RESEARCH ARTICLE

Flavor perception of wine is unchanged during commercial flight: a comparative field study [version 1; peer review: 2 not approved]

Anders Gram-Hanssen , Cecilie Bøge Paulsen, Jacob Rosenberg

Center for Perioperative Optimization, Surgical Department, Herlev Hospital, Herlev, DK-2730, Denmark

V1 First published: 12 Jun 2020, 9:597
<https://doi.org/10.12688/f1000research.24319.1>
 Latest published: 12 Jun 2020, 9:597
<https://doi.org/10.12688/f1000research.24319.1>

Abstract

Background: It is generally accepted that the human perception of flavor and odor is altered in low-pressure environments such as airplane cabins. This has been demonstrated in several simulation studies, but never in a field study conducted in an authentic environment, and never using wine as the object of study.

Methods: We performed a comparative field study composed of two wine tastings. The first tasting was conducted on board an aircraft flying at standard cruising altitude and the second tasting was conducted at ground level. Subjective taste experience and current mood were evaluated through a validated questionnaire. The study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.

Results: The study included 22 participants, none of whom had any special training in wine tasting. No statistically significant difference in experienced flavor intensity was found between the high and low altitude tests, with median aromatic intensities of 5 (interquartile range 3.5-6.0) and 5 (interquartile range 4.0-6.5) respectively, measured on a 9-point hedonic scale. Additionally, there was no detectable difference in several other taste parameters.

Conclusions: These findings suggest that even though experimental studies have demonstrated that senses of taste and smell may be suppressed on commercial flights, the subjective wine tasting experience of non-professionals in real life testing may not be affected.

Keywords

Sensation, Gustation, Aviation, Oenology, Wine, Taste, Aircraft, Low pressure environment, Sense of taste

Open Peer Review

Approval Status **XX**

	1	2
version 1	X	X
12 Jun 2020	view	view

1. **Sanne Boesveldt**, Wageningen University, Wageningen, The Netherlands

2. **Barry C. Smith** , University of London, London, UK
 University of London, London, UK

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding author: Anders Gram-Hanssen (anders@gram-hanssen.dk)

Author roles: **Gram-Hanssen A:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Validation, Writing – Original Draft Preparation, Writing – Review & Editing; **Bøge Paulsen C:** Conceptualization, Investigation, Methodology, Project Administration, Writing – Review & Editing; **Rosenberg J:** Conceptualization, Investigation, Methodology, Project Administration, Supervision, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: The author(s) declared that no grants were involved in supporting this work.

Copyright: © 2020 Gram-Hanssen A *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

How to cite this article: Gram-Hanssen A, Bøge Paulsen C and Rosenberg J. **Flavor perception of wine is unchanged during commercial flight: a comparative field study [version 1; peer review: 2 not approved]** F1000Research 2020, 9:597 <https://doi.org/10.12688/f1000research.24319.1>

First published: 12 Jun 2020, 9:597 <https://doi.org/10.12688/f1000research.24319.1>

Introduction

Modern air travel is a multi-billion-dollar industry and more than four billion passengers flew on commercial airlines in 2017, which generated an industry-wide revenue of 755 billion USD¹. Labor, fuel, and equipment are the three biggest running expenses of the industry, but airline catering is also a costly venture, estimated to constitute an average of 2–3% of total operating costs². Despite this, airplane meals generally have a poor reputation among passengers. This may be due to the sheer quality of the food, but could also be a result of altered perception of flavor and odor in an airplane cabin^{3–5}.

Food perception is a complex multisensory experience depending on both taste, smell, and mouthfeel, which collectively form an impression of flavor⁶. Simulation studies have suggested that our sense of taste and smell is generally reduced in low-pressure environments such as airplane cabins, diminishing the perception of flavor intensity of food products^{7–10}. This is thought to be caused by elevated sensory thresholds for detection of tastants in low-pressure environments⁵. Moreover, this transitory impairment of the gustatory and olfactory senses may impair the general enjoyment of food as well⁸. In addition to the low air pressure, several other factors present in a standard commercial airline cabin are also assumed to contribute to this, such as dry recirculating air, cold temperature, and low oxygen levels^{5,8,9}. While the exact physiology behind these phenomena is not definitively determined, some explanatory mechanisms have been suggested: cold and dry air are impeding the interaction between odorants and olfactory receptors, and low oxygen levels are inducing hypoxia which may modulate receptor functioning^{5,11}. Other sensory modalities (e.g. hearing) can also impact flavor perception – a phenomenon known as crossmodal correspondence – and in this regard, the constant background noise in an airplane cabin may be another important sensory influence^{10,12–15}. Psychological stress is also assumed to modulate flavor perception to some degree^{16,17}, and commercial air travel is a source of – perhaps minor – psychological stress^{18,19}. Clearly, flavor perception during flight is a multifactorial process that has not yet been sufficiently characterized, which is ultimately to the disadvantage of the end consumer.

