Received: 1 September 2020 | Revised: 4 November 2020 | Accepted: 17 November 2020
DOI: 10.1111/joss.12629

ORIGINAL ARTICLE

Journal of Sensory Studies
WILEY

A short training as an enhancer of sensory ability: The case of red wine consumers

Caio Monteiro Veríssimo[1,2] | Samara de Macêdo Morais[1] | Luciana Leite de Andrade Lima[2] | Giuliano Elias Pereira[3] | Maria Inês Sucupira Maciel[1,4]

[1]Food Science and Technology Graduate Program, Universidade Federal da Paraíba, Cidade Universitária, João Pessoa, Paraíba, Brazil

[2]Department of Rural Technology, Universidade Federal Rural de Pernambuco, Recife, Prince Edward Island, Brazil

[3]Embrapa Grape & Wine Department, Brazilian Agricultural Research Corporation, Bento Gonçalves, Rio Grande do Sul, Brazil

[4]Consumer Science Department, Universidade Federal Rural de Pernambuco, Recife, Prince Edward Island, Brazil

Correspondence
Maria Inês Sucupira Maciel, Consumer Science Department, Universidade Federal Rural de Pernambuco, Dois Irmãos, Rua Dom Manuel de Medeiros s/n, CEP 52171-900, Recife, PE, Brazil.
Email: m.inesdcd@gmail.com

Funding information
Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

Abstract

The need for rapid and low-cost methods has made consumer-based methodologies, such as check-all-that-apply (CATA), a reality in sensory science instead of the traditional tools, namely, descriptive analysis (DA). This research investigated how training, even short and simple, and reduction of panel size may affect the consumers evaluation of tropical red wines (*Vitis vinifera* L.). To achieve this goal, nine samples were characterized by DA with trained assessors (n = 8), CATA with consumers (n = 100) and CATA with semi-trained panelists (n = 30). The results were compared in terms of configuration and sample discrimination similarities between methodologies. DA and CATA with semi-trained panelists provided the highest capacity of discrimination and the highest index of similarity for aged samples (95%). The two-hour training period, as well as previous experience with the methodology and products, had a positive effect in reducing the panel size and on the discrimination and characterization of samples, presenting itself as a valuable tool when time- and cost-efficient sensory profiling is needed.

Practical Applications: For decades, consumers were considered only capable of hedonic judgments, however with the development of sensory science and new consumer market dynamics, alternative methods could be studied, providing not only reliable data, but also an accessible language and an easy application. Thus, this study focused on the evaluation of the effect of a short training on the characterization of red wines by consumers, showing that with this step it was possible to reduce 70% of the consumer panel size and to improve 30% in the descriptive power of the samples, in addition to reduce inconsistencies in the responses, using a rapid, low-cost and easy to apply method.

1 | INTRODUCTION

The quality of consumer goods covers three fundamental aspects: physicochemical, sensory, and microbiological. Sensory quality is unquestionably the most important aspect perceived by the consumer and is, therefore, the main factor responsible for product purchase decisions. Thus, sensory quality attributes, need to be monitored and have economic implications (Meilgaard, Civille, & Carr, 2015).

Descriptive analysis (DA) has been the most powerful sensory tool for acquiring detailed, reliable and reproducible sensory data of food and beverages, especially those with small differences or that are not consumed daily, such as alcoholic beverages. However, this methodology is time-consuming and expensive and may not suit all research groups (Ares & Varela, 2017a).

The desire to implement rapid sensory methods and product description by consumers led to the methodological development of techniques such as check-all-that-apply (CATA), which has gained popularity due to its simple format, low cognitive effort, and quick elicitation of sensory characteristics (Ares & Varela, 2017b).

Since CATA is a non-comparative method, it does not require simultaneous product evaluation, which makes it appropriate for samples such as wine (Ares, 2015). This beverage has sensory characteristics determined by a series of natural or induced factors, namely, production location and its climatic conditions, grape cultivar, winemaking protocol, and physicochemical composition. Such variations may be responsible for numerous visual, olfactory or gustatory stimuli, making sensitive and careful assessment necessary (Oliveira et al., 2019).

On the other hand, low discriminant power in products with subtle differences has been reported for CATA (Ares et al., 2015). This can be attributed to the binary nature (0/1) of the method, which makes it impossible to demonstrate attributes intensity differences (Ares & Varela, 2017a). Furthermore, trained panelists focus on assessment via pre-established standardization according to the type of product evaluated, acting as “instruments” (Moskowitz, 2017).

Another determining factor to ensure the validity of consumer-based methodologies is the use of a large number of participants (n = 60–80) due to the high possibility of inconsistencies during evaluations. Knowing that training is an effective way to reduce response variation, its application, even for a short duration, has been considered a variant of CATA, making possible not only the improvement of data quality but also a reduction in the number of participants (Alexi et al., 2018).

The novelty of this study is based on the fact that samples of alcoholic beverages, which require careful assessment, were used, and the sensory panels were composed only of potential consumers, which allowed for a direct comparison of the efficiency of the different employed methodologies.

In this context, it is stated as hypothesis that consumers, with some experience and training can analytically describe sensory characteristics of wine. The objective of this study was to compare the application of the CATA methodology with consumers (C-CATA) and with semi-trained panelists (ST-CATA) when tasked with describing a product with regional particularities to determine how training, presentation of physical references of the attributes and reduction of panel size may affect the evaluation. To achieve this, the results were compared in terms of their similarity to trained assessor data (TP-DA), the configuration and discrimination of samples, and quantitative differences in samples between each methodology.

2 | MATERIALS AND METHODS

2.1 | Samples

Nine samples of commercial red wine (*Vitis vinifera* L.) from São Francisco Valley (Pernambuco State, Brazil; Table 1) were profiled. Wines were chosen according to their possibility to receive the region's Indication of Origin seal.

São Francisco Valley, located in the northeastern part of Brazil between the southern hemisphere parallels of 8–9° and at an altitude of 350 m, is characterized by a semiarid tropical climate, with high average temperatures, high sunlight intensity, and low annual rainfall (Padilha, Camarão, Correa, Lima, & Pereira, 2017). These climatic conditions, associated with the use of water for irrigation and the absence of winter, result in at least two crops in the same year and a final product with a unique chemical and sensory profile (Oliveira et al., 2019).

