=0), where the citation rate for all attributes was 0. The citation rate increased rapidly to its maximum between 10 sec (where treatment labels are placed) and 15 sec, slowly declined from 20 sec until the end of the evaluation, when the maximum citation rate returned to 0.
- Overall, increases in carbonation level in the sparkling wine corresponded with an increase in maximum citation rate, as evidenced by the positive change in PC1.

Table 2. Average proportion of panel citations of mouthfeel attributes of 11 sparkling wine treatments as evaluated by the trained TCATA panel across all time points of evaluation (125 s). Low level plateaus shown in red and high level plateaus in green.

CO_2 (g/L)	Bite/Burn	Carbonation/ Bubble pain	Foamy	Numbing	Prickly/ Pressure	Tingly
0.0 a	0.040 a	0.025 ab	0.016 a	0.105 a	0.030 a	0.099 ab
1.2 b	0.033 a	0.017 a	0.017 a	0.104 a	0.020 a	0.069 a
2.0 c	0.060 ab	0.048 bc	0.018 a	0.141 ab	0.040 ab	0.105 ab
2.8 d	0.078 bc	0.062 cd	0.028 a	0.157 ab	0.054 bc	0.129 bc
3.1 d	0.085 bcd	0.076 de	0.027 a	0.185 bc	0.075 cd	0.128 bc
4.0 e	0.113 efg	0.093 ef	0.051 bc	0.235 cd	0.099 ef	0.176 cd
4.6 ef	0.102 def	0.098 efg	0.046 b	0.245 cd	0.083 de	0.178 cde
4.9 f	0.131 efg	0.111 fgh	0.062 cd	0.292 de	0.094 def	0.199 de
5.8 g	0.146 g	0.111 fgh	0.068 d	0.322 e	0.106 ef	0.201 de
6.7 h	0.134 fg	0.123 h	0.088 e	0.326 e	0.092 def	0.214 de
7.5 i	0.149 g	0.122 gh	0.089 e	0.348 e	0.114 f	0.237 e

- For bite/burn, carbonation/bubble pain, and prickly/pressure, the lowest concentration at which there was a significant difference in proportion of citations from the control wine was 2.8 g CO_2/L.
- For numbing, 3.1 g CO_2/L was required to see a difference from the control, while a concentration of 4.0 g CO_2/L was required for separation from the control based on foamy and tingly perceptions.
- Non-discrimination among wines was considered to be a plateau in the proportion of citations. Citation rates for mouthfeel attributes plateaued at different CO_2 concentrations.

CONCLUSIONS

- Using trained panelists, sparkling wines of varying carbonation levels were evaluated by DA and TCATA, thus generating a detailed profile of carbonation perception.
- Mouthfeel attributes were separated into those that were perceived **early** in the sensory experience (peaked within the first 15 s of evaluation) and those with **delated onset** (peaked after 15 s of evaluation).

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