Wine has a complex composition of flavors and wine tasting requires a special attention to nuance. Therefore, the perception and appreciation of wine may also be affected by the suboptimal conditions in an airplane cabin. In current literature, the specific mechanisms of this process have not been described in its entirety and not all details are fully understood. In **Figure 1** we propose a simplified theoretical framework illustrating how these factors may interact and how environmental and individual factors modulate the process of forming a wine consumption experience. Simulation studies have heavily suggested that wine consumption experience is negatively affected during flights^{8–10}, and reportedly, the bitterness of wine is more prominent when consumed in the air⁵. However, to the best of our knowledge, the impact of airplane cabin conditions on wine consumption experience has not yet been tested in a field study. In this study, we elected to focus specifically on the concept of flavor intensity and the subjective perception of this.

We hypothesized that the subjective perception of flavor intensity of wine is reduced while on board a commercial aircraft flying at standard cruising altitude compared with on the ground. Furthermore, we speculated that this would lead to a decreased overall liking and appreciation of wine, likely resulting in a worse consumer experience. To test these pre-specified hypotheses, we performed a comparative field study of high and low altitude wine tastings, and we aimed to verify the discrepancy in taste sensation, as suggested by simulation studies.

Methods

Study design

The present study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline²⁰ and was performed as a single-blinded, non-randomized field study. The study was carried out in May 2019 and all participants were healthcare professionals (medical doctors, nurses, or medical students) travelling from Denmark to Turkey to attend a scientific conference. Participants were enrolled in February 2019 and all conference attendees

Figure 1. Theoretical framework proposal.

were eligible for inclusion in the study. Potentially eligible participants were excluded from the study if they were reluctant to consume alcohol, if they were pregnant or breastfeeding, or if they had a history of dysosmia or dysgeusia (i.e. olfactory or gustatory dysfunction).

During the experiment, all participants taste-tested two separate samples of the same wine. The wine samples were distributed to the study participants in two transparent Corning™ Falcon 50 mL Conical Centrifuge Tubes (outside diameter: 30 mm; length: 115 mm). Each tube contained only 25 mL of wine, which corresponds to approximately one sixth of a standard serving size. This conforms to general wine tasting standards and is generally considered sufficient for a simple taste assessment²¹. The participants were carefully instructed (verbally and in writing) to open the plastic tube and let the wine oxygenate for 60 seconds before drinking the sample directly from the container. Each participant consumed either red or white wine according to personal preference. The red wine of choice was the Majestik Syrah & Kalecik Karasi, 2017 (alc. 13.5%), and the white wine was the Majestik Sauvignon Blanc & Sultaniye, 2017 (alc. 12.5%). Both wines are produced by Sevilen Group, Izmir, Turkey (<http://www.sevilengroup.com/en>). These wines were chosen as they were the only wines available for purchase on the flight, and because consumption of alcoholic beverages not purchased on the flight was not permitted. Participants were blinded as to the name and production year of the wines, in order to reduce bias²².

At the first tasting the participants were instructed to fill out a form on basic demographic data and a 12-item questionnaire. The first tasting was conducted on board a Boeing 737–800 (73H) aircraft, which is a short- to medium-range, narrow-body jet airliner that seats 189 passengers and is part of the Boeing 737 Next Generation series. The taste-testing commenced approximately 1h 45m after take-off at an altitude of approximately 37,000 ft (11,278 m) above sea level, which is considered standard cruising altitude. Due to the severe security restrictions on commercial aircrafts, we were not allowed to bring measurement equipment onboard the plane. Therefore, we can only provide a general estimate of the cabin pressure: Aircraft pressurization systems always maintain a cabin pressure above 750 hPa, equivalent to a maximum cabin altitude (i.e. the equivalent altitude with the same air pressure outside the cabin according to the International Standard Atmosphere) of 8,000 ft (2,438 m)²³. However, when accounting for the Boeing 737–800's maximum pressure differential²⁴, the actual cabin pressure would have been between approximately 750 and 790 hPa. This corresponds to a cabin altitude between 6,650 and 8,000 ft (2,027 to 2,438 m).

The second tasting was performed at ground-level, where the participants were asked to fill out the same questionnaire again. This took place en-route to the hotel on board the airport shuttle bus, an Isuzu Novo Lux, which is a medium-sized coach that seats 25 people. The time of tasting was approximately 1h after landing and the altitude was approximately 305 ft (93m) above sea level. In May of 2019 the average air pressure in Izmir, Turkey was 1013 hPa²⁵.

Our primary outcome was the difference in experienced flavor intensity between high and low altitude testing. The secondary outcomes included differences in the overall liking of the wine and differences in the various other subjective taste parameters.

Questionnaire

We developed and face validated a 2-part questionnaire for this study. The first part was given before taste-testing and concerned basic demographic data and self-assessed wine-tasting expertise on a scale from 1–9 (“poor” to “outstanding”). Part two was given after taste-testing and contained seven items regarding the wine, including overall liking, as well as five items concerning current mood. The questionnaire was developed based on flavor descriptors hand-picked from the literature²⁶. Two additional items on subjective drinkability were included (“chugability” and “inebriating effects”), and four items considered relevant to this study was incorporated from the validated Profile of Mood States for Adolescents (POMS-A) questionnaire²⁷. For the seven items regarding wine, we adopted the widely used 9-point Hedonic Scale²⁸, the de-facto gold standard for sensory testing²⁹.