2.2 | Sensory vocabulary development

For DA methodology, sensory descriptors were instituted by a modified repertory grid method with 20 pre-selected judges (Damasio & Costell, 1991). At first, an open discussion with a previous list with common red wine descriptors was conducted to support to the sensory attributes acquisition. Then, two samples of tropical red wine were presented together and the assessors were asked to compare them in relation to their appearance, aroma, and flavor. The most cited

TABLE 1 Basic characteristics of commercial red wine samples (*Vitis vinifera* L.) from São Francisco Valley, northeastern Brazil

Sample	Grape variety	Aging[a]	Vintage
CS	Cabernet Sauvignon	No	2018
CS/SY	Cabernet Sauvignon, Syrah	No	2018
SY	Syrah	No	2018
TP	Tempranillo	No	2018
RC	Ruby Cabernet	No	2017
RES	Cabernet Sauvignon, Syrah, Alicante Bouschet	6 months	2018
AB	Alicante Bouschet	9 months	2018
TN	Touriga Nacional	9 months	2018
PR	Cabernet Sauvignon, Syrah, Alicante Bouschet, Touriga Nacional, Aragonês	12 months	2017

[a]French oak barrel.

terms had the language unified and were used to build the sensory evaluation form, obtaining 27 attributes (4 visual, 11 olfactory, and 12 flavor attributes).

The list of sensory attributes used in C-CATA and ST-CATA was similar to that used in TP-DA, except for one appearance attribute (color), which was divided into two terms corresponding to anchors of the color scale (reddish and purplish), and the exclusion of four terms that could be difficult for consumers to understand. The resulting 24 sensory attributes (3 visual, 9 olfactory, and 12 flavor attributes) were simplified in terms of vocabulary to produce a relatively simple list, avoid misunderstandings, and reflect how consumers perceive and describe products in real life (Ares & Varela, 2017a).

2.3 | Sensory analysis

Sensory evaluations were performed in standardized individual booths according to guidelines of the ISO 8589:2007 standard (ISO, 2007), and 25 ml of each sample was served to assessors in wine tasting glasses, as recommended by ISO 3591:1977 (ISO, 1977) at 18 ± 0.5°C. Samples were accompanied by mineral water and a water cracker to remove any residual taste between samples.

All samples were blind-labeled with a three-digit random code and presented in balanced order to account for first order and carry-over effects (Williams design). An overview of the three methodologies is presented in Table 2.

2.3.1 | Trained assessor panel—Quantitative descriptive analysis

The sensory panel consisted of eight trained assessors of tropical red wines. They all had a minimum of 30 h of training and were chosen according to their sample discrimination, repeatability of assessment and group consensus capabilities in accordance with ISO 8586 (ISO, 2012). Assessor performance was evaluated using analysis of variance (ANOVA).

Nine samples were evaluated in triplicate in a total of nine sessions of approximately 1 h each. In addition to the attribute definition form, during the entire evaluation, the physical references (Table S1) were available to all panelists to avoid doubts.

The panel was asked to evaluate the 27 attributes on a 10-cm unstructured line scale anchored with "low" or "absent" at the left and "high" at the right. The attributes "color" and "limpidity" had the anchors "violet" and "amber" and "limpid" and "turbid," respectively, on the left and right.

2.3.2 | Consumer panel—CATA questions

One hundred consumers, with ages ranging from 18 to 56 years old, were recruited based on an online survey that measured demographic and psychographic issues, the ability to answer questions about basic characteristics of wines and consumption habits.

Five sessions of 20 min each, with a maximum of two wines and no repetitions, were carried out. Sample presentation order was randomized across sessions and consumers and wines were presented monadically. In evaluation form, attributes had also a randomized presentation within the sensory categories (visual, olfactive, and flavor). To complete the study, consumers participated to all sessions and profiled all samples.

The consumers were asked to try the samples and evaluate them following the wine tasting dynamics (visual, olfactory, and flavor aspects), reducing the cognitive effort of the evaluators.

2.3.3 | Semi-trained panel—CATA questions

Thirty ST-CATA assessors who had conducted the previous CATA sessions and had time availability for training were recruited. Potential

TABLE 2 Summary of the methodologies applied in the characterization of commercial red wine samples (*Vitis vinifera* L.) from São Francisco Valley, northeastern Brazil

	Trained panel	Semi-trained panel	Consumer panel
Method	Descriptive analysis	Check-all-that-apply	Check-all-that-apply
Number of assessors	8	30	100
Vocabulary development	Yes	No[a]	No[a]
Number of attributes	27	24	24
Training duration	30 h	2 h	No training
References	Physical references (low and high)	Physical references (high)	No references
Attribute definitions	Written definitions	Written definitions	Written definitions
Instructions	During training	During training	Prior to evaluation
Attribute order	Fixed	Randomized	Randomized
Sample presentation	Monadic and randomized	Monadic and randomized	Monadic and randomized
Number of sessions	9 (3 replicates)	3 (no replicates)	5 (no replicates)
Total duration	40 h	3 h	1 h

[a]Vocabulary was adapted from descriptive analysis.

consumers were given preference over those with technical experience with this type of product, such as wine researchers and experts. This experimental design was used to explore how consumer performance can change when receiving physical references instead of written ones.

The two-hour training was performed in three different steps. Initially, the assessors had a short class about the type of wine to be evaluated and its producing region. Then, a clear definition of sensory attributes was provided; at the end, presentation and evaluation of the different physical references was conducted (Table S1).

After training, the assessors, with ages ranging from 21 to 43 years old, proceeded with the sensory evaluation in three sessions with three wines each, following the same dynamics as described in Section 2.3.2.

2.4 | Data analysis

2.4.1 | Trained assessor panel—Quantitative descriptive analysis

ANOVA was carried out on trained assessor data considering sample, replicate, assessors and their interactions as sources of variation using a 5% significance level. When no interactions occurred, significant differences were calculated by Duncan's test ($p \le .05$).

Principal component analysis (PCA) was performed on the correlation matrix of the average attribute scores among assessors. Only significant characteristics of sample discrimination were considered.

