beverages

MDPI

Article

Construction of Sensory Wheel for Grape Marc Spirits by Integration of UFP, CATA, and RATA Methods

Evangelia Anastasia Tsapou, Panagiotis Ignatiou, Michaela Zampoura and Elisabeth Koussissi *

Department of Wine, Vine and Beverage Sciences, University of West Attica, Agiou Spyridonos, 12243 Egaleo, Greece; etsapou@uniwa.gr (E.A.T.); panagiotisignatiou2002@gmail.com (P.I.); michaela.zampoura@gmail.com (M.Z.)
* Correspondence: ekoussissi@uniwa.gr

Abstract

Grape marc spirits represent a significant category within the alcoholic beverage sector, particularly across Mediterranean Europe. This study aimed to construct a sensory flavor wheel—covering aroma, taste, and mouthfeel modalities—specifically for non-flavored and non-wood-aged grape marc distillates. To achieve this, we explored the feasibility of a novel methodological approach combining three rapid sensory techniques: Ultra Flash Profiling (UFP), Check-All-That-Apply (CATA), and Rate-All-That-Apply (RATA). Forty-five (45) samples from Greece, Cyprus, and Italy were evaluated by a trained panel of 12 assessors. UFP generated 205 initial descriptors, which were refined to 59 for CATA. Despite the long attribute list, CATA data helped identify the most relevant terms for the final RATA experiment. The sequential application of these methods, along with intermediate data filtering, led to the selection of 45 key descriptors with occurrence frequencies ranging from 33.3% to 97.7%. These were organized into a comprehensive flavor wheel grouped into 12 general categories. This approach offers a flexible framework for future flavor wheel construction in other under-characterized product categories.

Keywords: grape marc spirits; sensory wheel; tsipouro; zivania; UFP; CATA; RATA

check for updates

Academic Editor: Koushik Adhikari

Received: 14 May 2025
Revised: 24 June 2025
Accepted: 26 June 2025
Published: 3 July 2025

Citation: Tsapou, E.A.; Ignatiou, P.; Zampoura, M.; Koussissi, E. Construction of Sensory Wheel for Grape Marc Spirits by Integration of UFP, CATA, and RATA Methods. *Beverages* **2025**, *11*, 101. https://doi.org/10.3390/beverages11040101

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The solid by-product remaining after grape pressing and juice extraction in winemaking—commonly known as grape marc—is widely utilized in Mediterranean Europe for crafting traditional distilled alcoholic beverages. Countries such as Italy, Spain, France, Greece, and Cyprus collectively generate around 10 million tons of this by-product annually, which is then repurposed for spirit production, adding economic value to the winemaking process [1–3]. Those grape marc spirits, recognized under different names depending on their country of origin—like Grappa in Italy, Orujo in Spain, Eau de vie de marc in France, and Zivania in Cyprus—are integral to the cultural identity of their regions [4–6]. Despite their significance, sensory research on those spirits remains relatively limited, with only a few studies exploring their characteristics.

Sensory lexicons are standardized systems of collection of the sensory vocabulary relevant to a product category created using various sensory methods. Those serve as reference lists for describing various products, including beverages like wine, beer, spirits, and coffee [7–10]. Over time, specific descriptive lexicons have been created for beer [11], wine [12,13], whisky [14], and other alcoholic beverages, such as brandy [15] and rosé port wines [16]. Those lexicons help qualitatively differentiate products based on specific

attributes, while, for the quantitative aspect, one could focus on the intensity of those. Sensory lexicons for food and beverages are often organized into flavor wheels, which serve as a tool for descriptive terminology to characterize a product's attributes. Such tools facilitate the harmonization of sensory terminology, enhancing clarity in communication among stakeholders such as producers, traders, and consumers when describing product attributes [1,17].