We performed a pilot test using two individuals considered representative of the study population. To ensure face validity, these two individuals consumed two sample of wine in a high- and low-altitude setting, respectively. They were subjected to the questionnaire and subsequently interviewed about comprehensibility, relevance, and feasibility of the questionnaire. The pilot study resulted in only minor revisions of the questionnaire to optimize the flow and comprehensibility, specifically regarding Items 5 and 6. Reliability testing was not performed. The questionnaire is provided as *Extended data*.

Statistical analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp). The study characteristics were described with proportions for categorical data (number (%)), and median with interquartile range for non-normally distributed data. Paired data were compared using Wilcoxon signed-rank test, with $P < 0.05$ considered significant. Bonferroni correction for multiple comparisons did not significantly affect our results (data not presented), and therefore, the presented results are uncorrected. Missing values ($n = 2$) were assumed to be missing completely at random and were excluded on a test-by-test basis.

Due to the lack of existing comparable data, we were unable to form any reasonable assumptions about magnitude of the hypothesized difference between taste tests. Therefore, participants were selected through convenience sampling and all eligible attendees at the aforementioned scientific conference were enrolled in the study.

Ethical considerations

All participants gave verbal consent to participate. According to Danish law, the study did not require approval from the Danish Data Protection Agency nor from the local ethics committee (registration number: H-19013122), because the study did not involve an intervention or collection of biometric data.

Results

In total, 22 participants were enrolled in the study. Of these, 45% were females and the majority were below 40 years of age (77%). 86% chose to drink red wine and the remaining participants drank white wine. The characteristics of the study participants are shown in Table 1.

The experienced aromatic intensities at both high- and low-altitude tastings had a median score of 5 on the 9-point hedonic scale (interquartile ranges of 3.5–6.0 and 4.0–6.5 respectively),

and Wilcoxon signed-rank test did not demonstrate any statistically significant difference ($p = 0.176$). The differences between the remaining taste parameters at high and low altitude were also not significant (p -values 0.153 – 0.858). Nor was there any significant difference in the participants' POMS-A scores at high altitude compared with their scores at low altitude (p -values 0.058–0.705). Among these, there was a non-significant tendency towards a higher level of sleepiness at low altitude than at high altitude ($p = 0.058$). The results are listed in Table 2.

Table 1. Characteristics of the 22 participants.

Characteristics	Number (%) or median (IQR)
Female sex	10 (45%)
Age (years)	
20–29	9 (41%)
30–39	8 (36%)
40–49	4 (18%)
≥50	1 (5%)
Self-estimated expertise ¹	4(3–5)
Red wine	19 (86%)
White wine	3 (14%)

IQR = Interquartile range. ¹ Self-estimated expertise in wine tasting on a scale from 1–9.

Table 2. Primary and secondary outcomes.

Characteristics	High altitude	Low altitude	p-value
	Median (IQR)	Median (IQR)	
Wine characteristics ¹			
Aromatic intensity ²	5.0 (3.5–6.0)	5.0 (4.0–6.5)	0.176
Fruit notes ²	4.5 (3.0–6.0)	5.0 (3.0–6.0)	0.795
Bitterness ²	5.5 (3.5–7.0)	6.0 (4.5–6.5)	0.621
Oak integration ³	3.5 (3.0–5.0)	3.0 (2.0–4.5)	0.412
Inebriating effects ³	5.5 (4.0–6.5)	4.5 (4.0–5.5)	0.267
Chugability ³	3.0 (2.0–6.0)	4.0 (2.0–5.0)	0.858
Overall liking ⁴	3.5 (2.0–6.0)	3.0 (2.5–4.0)	0.153
POMS-A ⁵			
Happy	3 (2–3)	3 (2–3)	0.593
Annoyed	0 (0–1)	0 (0–1)	0.388
Confused	0 (0–0)	0 (0–0)	0.705
Miserable	0 (0–0)	0 (0–0)	0.317
Sleepy	1 (1–2)	2 (1–3)	0.058

IQR = Interquartile range. POMS-A = Profile of Mood States for Adolescents questionnaire.

¹: Ranging from 1 to 9. ²: 1 being "low", 5 being "neutral", and 9 being "intense".

³: 1 being "poor", 5 being "neutral", and 9 being "outstanding". ⁴: 1 being "dislike extremely", 5 being "neither like, nor dislike", and 9 being "like extremely". ⁵: Ranging from 0 to 4. With 0 being "not at all", 2 being "moderately" and 4 being "extremely".

Discussion

Among our 22 enrolled participants, the flavor perception and overall liking were unchanged between high and low altitude. Additionally, there was no statistically significant change in participant mood evaluated through the adapted POMS-A questionnaire.