2.4.2 | Semi-trained and consumers panel—CATA questions

For CATA datasets, the frequency of use of each sensory attribute was determined by counting the number of assessors that used that term to describe each sample. Cochran's Q test was used to estimate the significance between samples and attributes (Meyners, Castura, & Carr, 2013). Correspondence analysis (CA) was carried out to construct a bi-dimensional representation of samples and determine the relationship between samples and terms from the CATA questionnaire (Vidal, Tárrega, Antúnez, Ares, & Jaeger, 2015).

2.4.3 | Comparison of methodologies

The similarity of sample configurations among sensory methodologies was assessed using multiple factor analysis (MFA). Two frequency matrices (C-CATA and ST-CATA) and one matrix with average assessment intensities were constructed and each served as an individual group for performing MFA analysis.

To assess a quantitative measure of proximity between samples, the regression vector (RV) coefficient (Robert & Escoufier, 1976) was calculated for the first two dimensions of MFA. In addition, for each of the three methodologies, the normalized difference between the minimum and maximum (normalized maximum range) ratings of an attribute across samples was calculated as described by Alexi et al. (2018). For CATA datasets, the normalized total citation frequency of an attribute was also calculated (Alexi et al., 2018). All statistical analyses were performed using XLSTAT Software (Addinsoft).

3 | RESULTS

3.1 | Sensory configuration of samples

3.1.1 | Trained assessor panel (TP-DA)

Among the 27 evaluated attributes, 24 showed significant differences, providing a great description of samples. PCA, performed with the trained assessor data, indicated that the first and second dimensions accounted for 59.12 and 11.36% of the variance in the experimental data, respectively (Figure 1a).

The first dimension (F1) was able to discriminate samples according to the maturation time. In the positive values of F1, aged wines (AB, TN, RES, and PR) were evident, as were descriptors most related to this category of products, including "body," "flavor and aroma persistence," "color intensity" and "dried fruit aroma." Negative F1 values were attributed to young wines (CS, CS/SY, SY, TP, and RC) and the most associated sensory characteristics, for example, "fresh fruit aroma," "acidity" and "astringency." In the two discriminated classes of wines, defect-related attributes, such as "alcoholic aroma and flavor" in young samples and "bitterness" in aged samples, were observed.

3.1.2 | Semi-trained assessor panel (ST-CATA)

In general, the terms "reddish color," "clear," "alcoholic aroma," "fruit jam aroma," "sour taste," "bitter taste," "astringent taste," "alcoholic flavor," and "woody flavor" were the most widely used to describe the wine samples, exhibiting a frequency of more than 40% (Table 3). ST-CATA panelists were capable of discriminating samples by 12 of 24 attributes listed in CATA ballots.

As shown in Figure 1b, the first and second dimensions of the CA accounted for 40.27 and 29.79% of the variance in the experimental data, respectively. The system, unlike TP-DA analysis, did not discriminate wine by maturation but more clearly distinguished the sample by color attribute, with PR and CS/SY most represented by a "purplish color" and the others (SY, CS, RC, TP, AB, TN, and RES) typified by a "reddish color."

It is interesting to highlight that the term "purplish color" may be more related to color intensity, showing a misunderstanding of the semi-trained panelists or a dumping effect (Lawless & Heymann, 2010) since the term "intense color" was not available in the CATA questionnaire. Similarly, the TP-DA panel associated both PR and CS/SY with the characteristic "color intensity" (cf. Figure 1a).