Most sensory professionals use descriptive analyses by trained sensory panels in order to develop such lexicons. On highly alcoholic beverages specifically, there are few works in which sensory lexicons have been developed using descriptive analyses. In the research by Donnell and co-workers (2007) [18], for example, a sensory lexicon for the olfactory assessment of distilled spirits was developed using descriptive analysis, in which 16 assessors initially generated a list of over 100 odor attributes, which was further reduced to a final list of 20 descriptors. Key sensory attributes included terms like alcohol strength, aniseed, fruity, aromatic spices, and woody. In that study, Principal Component Analysis (PCA) and Analysis of Variance (ANOVA) were used to assess the panel's ability to discriminate between samples, and, throughout three sessions, the panel showed significant improvement in their ability to describe and differentiate between the odors of eight colorless distilled beverages, such as vodka, gin, and tequila. The study demonstrated how dynamic sensory learning occurs during vocabulary development, providing useful tools for the future sensory analysis of beverages [18].

Related to the category of grape marc distillates, there are to date two studies, to our knowledge, that have created sensory lexicons or an aromatic wheel to characterize them. Namely, first, Tsahaki and co-workers in 2010 [19] attempted to create a lexicon for ouzo and tsipouro with aniseed addition, spirits. In that study, descriptors like anise, sweet, menthol, and herbal for odor and sweet, alcoholic, and spicy for taste were included, and PCA and cluster analysis were used to highlight sensory differences between the aniseed samples assessed. Later, in the work of Darici et al. (2021) [1], a sensory lexicon and wheel for Turkish Raki products were developed, identifying 78 attributes for aroma, mouthfeel/taste, and appearance. For aroma, the attributes with the highest frequency were "fresh aniseed", "sweet odour", "green apple", "suma", and "spicy". Descriptive sensory and Principal Component Analyses (PCA) revealed strong relationships between Raki samples and sensory terms. Both those studies, emphasizing the importance of the identification and categorization of unique sensory descriptors relevant to the flavor profiles of those spirits, were based on the aniseed-flavored version of that product category and not the spirits that result from the distillation of grape marc without any flavor addition/intervention or aging.

Moreover, and more recently, alternative methods such as rapid sensory methodologies have been used to construct sensory lexicons and flavor wheels. Namely, in the work of Silvello and coworkers (2020) [9], Ultra Flash Profiling (UFP), a method using verbal product descriptions, and Napping, a method focused on measuring similarities between products, were employed in order to construct a new barrel-aged beer flavor wheel. Similarly, a free sorting task, another method focusing on similarities and/or differences between products, was used by Spencer and coworkers (2016) [7] to design a new coffee flavor wheel. Finally, Phetxumphou and coworkers (2020) [8] developed a lexicon for Virginia hard (alcoholic) ciders with the Check-All-That-Apply (CATA) method. In that case, CATA was employed to eliminate the need for a time-consuming and costly descriptive analysis of the products by trained panels, and the rapidly developed lexicon encompassed adequate sensory attributes [8]. CATA and Rate-All-That-Apply (RATA) questions provide a flexible multiple-choice-format type of approach where respondents are given a list of words and asked to select all the terms that they find relevant [20,21].

This work was primarily aimed at constructing a sensory flavor wheel—covering aroma, taste, and mouthfeel modalities—specifically for grape marc distillates that were unaged and free from any added botanicals. To achieve this, we explored the feasibility of applying a novel methodological approach that combined three relatively rapid sensory techniques: Ultra Flash Profiling (UFP), followed by Check-All-That-Apply (CATA), and then Rate-All-That-Apply (RATA). Constructing a sensory wheel by applying a sequential combination of the above methods had a parallel aim. The latter was based on supporting the development of a preliminary sensory lexicon and identifying both the most discriminative descriptors among samples and those most frequently expressed across all of them. To our knowledge, this is the first time that rapid sensory methods such as UFP, CATA, and RATA have been systematically applied to grape marc spirits in Greece. While countries like Italy have established official bodies—such as the Istituto Nazionale Grappa—that define sensory profiles for grappa, no such formal sensory committees currently exist in Greece or Cyprus for products like tsipouro/tsikoudia or zivania. This highlights the novelty and potential value of our approach.