Our findings suggest that lay people do not experience a subjective difference in flavor intensity in a real-life aircraft cabin, when flying at standard cruising altitude compared with at ground level. Furthermore, our study was unable to detect a statistical difference in a variety of taste parameters, including overall liking of wine, fruit notes, and bitterness. This disagrees with multiple simulation studies conducted in controlled environments, simulating the conditions of an aircraft cabin and using test panels of both lay people and gastronomic professionals^{8–10}. Our results suggest that even though the gustatory and olfactory senses may be suppressed, it might not affect the subjective tasting experience of lay people (i.e. the final consumer experience) when tested in a real-life setting. Thus, the poor reputation of aircraft cuisine may not be a reflection of a changed perception of flavor and odor in high altitude environments. The mood of our participants was unaffected by the high and low altitude settings. The only parameter of the POMS-A questionnaire that came close to show a statistical difference was the sleepiness of our participants. This can be explained by the late hour of the low altitude tasting and therefore this result is negligible.

A strength of this study is that participants were neither wine professionals nor sommeliers, but lay people with an average knowledge and experience in wine tasting. Thus, the results of this study have high external validity in the general non-wine-proficient population. However, our study population was fairly limited as only 22 participants were eligible for inclusion, and all participants were Danish healthcare professionals making the study population quite homogenous in that regard. Future studies should include a larger and more heterogeneous population in terms of nationality, profession, socio-economic status, etc.

This study was conducted in a largely authentic setting, which ensures high ecological validity and makes our conclusions generalizable. In this context, “authentic” refers to a setting that approximates normal circumstances for wine consumption during flight. However, such an uncontrolled study environment does allow for a possible influence of unrecognized and potentially confounding external factors. This is the nature of a field study and the influence of undesirable external factors is inherently unavoidable. It could be argued that the two testing environments in this study were fundamentally different, and in the future, these results could be expanded upon by performing two taste tests in the same airplane cabin, one at cruising altitude and another at ground level. This would reduce the influence of possible environmental confounders. Nonetheless, it could also be argued that the two testing environments in this study were comparable in several aspects. For instance, the presence

of constant background noise is quite similar in an airplane cabin and a bus cabin, and the possible influence of auditory-gustatory crossmodal correspondence is therefore not expected to be a significant confounder^{12,13}. Since we were not allowed to bring measurement equipment onboard the airplane, the exact levels of background noise were not measured and some degree of auditory influence cannot be ruled out. Psychological stress is also thought to have an impact on flavor perception, but as all forms of public transportation can be considered a minor source of stress, the testing conditions were also in this regard quite similar. Psychological stress is therefore not considered a significant confounder in our study.

Some studies have suggested that the five basic flavors (i.e. sweet, sour, salty, bitter, and umami) may be affected differently by the conditions in an airplane cabin¹³. Consequently, future studies should include a variety of wines of different characteristics and quality in order to exclude any possible influence of the specific flavor composition of the wines chosen for this study. It may also be interesting to make a similar field study as the present, but including wine experts instead of lay people without special wine tasting abilities or training. It is also recommended that future studies should employ measures to control for confounders related to the individual, such as current satiety, appetite, and thirst. A limitation of the present study is the lack of experimental control. Under optimal circumstances, we would have preferred to implement a randomized crossover design, include a pre-flight taste test, and expand the time-frame in order to reduce the effect of recall bias. Unfortunately, this was not practically or economically feasible given the extensive security restrictions of commercial air travel, which is why we settled on the current experimental design. Another limitation of this study is the use of Falcon tubes as a vessel for the wine, as opposed to normal wine glasses. The experience of drinking a beverage is greatly influenced by the properties of its container³⁰, and these narrow plastic tubes could be an inhibiting factor in the consumption experience, e.g. inhibiting the odor sensation and diminishing the overall aesthetic experience and its emotional impact on the consumer^{31,32}.

In general, future research into improving the quality of airline catering could be of great benefit to the industry, as we believe that the current relationship between catering expenses and the quality of the final consumer experience may be disproportionate. The theoretical framework presented in [Figure 1](#) was developed for generating hypotheses and is only intended as a preliminary proposal illustrating the mechanisms at work. It is intended as a basis for further discussion of the topic, and actual testing or validation of the framework is beyond the scope of this article. Further research is necessary on the physiology and psychology of flavor perception onboard airplanes, which will inspire new and innovative methods and techniques for designing meals and beverages optimized for consumption on airplanes. This is part of an emerging field of science known as gastrophysics, which will hopefully pave the way for future improvements in airline gastronomy⁵.

In conclusion, we were unable to verify the findings of previous simulation studies, as we did not find a difference in either subjective perception of flavor intensity or overall liking of wine between high- and low-altitude tests. This suggests that any possible perceptual change that exists while flying may not affect the subjective taste experience of lay people. Ultimately, current knowledge regarding flavor perception onboard airplanes is inadequate.

Data availability

Underlying data

Open Science Framework: Flavour perception of wine is unchanged during commercial flight: a comparative field study, <http://doi.org/10.17605/OSF.IO/NMECS33>.