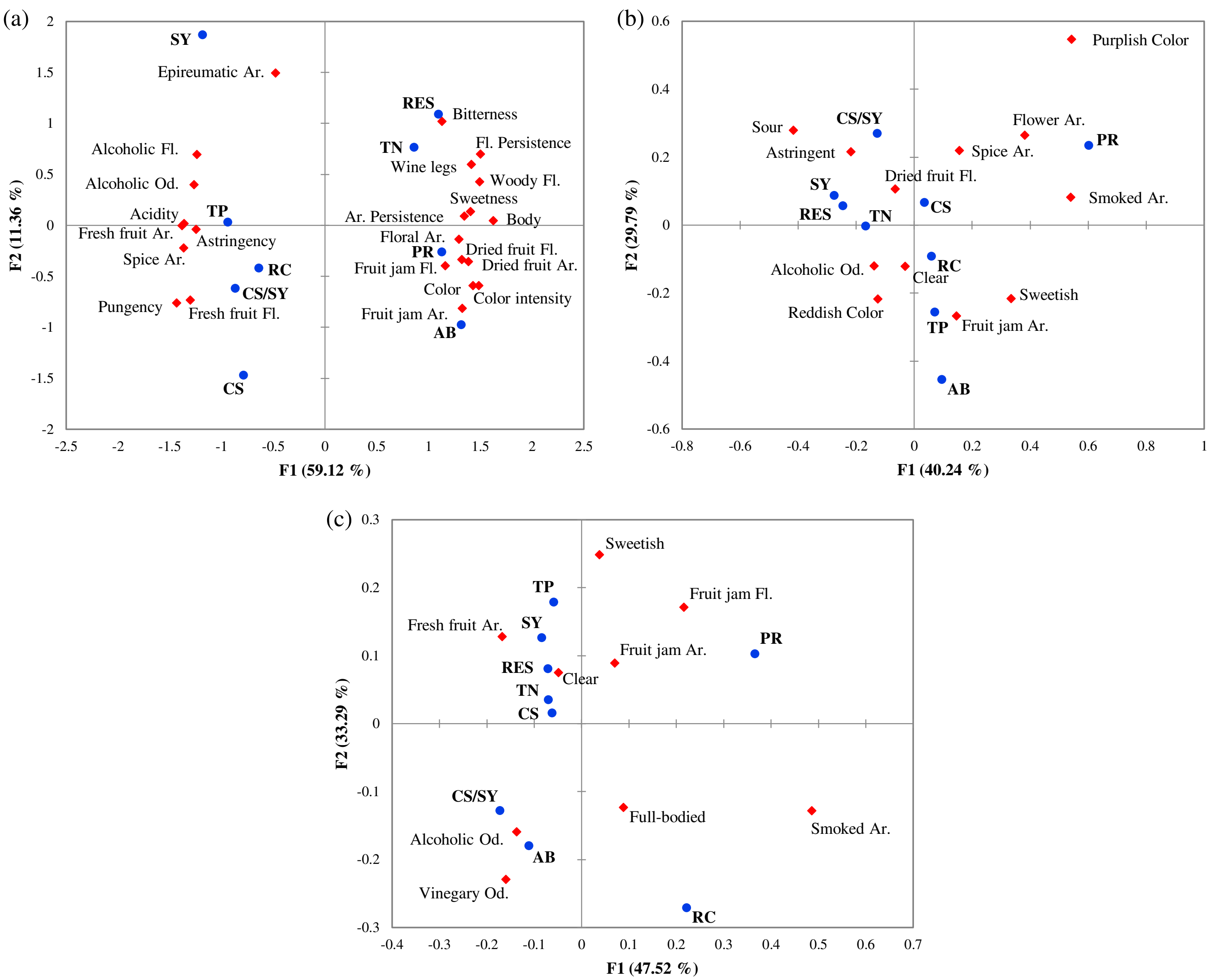

FIGURE 1 Principal component analysis (a) and correspondence analysis (b, c) plots illustrating wine samples (●) and significant ($p \le .05$) attributes (◆) for descriptive analysis with a trained panel (a), CATA with a semi-trained panel (b) and CATA with consumers (c). Abbreviations: AB, Alicante Bouschet; Ar, aroma; CS, Cabernet Sauvignon; CS/SY, Cabernet Sauvignon/Syrah; Fl, flavor; Od, odor; PR, Cabernet Sauvignon/Syrah/ Alicante Bouschet/Touriga Nacional/ Aragonês; RC, Ruby Cabernet; RES, Cabernet Sauvignon/Syrah/Alicante Bouschet; SY, Syrah; TP, Tempranillo; TN, Touriga Nacional

3.1.3 | Consumer panel (C-CATA)

When consumers were asked to describe the sensory characteristics of the wine samples, the terms "reddish color," "clear," "alcoholic aroma," "sour taste," "astringent taste," "alcoholic flavor," and "persistent flavor" showed the highest frequency of use, all of which had a frequency over 40% (Table 3). Assessing significant differences, this methodology showed the smallest number of significant attributes, 9 of the 24 evaluated (Table S2), showing poor comprehension of the terms used in the CATA questionnaire.

The first two dimensions accounted for 47.52 and 33.29% of the variance in the experimental data, respectively (Figure 1c). The distribution of samples in the system was similar to that of samples evaluated by the semi-trained assessors, and the samples were sorted into two different groups, mixing aged and young wines, that were separated by F1. Samples PR and RC were mostly represented by positive values of F1 and the terms "sweetish," "fruit jam aroma," "fruit jam flavor," "full-bodied," and "toasted/smoked aroma". Samples TP, SY, RES, TN, CS, CS/SY, and AB were characterized by negative values of PC1 and were associated with sensory attributes, such as "fresh fruit aroma," "clear," "alcoholic aroma," and "vinegary odor."

Although the evaluation was simple and somewhat deficient, the panel was able to group wine samples with typical features, such as aged samples (PR) with the term "full-bodied" and young samples (TP, SY, and CS) with the term "fresh fruit aroma." However, it seemed that the term "clear" may have been used to reflect "low color intensity" instead of "limpidity" since most young wines are associated

TABLE 3 Normalized maximum range of differences between samples (%) and citation frequencies (%) for significant attributes in at least one of the three methodologies

	Normalized maximum range (%)[a]			Citation frequency (%)[a]	
Attributes	TP-DA[b]	ST-CATA[b]	C-CATA[b]	ST-CATA[b]	C-CATA[b]
Color	16.2				
Reddish color[c]		60.0	15.0	68.9	74.6
Purplish color[c]		26.7	18.0	8.9	25.1
Color intensity	75.2				
Limpidity	2.9				
Clear[c]		40.0	30.0	75.2	60.9
Wine legs	35.4				
Fresh fruit aroma	40.3	23.3	22.0	30.0	30.4
Fruit jam aroma	32.8	53.3	22.0	40.7	30.7
Dried fruit aroma	29.7	13.3	15.0	21.1	26.4
Spice aroma	29.8	43.3	15.0	34.1	24.4
Floral aroma	34.0	56.7	14.0	31.5	22.6
Empireumatic aroma	42.3				
Smoked aroma[c]		36.7	29.0	19.3	18.9
Alcoholic odor	16.9	43.3	27.0	49.6	41.8
Oxidized odor	0.6				
Vinegary odor[c]		20.0	20.0	24.4	19.9
Aroma persistence	48.3				
Sweet taste	6.1	36.7	20.0	26.3	17.6
Sour taste	34.0	76.7	17.0	41.8	48.8
Bitter taste	37.4	30.0	11.0	41.8	36.2
Astringent taste	31.0	56.7	16.0	50.0	52.9
Alcoholic flavor	36.7	20.0	19.0	50.4	49.8
Fresh fruit flavor	15.3	13.3	14.0	18.5	17.6
Fruit jam flavor	34.7	23.3	15.0	17.8	10.6
Dried fruit flavor	21.1	33.3	14.0	17.4	22.6
Pungent flavor	49.2	26.7	13.0	27.4	25.2
Woody flavor	23.3	23.3	17.0	43.3	37.1
Body sensation	44.2	23.3	20.0	24.1	30.4
Flavor persistence	45.0	36.7	16.0	37.0	44.4

[a]Calculated according Alexi et al. (2018).
[b]TP-DA: trained panel—descriptive analysis; ST-CATA: semi-trained panel—check-all-that-apply; C-CATA: consumer—check-all-that-apply.
[c]Alternative attribute used in CATA questionnaire as replacement of color, limpidity, empireumatic aroma and oxidized odor.

with this characteristic. In addition, according to the TP-DA panel results, all wines were evaluated as "limpid." This may also has been a consequence of a poor understanding of the presented terms or attribute dumping, as described in the Section 3.1.2.

3.2 | Comparison of methodologies

3.2.1 | Attribute ranges and citation frequencies

In general, the TP-DA and ST-CATA methodologies presented a higher normalized maximum range (Table 3), which represents a greater differentiation between samples, allowing for a better discrimination of attributes than the C-CATA methodology.