2. Materials and Methods

2.1. Samples

Forty-five (45) grape marc spirits were collected. Thirty-six (36) of the spirits were Tsipouro/Tsikoudia spirits from Greece, two (2) were Grappa spirits from Italy, and the remaining seven (7) were Zivania spirits from Cyprus. Samples were either sourced directly from producers or obtained through retail outlets. To preserve confidentiality, and due to the nature of this study, brand names are not disclosed. However, all samples were selected to represent a wide range of production styles and geographic origins (Table 1). None of the samples contained anise or other added spices, and none had undergone wood maturation. Samples were stored in the dark at room temperature prior to sensory evaluation.

Table 1. Spirits used, country and specific geographical region of origin of the products, code names, and inclusion in each sensory method of this study (UFP, CATA, and RATA).

Region		Code	UFP	CATA	RATA
Greece	Tyrnavos	T1	✓	✓	
		T2	✓	✓	✓
		T3	✓	✓	✓
		T4	✓	✓	✓
		T5	✓	✓	✓
		T6	✓	✓	
		T27	✓	✓	✓
		T28	✓	✓	✓
		T29	✓	✓	✓
		T30	✓	✓	✓
		T31	✓	✓	✓
		T32	✓	✓	✓
	Thessaly	T7	✓	✓	
		T8	✓	✓	✓
		T9	✓	✓	✓
		T10	✓	✓	✓
		T11	✓	✓	✓

Table 1. *Cont.*

Region		Code	UFP	CATA	RATA
Greece	Peloponnese	T12	✓	✓	
		T13	✓	✓	✓
		T15	✓	✓	
		T16	✓	✓	✓
		T17	✓	✓	✓
	Thrace	T18	✓	✓	✓
		T19	✓	✓	
	Central Greece	T14	✓	✓	✓
		T22	✓	✓	✓
		T20	✓	✓	✓
		T21	✓	✓	
		T35	✓	✓	✓
		T36	✓	✓	✓
	Crete	T23	✓	✓	
		T24	✓	✓	✓
		T25	✓	✓	
		T33	✓	✓	✓
		T34	✓	✓	✓
	Cyclades	T26	✓	✓	✓
Italy		T37	✓	✓	✓
		T38	✓	✓	✓
Cyprus		T39	✓	✓	✓
		T40	✓	✓	✓
		T41	✓	✓	✓
		T42	✓	✓	✓
		T43	✓	✓	✓
		T44	✓	✓	✓
		T45	✓	✓	✓

2.2. Sample Preparation

The beverages typically contained approximately 40% alcohol by volume. To support sensory evaluation, enhance aroma perception, and reduce ethanol-induced fatigue, all spirit samples were diluted with water prior to testing, following the procedure outlined in Tsapou et al. (2024) [3]. Commercial still water was used for dilution (Zagori natural mineral water, Epirus, Greece), adjusting the final alcohol concentration of each sample to 25% v/v. After preparation, the diluted spirits were transferred into transparent glass bottles, sealed, and stored at ambient temperature (20–22 °C). The same bottled water used for dilution was also made available to panelists during the sessions for palate cleansing between samples.

2.3. Assessors

The sensory panel consisted of twelve individuals (seven women and five men) aged between 27 and 65, all affiliated with the Department of Wine, Vine, and Beverage Sciences at the University of West Attica, either as staff or postgraduate students. A total of 45 samples were evaluated using the UFP and CATA methods, while a subset of 36 samples was assessed using RATA. The evaluations were carried out across thirteen sessions covering all three methods. Prior to participation, all assessors underwent screening to confirm

normal olfactory and gustatory function and had previous experience as trained panelists in both wine and beer evaluations, with a stronger background in wine, as detailed in Tsapou et al. (2024) [3]. Although no specific training on spirits or the particular spirit type used in this study was provided, assessors were already familiar with the flavor profile of these products through earlier experiments. Ethical approval was obtained from the University of West Attica's Research Ethics Committee (ref. no. 97565). Informed consent was secured from all participants, who confirmed their understanding of this study's confidentiality terms and their right to withdraw at any time. All tested products were safe for consumption.