This project contains the following underlying data:

- Participants data.csv (Descriptive participant data)
- Questionnaire data.csv (Raw data from questionnaires). Each column is titled in the following manner: [first/second administration]_[item]_[description]. For example, "2_03_bitter" is the second administration of item 3 "bitterness".

Extended data

Open Science Framework: Flavour perception of wine is unchanged during commercial flight: a comparative field study, <http://doi.org/10.17605/OSF.IO/NMECS33>.

This project contains the following extended data:

- Questionnaire.pdf (The adapted questionnaire used in the study)
- STROBE_checklist.docx (Completed STROBE checklist)

Data are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver](#) (CC0 1.0 Public domain dedication).

Acknowledgements

The authors would like to thank Mr. Anders Tolstrup and Mr. Joachim Hjalde Halmsted Olsen for their valuable input regarding design and face validation of the questionnaire used in this field study.

References

1. International Air Transport Association: **Industry Statistics Fact Sheet**. 2018 [cited 2019 May 31]. [Reference Source](#)
2. Airlines For America: **A4A Passenger Airline Cost Index (PACI)**. 2019 [cited 2019 Jun 28]. [Reference Source](#)
3. Gajanan M: **Why Airplane Food Is So Bad**. *Time Magazine*. 2017 [cited 2019 May 31]. [Reference Source](#)
4. Calder S: **Haute cuisine: Why do airlines persist in serving us in-flight meals?** *The Independent*. 2014 [cited 2019 Dec 13]. [Reference Source](#)
5. Spence C: **Tasting in the air: a review**. *Int J Gastron Food Sci*. AZTI-Tecnalia. 2017; **9**: 10–15. [Publisher Full Text](#)
6. Auvray M, Spence C: **The multisensory perception of flavor**. *Conscious Cogn*. 2008; **17**(3): 1016–31. [PubMed Abstract](#) | [Publisher Full Text](#)
7. Bert P: **La pression barométrique. Recherches de physiologie expérimentale**. Paris: G. Masson; 1878. [Reference Source](#)
8. Burdack-Freitag A, Bullinger D, Mayer F, et al.: **Odor and taste perception at normal and low atmospheric pressure in a simulated aircraft cabin**. *J für Verbraucherschutz und Leb*. 2011; **6**(1): 95–109. [Publisher Full Text](#)
9. Kuehn M, Welsch H, Zahnert T, et al.: **Changes of pressure and humidity affect olfactory function**. *Eur Arch Otorhinolaryngol*. 2008; **265**(3): 299–302. [PubMed Abstract](#) | [Publisher Full Text](#)
10. Rahne T, Köpke R, Nehring M, et al.: **Does ambient noise or hypobaric atmosphere influence olfactory and gustatory function?** *PLoS One*. 2018; **13**(1): e0190837. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
11. Huppertz T, Freiherr J, Olzowy B, et al.: **Reduction of olfactory sensitivity during normobaric hypoxia**. *Auris Nasus Larynx*. 2018; **45**(4): 747–52. [PubMed Abstract](#) | [Publisher Full Text](#)
12. Knöferle K, Spence C: **Crossmodal correspondences between sounds and tastes**. *Psychon Bull Rev*. 2012; **19**: 1–15. [PubMed Abstract](#) | [Publisher Full Text](#)
13. Spence C, Michel C, Smith B: **Airplane noise and the taste of umami**. *Flavour*. 2014; **3**(1): 2. [Publisher Full Text](#)
14. Spence C, Velasco C, Knoeflerle K: **A large sample study on the influence of the multisensory environment on the wine drinking experience**. *Flavour*. 2014; **3**(1). [Publisher Full Text](#)
15. Woods AT, Poliakoff E, Lloyd DM, et al.: **Effect of background noise on food perception**. *Food Qual Prefer*. 2011; **22**(1): 42–7. [Publisher Full Text](#)
16. Al'absi M, Nakajima M, Hooker S, et al.: **Exposure to acute stress is associated with attenuated sweet taste**. *Psychophysiology*. 2012; **49**(1): 96–103. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
17. Ileri-Gürel E, Pehlivanoglu B, Dogan M: **Effect of acute stress on taste perception: In relation with baseline anxiety level and body weight**. *Chem Senses*. 2013; **38**(1): 27–34. [PubMed Abstract](#) | [Publisher Full Text](#)
18. McIntosh IB, Swanson V, Power KG, et al.: **Anxiety and health problems related to air travel**. *J Travel Med*. 1998; **5**(4): 198–204. [PubMed Abstract](#) | [Publisher Full Text](#)
19. Evans GW, Wener RE: **Rail commuting duration and passenger stress**. *Heal Psychol*. 2006; **25**(3): 408–12. [PubMed Abstract](#) | [Publisher Full Text](#)
20. Vandenberghe JP, von Elm E, Altman DG, et al.: **Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): Explanation and Elaboration**. *Epidemiology*. 2007; **18**(6): 805–35. [PubMed Abstract](#) | [Publisher Full Text](#)
21. Jackson RS: **Qualitative (general) wine tasting**. In: *Wine tasting: a professional handbook*. 1st ed. Academic Press; 2002; 187–210.
22. Siegrist M, Cousin ME: **Expectations influence sensory experience in a wine tasting**. *Appetite*. 2009; **52**(3): 762–5. [PubMed Abstract](#) | [Publisher Full Text](#)
23. International Air Transport Association: **Medical Manual 11th Edition**. 2018; [cited 2020 Mar 3]. [Reference Source](#)
24. Brady C: **The Boeing 737 technical site; Pressurisation**. 2014; [cited 2020 Mar 3]. [Reference Source](#)
25. World Weather Online: **Izmir monthly climate averages**. 2019; [cited 2020 Mar 3]. [Reference Source](#)
26. Parr WV, Valentin D, Reedman P, et al.: **Expectation or sensorial reality? An empirical investigation of the biodynamic calendar for wine drinkers**. Ryabinin AE editor. *PLoS One*. 2017; **12**(1): e0169257. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
27. Terry PC, Lane AM, Lane HJ, et al.: **Development and validation of a mood measure for adolescents**. *J Sports Sci*. 1999; **17**(11): 861–72. [PubMed Abstract](#) | [Publisher Full Text](#)