According to the TP-DA results, high-intensity differences among samples were found in all evaluated sensory classes. Specifically, 17 out of the 24 significant attributes had a normalized maximum range very close to or greater than 30%, and the largest one was "color intensity,", with a 75.2% normalized maximum range.

Examining the results of attributes within the sensory methods, a smaller range of differences, very close or less than 20%, existed between ST-CATA and C-CATA for three aroma attributes: "fresh fruit aroma," "dried fruit aroma," and "vinegary aroma" and three flavor attributes: "alcoholic flavor," "fresh fruit flavor," and "body sensation"). This fact corroborated the lower power of discrimination of these methods since most of the mentioned attributes did not present significant differences (Table S2).

On the other hand, a large normalized maximum range difference for the attributes "limpidity," a non-significant attribute, and "clear" ($p < .05$) was found between TP-DA and the other methodologies, reinforcing the fact that consumers and semi-trained panelists may have often misunderstood some attributes (cf. Section 3.1.3.). Similarly, the attributes "alcoholic odor," "sweet taste," "sour taste," and "astringent taste," which could be translated into possible wine defects, were found to be highly discriminant ($p < .01$) and had a much higher normalized maximum range in ST-CATA than in the other methodologies, which can be interpreted as a side effect of quick training and an inability to specify intensities.

Regarding attribute citation frequency for ST-CATA, most attributes showed a similar (± 5%) or a higher frequency than those of C-CATA; specifically, 7 of the 12 significant attributes from all categories increased up to 15% (Table 3; Table S2).

3.2.2 | RV coefficient and MFA

The first two factors of MFA explained 33.4 and 19.7% of experimental variance, respectively (Figure 2a). Analyzing Figure 2a and, in accordance with Table 4, it was not possible to identify a clear relationship among methodologies when MFA was carried out with all wines, but it seemed that, despite the low RV coefficient (.583), the greatest similarity was found between ST-CATA and C-CATA.

However, a strong connection between wines of the same class (cf. Figure 1a), young and aged, was observed, so further investigation was conducted by carrying out MFA separately for each wine class.

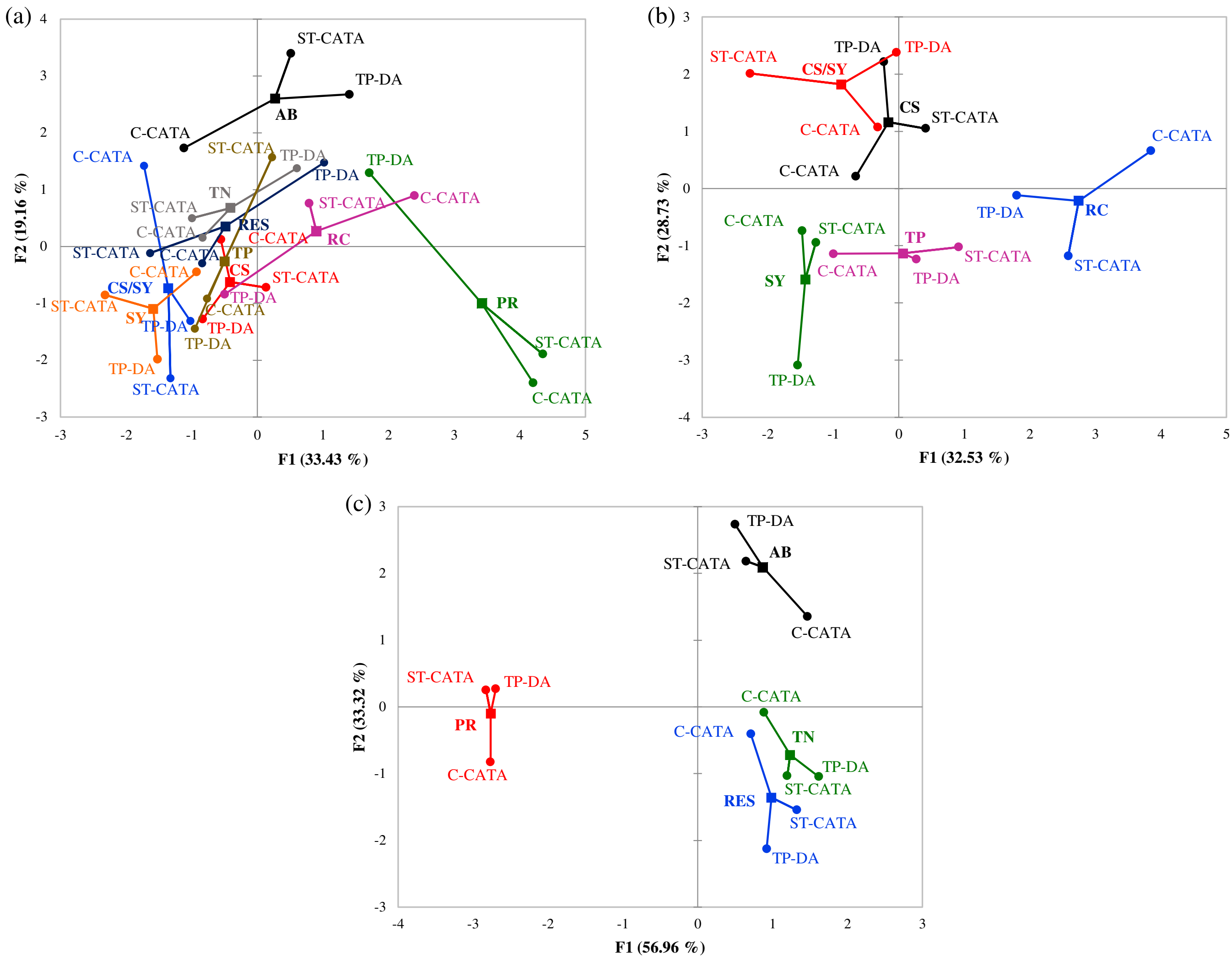

FIGURE 2 Multiple factor analysis map with partial points from different methods (●) and consensus points (■) of all wines (a), young wines (b) and aged wines (c). Method abbreviations: TP-DA, trained panel—descriptive analysis; ST-CATA, semi-trained panel—check-all-that-apply; C-CATA, consumer—check-all-that-apply. Sample abbreviations: AB, Alicante Bouschet; CS, Cabernet Sauvignon; CS/SY, Cabernet Sauvignon/Syrah; PR, Cabernet Sauvignon/Syrah/Alicante Bouschet/Touriga Nacional/Aragonês; RC, Ruby Cabernet; RES, Cabernet Sauvignon/Syrah/Alicante Bouschet; SY, Syrah; TP, Tempranillo; TN, Touriga Nacional