The sensory evaluations were conducted in individual, neutral-colored booths under a combination of natural and artificial lighting within a temperature-controlled environment (20 ± 2 °C) compliant with ISO standards [22]. Samples were served in a randomized sequence across participants and sessions, using a partially balanced design. Each sample was identified with a unique three-digit code. Prior to evaluation, 20 mL portions of diluted samples were served at ambient temperature (18–21 °C) in ISO-standard tasting glasses, covered with plastic Petri dish lids. Participants received printed instructions for both the UFP and CATA/RATA tasks, which were also explained verbally by the experimenter. Responses were recorded on paper questionnaires. Assessors were instructed to consider all relevant sensory dimensions: orthonasal and retronasal aroma, basic tastes, mouthfeel, and aftertaste. Bottled water (identical to that used for dilution) and neutral-flavored cream crackers (Papadopoulos Cream Crackers wheat, Athens, Greece), were provided to cleanse the palate between samples. Visual attributes were excluded from the evaluation, as all samples were clear and colorless. Panelists were allowed as much time as needed to complete their assessments.

2.4. Experimental Design

This sequential combination of UFP, CATA, and RATA was designed to support the identification of both the most discriminative descriptors among samples and those most frequently expressed across all of them, thus ensuring a comprehensive and representative flavor wheel for this product category. Figure 1 is a graphical representation of the experimental design.

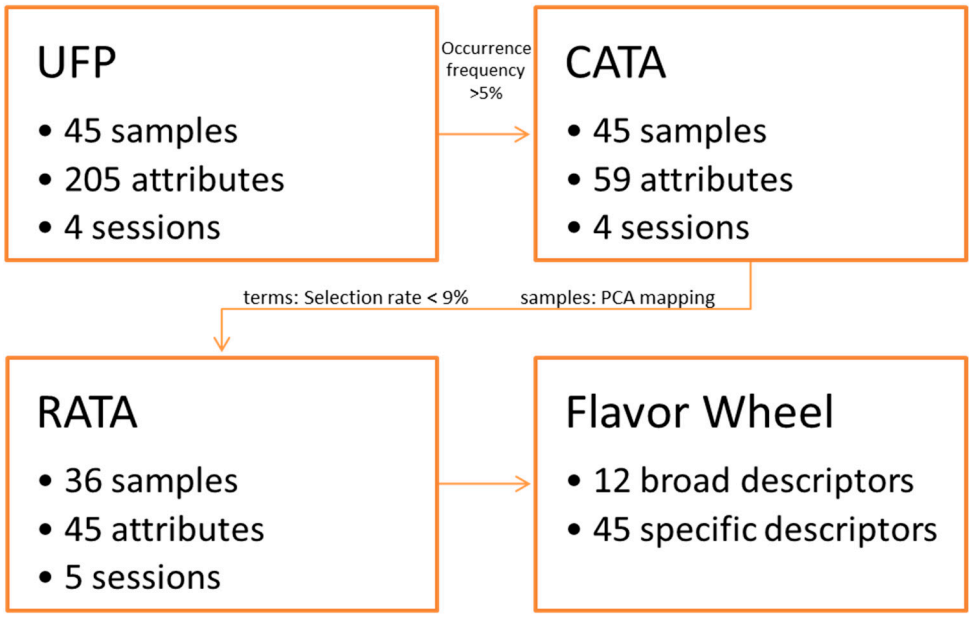


Figure 1. Flowchart illustrating the sequential application of sensory methods—UFP, CATA, and RATA—in the development of a flavor wheel for grape marc spirits.