28. Peryam DR, Pilgrim FJ: **Hedonic scale method of measuring food preferences.** *Food Technol.* 1957; **11**(Suppl): 9–14.
[Reference Source](#)
29. Wichchukit S, O'Mahony M: **The 9-point hedonic scale and hedonic ranking in food science: some reappraisals and alternatives.** *J Sci Food Agric.* 2015; **95**(11): 2167–78.
[PubMed Abstract](#) | [Publisher Full Text](#)
30. Schifferstein HNJ: **The drinking experience: cup or content?** *Food Qual Prefer.* 2009; **20**(3): 268–76.
[Publisher Full Text](#)
31. Mora P, Moscarola J: **Representations of the emotions associated with a wine purchasing or consumption experience.** *Int J Consum Stud.* 2010; **34**(6): 674–83.
[Publisher Full Text](#)
32. Charters S, Pettigrew S: **Is wine consumption an aesthetic experience?** *J Wine Res.* Routledge; 2005; **16**: 121–36.
[Publisher Full Text](#)
33. Gram-Hanssen A, Paulsen CB, Rosenberg J: **Flavour perception of wine is unchanged during commercial flight: a comparative field study.** 2020
<http://www.doi.org/10.17605/OSF.IO/NMECS>

Open Peer Review

Current Peer Review Status:

Version 1

Reviewer Report 03 August 2020

<https://doi.org/10.5256/f1000research.26832.r66757>

© 2020 Smith B. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Barry C. Smith

¹ Centre for the Study of the Senses, Institute of Philosophy, University of London, London, UK

² School of Advanced Study, University of London, London, UK

General:

The topic of how flavour perception is affected during commercial flights is a good one. It is currently underexplored and more research would be welcome to help fill out the small set findings in the literature. However, this rather badly designed and poorly conducted study is without proper controls and its findings do not support the declared aim of overturning previous findings in the field. It is not helped by giving different target conclusions at different points in the paper, ranging from the headline grabbing but overclaiming title: 'Flavor perception of wine is unchanged during commercial flight' to the more circumspect claim that there is no 'difference in either subjective perception of flavor intensity or overall liking of wine between high- and low-altitude tests' to the even narrower claim that 'on commercial flights, any possible perceptual change that exists while flying may not affect the subjective taste experience of lay people'. However, the findings from the data do not establish any of these conclusions, and as a result not much store can be set by the authors' assertion that: 'we were unable to verify the findings of previous simulation studies'. This is not surprising. A more plausible interpretation is that that was not a well enough conducted study either to verify or refute the previous simulation studies, nor to establish that there was no 'difference in either subjective perception of flavor intensity or overall liking of wine between high- and low-altitude tests'. The current article cannot be recommended for publication. Crucial limitations of the current study are declared by the authors themselves in the discussion section, suggesting the authors may have already faced or anticipate facing these criticisms. The list of limitations almost amounts to a self-review of the problems with the current paper, helping to reinforce the verdict offered here.

The authors reveal both a lack of knowledge of the existing literature and at times a failure to understand the literature they do cite. We are told early on that the effects of pressure and altitude on flavour perception has only been conducted in simulated environments and 'never in a field study conducted in an authentic environment, and never using wine as the object of study'.

Later, the authors are more cautious, 'to the best of our knowledge, the impact of airplane cabin conditions on wine consumption experience has not yet been tested in a field study.' But in fact it has. Together with British Airways, wine buyer Andy Sparrow carried out a controlled study tasting the same wines in the lounge before the flight, then in flight after two hours, and again after 5 hours. Most of the Bordeaux wines were perceived as less intense and more tannic although a high-altitude produced Catena Angelica Zapata Malbec tasted more intense:

<https://www.youtube.com/watch?v=0PzeuVCBzQc>.