TABLE 4 RV coefficient between sample configurations for the first two dimensions of multiple factor analysis for trained assessor, semi-trained or consumer panelist data

	TP-DA[a] versus ST-CATA[a]	TP-DA[a] versus C-CATA[a]	ST-CATA[a] versus. C-CATA[a]
All wines	0.214^{ns}	0.062^{ns}	0.583*
Young wines[b]	0.411^{ns}	0.309^{ns}	0.401^{ns}
Aged wines[c]	0.954***	0.586^{ns}	0.723^{ns}

Note: ns, non-significant; *$p < .05$; ***$p < .001$.
[a]TP-DA: trained panel—descriptive analysis; ST-CATA: semi-trained panel—check-all-that-apply; C-CATA: consumer—check-all-that-apply.
[b]Wines without maturation: CS, CS/SY, SY, TP, and RC (cf. Table 1).
[c]Wines with maturation in French oak barrels: AB, TN, RES, and PR (cf. Table 1).

The separated MFAs made it possible to determine more distinct relations between methodologies. The TP-DA and ST-CATA methodologies provided a higher discrimination capacity than that of C-CATA and similar sample configurations (cf. Figure 1a,b). As shown in Table 4, the RV coefficient also indicated a higher degree of similarity of configurations between these methodologies for aged wines. As occurred with all wines, there was also good similarity between ST- and C-CATA for aged wines; although this result was not significant, it presented an important trend. For young wine samples, non-significant and low similarities were found, but the same behavior was found with high RV coefficients between TP-DA and ST-CATA and ST-CATA, and C-CATA.

The variance explained by MFA for young wines (Figure 2b) was 32.53 and 28.73% for F1 and F2, respectively. For aged wine samples (Figure 2c), a higher explained variance was obtained, with the first two dimensions accounting for 90.28% of the variance. In 7 out of 9 samples, the characterization profile of samples by the ST-CATA methodology was more similar to that obtained by the TP-DA methodology than to that obtained by the C-CATA methodology (Figure 2b,c).

4 | DISCUSSION

Over the last decade, interest in rapid and simple methodologies has largely increased, and one of the central dogmas of sensory evaluation has been successfully challenged. Now, it is generally accepted that analytical tests can be conducted with consumers who have been proven to be capable of providing accurate and reliable information (Ares & Varela, 2017b). However, most studies that provided good results applying these innovative methodologies have dealt with products that are part of people's daily consumption, such as juices, meat or dairy products (Alexi et al., 2018; Bruzzone et al., 2015; Jaeger et al., 2020; Lima, Ares, & Deliza, 2019).

For tropical red wines, the results of this study agree with previous conclusions that the utilization of CATA, shows similar results in comparison with those of trained assessors or semi-trained assessors (Alexi et al., 2018; Antúnez, Vidal, de Saldamando, Giménez, & Ares, 2017; Ares et al., 2015; Bruzzone et al., 2015). However, the results obtained show that despite the similarity of the methods, consumers and semi-trained panelists seemed to have greater difficulty in perceiving technical attributes and had a propensity to evaluate samples in generalist way.

Previous studies warn that the main quality of the CATA questionnaire, its binary system, may not allow for a direct measurement of the intensity of the evaluated sensory attributes and could hinder detailed sample descriptions and discrimination (Ares et al., 2015; Reinbach, Giacalone, Ribeiro, Bredie, & Frøst, 2014).

Comparing the methodologies applied for the analysis of red wine, the trained assessor data showed a greater level of detail in the description and discrimination of the samples than the semi-trained or consumer assessor data, a fact that could be due to the long period of training, which allowed for a better identification of sample differences (Ares et al., 2015). Even using a more favorable experimental design to C-CATA assessors to minimize the effects of sensory fatigue caused by alcoholic beverages and to provide a possible balance of performance for this untrained group, they showed the lowest power of description and discrimination of the samples.

However, an improvement of 30% (9–12 attributes) in the descriptive power of the samples was achieved by implementing a quick sensory training to consumers who also had some experience with the CATA method and with the evaluated wines, allowing as well for a reduction of 70% in the size of the panel (cf. Table 2). Similar results were previously observed by Alexi et al. (2018), who showed a great improvement in sample configuration when applying a semi-training course to consumers.

Despite the short training, it was possible to observe a quantitative and qualitative improvement in the perception and use of the attributes by semi-trained panelists when compared to the consumers. In addition to the discrimination of samples by color hues (reddish and purplish), there was a separate perception of other technical sensations, such as acidity, astringency (commonly mistaken for bitterness) and nuanced aromas, such as floral and spiced (Table S2).

The results also showed a possible lack of understanding or attribute dumping of the sensory terms applied in the C-CATA and ST-CATA, showing that even with glossaries for all evaluated terms, the language used should be simple and as close as possible to the daily consumption experience in real life (Ares & Varela, 2017a; Fiszman, Salgado, Orrego, & Ares, 2015).

The normalized maximum range is a quantitative measurement that allowed for us to identify whether different methods provide the same range of difference for an attribute between samples; in other words, it can explain the discrimination power across methods (Alexi et al., 2018). In this context, the low index found for the C-CATA methodology (Table 3) corroborated Hough (2017) by indicating that a lack of training can lead to inconsistencies in the data, resulting in low sample discrimination.

The training- and experience-related improvement in performance could also be seen by a higher total citation frequency of an attribute in the ST-CATA methodology than in the C-CATA. Previous studies have reported that there appears to be a positive linear relationship between attribute intensity and the attribute citation frequency (Ares et al., 2015; Vidal, Ares, Hedderley, Meyners, & Jaeger, 2018); however, among the 14 sensorial attributes with an increase in citation frequency (Table 3), only seven presented significant differences (Table S2), showing that despite perceiving a more intense stimulus, it was not enough to discriminate samples.