In the first part of our experiment, the aim was to capture all relevant flavor attributes for all forty-five (45) grape marc spirits used in this study. Therefore, four sessions of UFP [9] per assessor were carried out in order to generate the descriptors relevant to the sensory profiling of all samples. The samples were presented in a randomized order across sessions and assessors, split into three sessions of 11 spirits and one session of 12 spirits. Attributes generated after the completion of all UFP sessions, 205 words, were collected and initially listed in alphabetical order. The terms were first assessed based on their occurrence frequency, with an acceptable threshold set at over 5% [23]. Following that, the main investigators of this study grouped the remaining terms based on their semantic similarities, the literature [3], and the expertise of the researchers. Redundant terms were removed, and expressions with similar or identical meanings were consolidated.

Subsequently, the fifty-nine (59) remaining terms were collected and used in the second part of our experiment, which comprised four (4) CATA [20,24] sessions per panelist. The purpose of CATA in the second phase was to screen relevant attributes for all forty-five (45) samples, and the presentation order of the samples was randomized across sessions and assessors using. The four sessions were split into three sessions of 11 spirits and one session of 12 spirits. The terms included in the CATA part of our study, even though possibly on the high end regarding the number of CATA words used, were easy to understand for the assessors, as they were generated by the same group of assessors in the first place. According to the CATA results and specifically the percentage of counts of checked attributes and their *p*-values (Table 2), the terms were reduced further (selection rate below 9%) to forty-five (45) terms, including those related to aromas, basic tastes, mouthfeel, and aftertaste modalities (Table 2).

Finally, in the last part of our experiment, which was the RATA method application, the number of samples used was reduced in parallel to the number of sensory terms in order to reduce assessor fatigue per session and enhance data value. The reduction of the samples to be further used in RATA was based on a mapping according to PCA of the spirits using the terms from CATA (Figure S1). Samples were removed if, after studying the first two PCA dimensions, they appeared very similar to each other regarding their mapping based on all fifty-nine (59) attributes (Figure S1). To reduce the number of terms, we used the selection rate of each term by the assessors. The RATA experiment was run, using forty-five (45) terms (Table 2) and thirty-six (36) spirit samples (Table 1), split into five sessions (four sessions of 7 and one session of 8 spirits). This time, besides the randomization of sample presentation across sessions and assessors, the words presented in the RATA questionnaire were categorized according to their modality (aroma, basic taste, mouthfeel) in order to make the task easier for the assessors [20].

2.5. Statistical Analysis

UFP, CATA, and RATA data were analyzed separately. CATA and RATA data were analyzed according to the suggested methods from XLSTAT. Specifically for CATA, we used Cochran's Q test, Correspondence Analysis (CA), Principal Coordinates Analysis (PCoA), and Agglomerative Hierarchical Clustering (AHC); for RATA, ANOVA and Correspondence Analysis (CA) were used, while UFP data were analyzed using PCA. Last, PCA was applied to the CATA data in order to acquire a quick mapping of the samples for the sole purpose of eliminating certain similar samples for the last experiment with RATA. All statistical analyses were conducted using XLSTAT Version 2024.3.0 (Addinsoft, 2024) [25].

3. Results

3.1. Ultra Flash Profile

Two hundred and five (205) terms were collected from all UFP sessions and panelists. A Principal Component Analysis was conducted for all terms and explained a variance of 28.83% in the first two axes (F1 23.01% and F2 5.82%) (Figure S2). The terms that stood out in F1 axes were *fruity*, *citrus*, *sweet*, and *floral* notes, as well as *grassy*, *herbal*, *green wood*, and *cooked/canned* aromas. These descriptors suggest that the initial UFP phase captured a wide range of both fresh and processed aromatic characteristics, reflecting the diversity of the grape marc distillates. However, the dispersion of terms and the relatively low explained variance indicated a high level of redundancy and overlap among descriptors. Therefore, in line with the previous literature [23,26], the terms were first evaluated based on their frequency of occurrence, with an acceptable threshold set at >5%. This filtering step eliminated 104 descriptors, leaving 101. These remaining terms were then grouped by the researchers according to their degree of similarity, reducing the list to 59 terms, which were subsequently used for the CATA evaluation (Table 2).