In addition, there is *The Wine in the Sky Questionnaire* (2018 Assouline) where a range of expert and non-expert tasters report on their experiences of wines in-flight.

The background to the experiment relies on an understanding of multisensory flavour perception and the possible factors affecting it. The authors' understanding can be questioned given their diagram in Figure 1.

Why are the authors separating flavour and odour characteristics? Are participants required to attend to each separately? On the far left-hand side should be volatile and non-volatile molecules. Flavour perception is a result of multisensory integration, so does not precede it. Cross-modal effects of one sense on another can happen at the level of sensory inputs that feed into the process of integration. How is the wine consumption experience judged? Is it the same thing as 'flavour intensity' or is it more about the intensity of the experience rather than intensity of sensations like bitterness, sweetness, etc. or is it just the hedonic scoring of the wine? It is unclear.

Study Design:

1. In taking advantage of a commercial flight that colleagues of the authors were travelling on, they were limited to the choice of wine samples sold on the plane. Therefore, there was no opportunity to have the participants taste the same wines on the ground before flying. A limitation the authors acknowledge.
2. The authors tell us that 'Wine has a complex composition of flavors and wine tasting requires a special attention to nuance.' But it is reasonable to wonder whether the small format bottles available on this flight really fell into this category. There may have been few nuances to attend to and there were no other wines by other producers to allow a comparison in the results. Another limitation of the study acknowledged by the authors.
3. A claimed strength of the study is its 'high ecological validity' and that it is a more authentic study than those carried out in simulated conditions (e.g. pressurised cabin on the ground). Here we have 'a setting that approximates normal circumstances for wine consumption during flight'. And yet; 'The wine samples were distributed to the study participants in two transparent Corning™ Falcon 50 mL Conical Centrifuge Tubes (outside diameter: 30 mm; length: 115 mm). Each tube contained only 25 mL of wine'(4). Far from being authentic, naturalistic conditions, this requires participants to sniff and sip from a narrow test tube. The authors tell us: 'This conforms to general wine tasting standards and is generally considered sufficient for a simple taste assessment'. On the contrary, standardized ISO wine tasting glasses have a much wider aperture than a centrifuge tube, and crucially, the bowl is wider than rim to encourage odour concentration in the headspace. These are far from suitable containers for wine testing purposes. This is yet another possible limitation of the

study acknowledged by the authors: 'these narrow plastic tubes could be an inhibiting factor in the consumption experience, e.g. inhibiting the odor sensation and diminishing the overall aesthetic experience and its emotional impact on the consumer' (60. They most certainly would have been.)

4. Exclusion conditions for participants included those who do not or should not imbibe alcohol, those who 'had a history of dysosmia or dysgeusia (i.e. olfactory or gustatory dysfunction.' But normally, for such a test it would include those with cold, hay fever, or sinus problems. Also, were participants asked not to eat or drink anything for more than an hour before the tests, as is standard practice for taste tests. We are not told. They were tested 1hr 45 minutes into the flight. Did they consume any more alcohol or food during the remainder of the flight? Again, we are not told. The authors acknowledge the problem: 'It is also recommended that future studies should employ measures to control for confounders related to the individual, such as current satiety, appetite, and thirst. A limitation of the present study is the lack of experimental control.' (6). Some of these could have been controlled for in this study.
5. To assess the samples, we are told the authors relied on 'the concept of flavour intensity'. No attempt is made to establish that participants understand what they are being asked to judge or show reliability in making 'flavour intensity judgements'. This is also conflated with 'aromatic intensity' in places. Is this judged by sniffing or tasting? No attempt is made to assess the participants' acuity in smelling or tasting. Were they not very discriminating? Could that be the reason 'the subjective wine tasting experience of [these] non-professionals in real life testing may not be affected' Were there individual differences?
6. The questionnaires draws on terms for evaluation said to be industry standard, though they are taken from Parr et.al. 2016 who is using these terms to test experts. Did the participants, who are largely inexperienced in wine tasting tests know what 'oak integration' means and are they reliably able to score it?
7. How do participants judge the added dimension of 'imbibing strength'? Is it from the trigeminal burning sensation of the alcohol, the full-bodied weight of the wine? Are all participants using the same criteria? For those without any experience of wine tasting, it can be hard to make discriminating judgements over a distanced time period – the re-testing is one hour after disembarking from the flight. Thus, the findings could be interpreted as suggesting a lack of ability to discriminate and compare across time rather than making reliably good judgements about the performance of the same wines in two different conditions. Yet a further possible limitation the authors acknowledge.

The re-testing of the test tubes of the same wine was carried out on the transit bus from the airport to the hotel. Were the samples in the same condition? Freshly poured into the centrifuge tubes or preserved from the first filling? The comparison of response is between tasting test tubes of wine in flight at altitude and then shortly after a 3.5 hour flight on a transit bus (after further food? alcohol?) Many further questions arise from this design.