Significant RV coefficients between sample configurations ranged between .583 and .954 (Table 4), and similar values have been previously shown as indicators of good agreement between sample configurations for products with subtle differences, such as white wine, coffee, and beer (Ares et al., 2015; Chollet, Lelièvre, Abdi, & Valentin, 2011; Moussaoui & Varela, 2010).

Comparing the two wine classifications, a higher RV coefficient for aged wines than for young wines was obtained between all methods (Table 4), possibly meaning easier identification of aged wine sensory characteristics in all methodologies since aged wines represent well-defined samples with greater sensory stability. As presented in Figure 2, higher configurational similarity was obtained between TP-DA and ST-CATA than between TP-DA and C-CATA, mainly for aged wine samples. This improved sensory explanation corroborates the data found by the RV coefficient (0.95), showing a greater discrimination of samples.

A correlation of almost 70% (Scott, Grygorczyk, Gilbert, & Duizer, 2017) was also obtained during the comparison of ST-CATA and C-CATA for aged wines. Despite training period or greater experience with analytical methods, the consumers tended to evaluate the samples similarly when supported by appropriate methodologies. Similar results were obtained by Ares et al. (2015) when comparing white wine elicitation between trained panelists and consumers and by Antúnez et al. (2017) when analyzing consumer-based methods in orange juice evaluation. Moreover, the improved RV coefficient was found to be non-significant since it presented only a trend.

The relatively low and non-significant correlations found between the methods for young wines may reflect the difficulty of sample evaluation since these wines present a more dynamic transformation pattern and less stability than aged wines. Furthermore, this fact could be related to the evaluation of samples with small differences (Ares et al., 2015; Oppermann, de Graaf, Scholten, Stieger, & Piqueras-Fiszman, 2017).

Taking into account differences and similarities obtained among the methodologies, the complementarity of trained assessor and consumer panels should be stressed, and both types of assessors can provide valid and reliable information in different application fields, such as identification of factors influencing preference, prediction of purchase behavior or quality control (Ares & Varela, 2017b).

5 | CONCLUSIONS

Training with physical references, even when short and simple, as well as previous experience with the method and products, who had the ST-CATA assessors, had a positive effect on the discrimination and characterization of tropical wine samples, increasing the citation frequency of CATA questionnaire attributes and enhancing the normalized attribute range, which meant a greater sensory ability when compared to that of untrained consumers. Although we agree that when accurate and technical results are required, rapid methods, such as CATA questionnaires, should not be regarded as a replacement of DA with trained assessors.

CATA questionnaires completed by using consumers, due mainly to lack of training and the binary response format, hinder discrimination between samples when attribute intensities are relatively low. Some misunderstandings related to technical terms, such as the dumping effect, were also observed in both consumers and semi-trained panelists, suggesting that for better results, a general and less technical vocabulary should be applied.

In general, the semi-trained CATA questionnaire is a valuable tool regarding specific and well-tailored wine training when a trained panel cannot be sustained or time- and cost-efficient sensory profiling is needed; moreover, more similarities than differences were obtained in the ST-CATA methodology in this study.

ACKNOWLEDGMENTS

The authors would like to thank wineries of São Francisco Valley for providing the samples and the staff of the Gastronomy and Culinary Arts Laboratory (Universidade Federal Rural de Pernambuco) for help in pilot work and data collection. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001.

CONFLICT OF INTEREST

All authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Caio Monteiro Veríssimo: Planned the research, performed statistical analyses and wrote the paper. **Samara de Macêdo Morais:** Contributed to acquisition and analysis of data. **Luciana Leite de Andrade Lima:** Was responsible to conceptualization of the study, methodology planning and manuscript review. **Giuliano Elias Pereira:** Obtained the samples and supervised the project. **Maria Inês Sucupira Maciel:** Supervised the project, planned the methodology and reviewed the manuscript. All authors have approved the final article.

ORCID

Caio Monteiro Veríssimo https://orcid.org/0000-0002-6848-6911
Maria Inês Sucupira Maciel https://orcid.org/0000-0002-8910-2833

REFERENCES

Alexi, N., Nanou, E., Lazo, O., Guerrero, L., Grigorakis, K., & Byrne, D. V. (2018). Check-all-that-apply (CATA) with semi-trained assessors:

Sensory profiles closer to descriptive analysis or consumer elicited data? *Food Quality and Preference*, *64*, 11–20. https://doi.org/10.1016/j.foodqual.2017.10.009

Antúnez, L., Vidal, L., de Saldamando, L., Giménez, A., & Ares, G. (2017). Comparison of consumer-based methodologies for sensory characterization: Case studywith four sample sets of powdered drinks. *Food Quality and Preference*, *56*, 149–163. https://doi.org/10.1016/j.foodqual.2016.09.013

Ares, G. (2015). Methodological challenges in sensory characterization. *Current Opinion in Food Science*, *3*, 1–5. https://doi.org/10.1016/j.cofs.2014.09.001

Ares, G., Antúnez, L., Bruzzone, F., Vidal, L., Giménez, A., Pineau, B., … Jaeger, S. R. (2015). Comparison of sensory product profiles generated by trained assessors and consumers using CATA questions: Four case studies with complex and/or similar samples. *Food Quality and Preference*, *45*, 75–86. https://doi.org/10.1016/j.foodqual.2015.05.007

Ares, G., & Varela, P. (2017a). Trained vs. consumer panels for analytical testing: Fueling a long lasting debate in the field. *Food Quality and Preference*, *61*, 79–86. https://doi.org/10.1016/j.foodqual.2016.10.006

Ares, G., & Varela, P. (2017b). Authors' reply to commentaries on Ares and Varela. *Food Quality and Preference*, *61*, 100–102. https://doi.org/10.1016/j.foodqual.2017.03.004

Bruzzone, F., Vidal, L., Antúnez, L., Giménez, A., Deliza, R., & Ares, G. (2015). Comparison of intensity scales and CATA questions in new product development: Sensory characterization and directions for product reformulation of milk desserts. *Food Quality and Preference*, *44*, 183–193. https://doi.org/10.1016/j.foodqual.2015.04.017

Chollet, S., Lelièvre, M., Abdi, H., & Valentin, D. (2011). Sort and beer: Everything you wanted to know about the sorting task but did not dare to ask. *Food Quality and Preference*, *22*, 507–520. https://doi.org/10.1016/j.foodqual.2011.02.004

Damasio, M. H., & Costell, E. (1991). Análisis Sensorial Descriptivo: Generación de Descriptores y Selección de Catadores. *Revista de Agroquímica y Tecnología de Alimentos*, *32*, 165–177.