This process demonstrated the role of UFP as an exploratory tool that provided a broad sensory vocabulary, which was then refined to create a more structured and manageable set of descriptors. This refined list formed the foundation for the subsequent CATA and RATA evaluations, allowing for more focused and statistically robust analysis of the sensory profiles.

Table 2. Percentage of counts of checked attributes and their *p*-values according to Cochran's Q test on CATA results. In bold are the attributes with important effects on explaining product differences from CATA.

Attributes	%	*p*-Values	Attributes	%	*p*-Values
sweet	45%	0.405	bread	12%	0.821
burning	41%	**0.066**	nuts	12%	0.162
coating	30%	0.157	spicy	12%	0.880
floral	28%	**0.086**	medical	12%	0.340
bitter	25%	**0.050**	salty	12%	0.680
citrus fruit	24%	**0.062**	**dill**	11%	**0.033**
fruity	22%	**0.036**	earthy	11%	0.277
eucalyptus	20%	**0.030**	smoky	11%	0.255
fresh	19%	0.568	**grape**	10%	**0.079**
grassy	19%	0.790	**rose**	10%	**0.022**
anise	19%	0.257	mint	10%	0.925
dried (hay, straw, tea)	18%	0.512	pine	10%	0.529
white flowers	18%	0.200	waxy	10%	0.581
petroleum	18%	**0.023**	berries	9%	0.159
woody	17%	0.147	lavender	9%	0.108
stone fruit	17%	0.232	**fishy**	9%	**0.005**
caramel	17%	**0.028**	**rubbery**	9%	**0.059**
ethyl acetate	17%	0.910	dry	7%	0.660
vanilla	16%	0.509	sea	7%	0.220
fatty	16%	0.579	cherry	7%	0.256
tropical fruit	16%	0.588	fruit jam	7%	0.686
honey	15%	0.693	pool	6%	0.101
rough	15%	0.128	butter	6%	0.893
soapy	14%	0.173	dusty	6%	0.457
pipfruit (apple/pear)	14%	0.233	soil	6%	0.397
canned/cooked	14%	0.605	mushroom	5%	0.333
dried fruit (plum, raisin, etc.)	13%	**0.055**	laurel	3%	0.325
orange blossom	13%	0.680	animalic	3%	0.325
			coffee	3%	0.488
			oily	2%	0.661
			acetic acid	1%	**0.025**

3.2. Check-All-That-Apply

Fifty-nine (59) terms were used for the CATA assessment on all forty-five (45) samples. According to the results from Cochran's Q test, fifteen attributes had important *p*-values, with nine of those showing *p*-values < 0.05, thus explaining significant differences between the products, and six with $0.05 < p < 0.1$, thus being less significant in differentiation (Table 2). Based on these observations, it is highly probable that the products differed meaningfully in terms of their sensory attributes. Correspondence Analyses (CAs) for those terms were conducted, explaining 34.65% of the variation between the products on the first two dimensions (F1 = 21.41%, F2 = 13.24%) (Figure 2). Although the Correspondence Analysis did not reveal strong separation among most samples, certain descriptors—such as *fruity*, *floral*, *herbal*, and *caramel*—appeared frequently and were positioned near the center of the plot, suggesting that they were commonly used across products. However, this did not imply clear differentiation among samples based on these attributes. In contrast, approximately 25% of the samples were differentiated primarily along the F1 axis by four descriptors typically regarded as defects: acetic acid, petroleum, rubbery, and fishy notes.