Conducting the experiment:

1. The dependent variable in the hypothesis of the study is the altitude/ air pressure at which

the wines were tested and re-tested. Although we are told the altitude of the aircraft was c.37,000 ft, we are not told more importantly what the air pressure was in the cabin. The authors explain that they were not able to take equipment on board to measure the cabin pressure. 'Therefore, we can only provide a general estimate of the cabin pressure' However, air crew are usually happy to ask the captain to let a passenger know the cabin pressure. The authors' estimates look rather high. Mostly at this altitude the cabin pressure corresponds to an altitude of between 5,500-6,500 ft.

2. Similarly, 'There are standard phone apps for measuring decibel levels in the environment. So special measuring equipment needed to be brought on board. This was a severe limitation since it was not possible to compare the noise levels on the in-flight and on the transit bus where the re-testing of the wines took place.
3. (The authors admit – yet again – this was a possible limitation of this study. However, they suggest: 'This reveals a major failure to understand the cross-modal effect at issue and how it provides a confound for this study: a significant failing in the article. If there was an interference effect of noise on the perceived intensity of wine's aroma or flavour in flight because noise changed the perception of the wine's flavour, and a similar effect of noise on flavour perception on the transit bus this may explain why the wine was perceived within the same ranges of intensity on the questionnaire in both conditions. This interpretation of the findings, given previous studies confirming the cross-modal effect of hearing white noise on perception of tastes, is more likely than the interpretation that there was no ' difference in either subjective perception of flavor intensity or overall liking of wine between high- and low-altitude tests'.
4. The most the authors can claim is they have not been able to replicate the earlier simulation tests. But given the considerable limitations of the study fully acknowledged by the authors their findings do not, as the authors claim, support their conclusion that 'Flavor perception of wine is unchanged during commercial flight'.
5. Without using a visual analogue scale instead of a 9 point scale subtle shifts can be missed., Besides, the p-values alone are not enough to reject the hypothesis. Bayesian statistics would need to be run. A Bayesian analysis would tell the authors whether they can reject the hypothesis on the basis of their data or whether it is just insufficiently powered to draw any conclusions of this sort. Why is it likely to be the former rather than the latter? We are not told.

The crucial weakness of the study – once again acknowledged by the authors – was the inability to test the same wines on the ground first and then in the air and the reasons they were not able to do so were purely logistical. The wines chosen for the study, a Turkish red wine blend (Majestik Syrah & Kalecik Karasi, 2017, alc. 13.5%), and white wine blend (Majestik Sauvignon Blanc & Sultaniye, 2017 alc. 12.5%) 'were chosen as they were the only wines available for purchase on the flight, and because consumption of alcoholic beverages not purchased on the flight was not permitted.' No opportunity to test before was possible and only one red and one white were used and this was opportunistic. For such a large conclusion as the authors propose in the title of the article, one would need much more evidence and to consider other, and often more plausible interpretations of the findings.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

No

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Taste, smell and multi sensory flavour perception; sensory evaluation of wine.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Reviewer Report 29 June 2020

<https://doi.org/10.5256/f1000research.26832.r64831>

© 2020 Boesveldt S. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Sanne Boesveldt

Division of Human Nutrition and Health, Wageningen University, Wageningen, The Netherlands

This is an interesting topic for investigation, with very little scientific research done so far, but may have large implications.

However, the study has some substantial limitations, mainly the very limited sample size, and the fact that the order of conditions was not randomized.

Even though the authors discuss these, I strongly question the validity of the outcomes and conclusions.

The authors state that a priori power calculation was not possible, but they could have considered what would be a relevant difference to detect in their outcomes, also based on the available literature on (changes in) smell/taste function under similar circumstances. This small sample size is likely the reason for their null effects, so I am not sure how valid it is to actually publish these findings. At least, phrase this clearly as an exploratory pilot study (e.g. also in the title etc).

At what time of day were the assessments done? The authors should then in more depth discuss potential effects of time of day or fatigue (also given the trend towards increased sleepiness during the 2nd assessment). Moreover, specifically for wine tasting, time of day and circumstances/context are important.

It does not make sense to me that *intensity* was assessed on a *hedonic* scale. Why was this chosen, and not an LMS or VAS? Also, why was intensity chosen as the main outcome (which is better assessed with a trained panel), rather than liking (which is better suited for a consumer panel, such as used here)?

The authors missed out on a relevant paper, on liking of foods in airplanes: Holthuysen *et al.* (2017¹).

I am not convinced that figure 1 adds any relevance to the paper and study described.

References

1. Holthuysen N, Vrijhof M, de Wijk R, Kremer S: "Welcome on board": Overall liking and just-about-right ratings of airplane meals in three different consumption contexts-laboratory, re-created airplane, and actual airplane. *Journal of Sensory Studies*. 2017; **32** (2). [Publisher Full Text](#)

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: (chemo)sensory science; eating behavior

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

The benefits of publishing with F1000Research:

- Your article is published within days, with no editorial bias
- You can publish traditional articles, null/negative results, case reports, data notes and more
- The peer review process is transparent and collaborative
- Your article is indexed in PubMed after passing peer review
- Dedicated customer support at every stage

For pre-submission enquiries, contact research@f1000.com

F1000Research