Fiszman, S. M., Salgado, N., Orrego, C. E., & Ares, G. (2015). Comparison of methods for generating sensory vocabulary with consumers: A case study with two types of satiating foods. *Food Quality and Preference*, *44*, 111–118. https://doi.org/10.1016/j.foodqual.2015.04.005

Hough, G. (2017). Commentary on Ares and Varela. *Food Quality and Preference*, *61*, 94–95. https://doi.org/10.1016/j.foodqual.2017.01.015

ISO. (1977). *Sensory analysis: Apparatus—Wine tasting glass. ISO Standard 3591:1977*. Geneva, Switzerland: International Organization for Standardization.

ISO. (2007). *Sensory analysis: General guidance for the design of test rooms. ISO Standard 8589:2007*. Geneva, Switzerland: International Organization for Standardization.

ISO. (2012). *Sensory analysis: General guidance for the selection, training, and monitoring of selected assessors and expert sensory assessors. ISO Standard 8586:2012*. Geneva, Switzerland: International Organization for Standardization.

Jaeger, S. R., Beresford, M. K., Lo, K. R., Hunter, D. C., Chheang, S. L., & Ares, G. (2020). What does it mean to check-all-that-apply? Four case studies with beverages. *Food Quality and Preference*, *80*, 103794. https://doi.org/10.1016/j.foodqual.2019.103794

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of foods: Principles and practices* (2nd ed.). New York: Chapman & Hall.

Lima, M., Ares, G., & Deliza, R. (2019). Comparison of two sugar reduction strategies with children: Case study with grape nectars. *Food Quality and Preference*, *71*, 163–167. https://doi.org/10.1016/j.foodqual.2018.07.002

Meilgaard, M. C., Civille, G. V., & Carr, B. T. (2015). *Sensory evaluation techniques* (5th ed.). Florida: CRC Press.

Meyners, M., Castura, J. C., & Carr, B. T. (2013). Existing and new approaches for the analysis of CATA data. *Food Quality and Preference*, *30*, 309–319. https://doi.org/10.1016/j.foodqual.2013.06.010

Moskowitz, H. R. (2017). Consumers vs experts: Opinions by an outspoken psychophysicist. *Food Quality and Preference*, *61*, 89–91. https://doi.org/10.1016/j.foodqual.2017.01.010

Moussaoui, K. A., & Varela, P. (2010). Exploring consumer product profiling techniques and their linkage to a quantitative descriptive analysis. *Food Quality and Preference*, *21*(8), 1088–1099. https://doi.org/10.1016/j.foodqual.2010.09.005

Oliveira, J. B., Egipto, R., Laureano, O., Castro, R., Pereira, G. E., & Ricardo-da-Silva, J. M. (2019). Chemical composition and sensory profile of Syrah wines from semiarid tropical Brazil—Rootstock and harvest season effects. *LWT—Food Science and Technology*, *114*, 1–9. https://doi.org/10.1016/j.lwt.2019.108415

Oppermann, A. K. L., de Graaf, C., Scholten, E., Stieger, M., & Piqueras-Fiszman, B. (2017). Comparison of rate-all-that-apply (RATA) and descriptive sensory analysis (DA) of model double emulsions with subtle perceptual differences. *Food Quality and Preference*, *56*, 55–68. https://doi.org/10.1016/j.foodqual.2016.09.010

Padilha, C. V. S., Camarão, T. B. A., Correa, L. C., Lima, M. D. S., & Pereira, G. E. (2017). Phenolic compounds profile and antioxidant activity of commercial tropical red wines (*Vitis vinifera* L.) from São Francisco Valley, Brazil. *Journal of Food Biochemistry*, *41*, 1–9. https://doi.org/10.1111/jfbc.12346

Reinbach, H. C., Giacalone, D., Ribeiro, L. M., Bredie, W. L., & Frøst, M. B. (2014). Comparison of three sensory profiling methods based on consumer perception: CATA, CATA with intensity and Napping®. *Food Quality and Preference*, *32*, 160–166. https://doi.org/10.1016/j.foodqual.2013.02.004

Robert, P., & Escoufier, Y. (1976). A unifying tool for linear multivariate statistical methods: The RV-coefficient. *Applied Statistics*, *25*(3), 257–265. https://doi.org/10.2307/2347233

Scott, N., Grygorczyk, A., Gilbert, C., & Duizer, L. (2017). Exploring the use of rapid profiling techniques for use in older adult populations. *Food Quality and Preference*, *62*, 199–207. https://doi.org/10.1016/j.foodqual.2017.06.012

Vidal, L., Ares, G., Hedderley, D. I., Meyners, M., & Jaeger, S. R. (2018). Comparison of rate-all-that-apply (RATA) and check-all-that-apply (CATA) questions across seven consumer studies. *Food Quality and Preference*, *67*, 49–58. https://doi.org/10.1016/j.foodqual.2016.12.013

Vidal, L., Tárrega, A., Antúnez, L., Ares, G., & Jaeger, S. R. (2015). Comparison of correspondence analysis based on Hellinger and chi-square distances to obtain sensory spaces from check-all-that-apply (CATA) questions. *Food Quality and Preference*, *43*, 106–112. https://doi.org/10.1016/j.foodqual.2015.03.003

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Veríssimo CM, de Macêdo Morais S, de Andrade Lima LL, Pereira GE, Maciel MIS. A short training as an enhancer of sensory ability: The case of red wine consumers. *J Sens Stud*. 2020;e12629. https://doi.org/10.1111/joss.12629