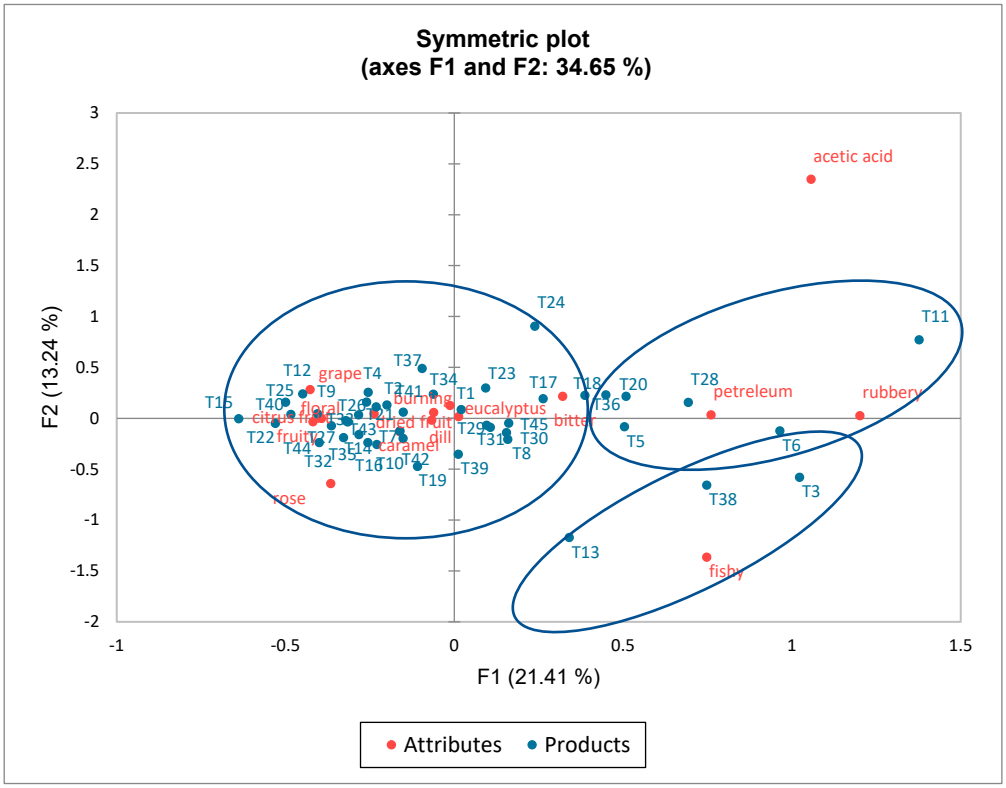
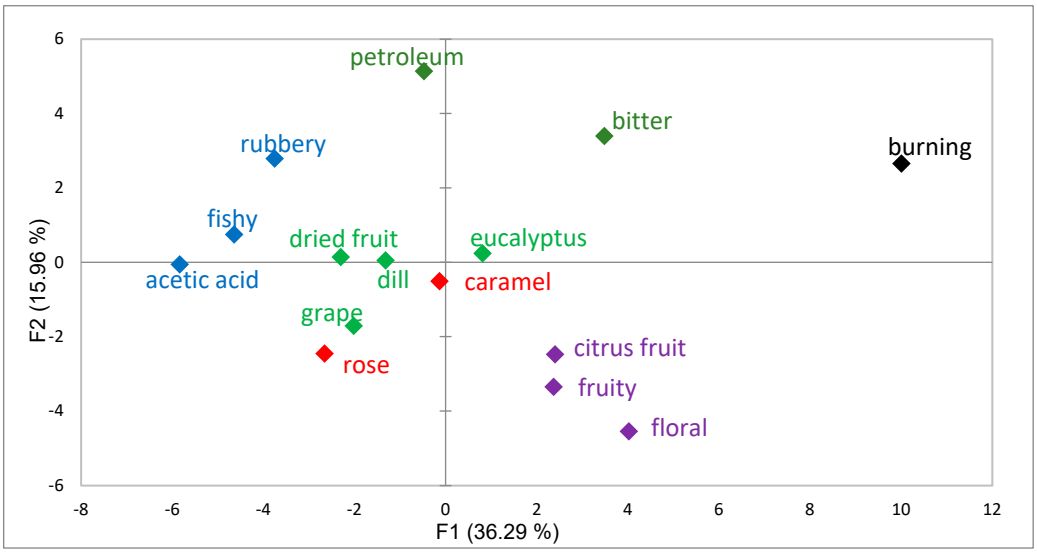


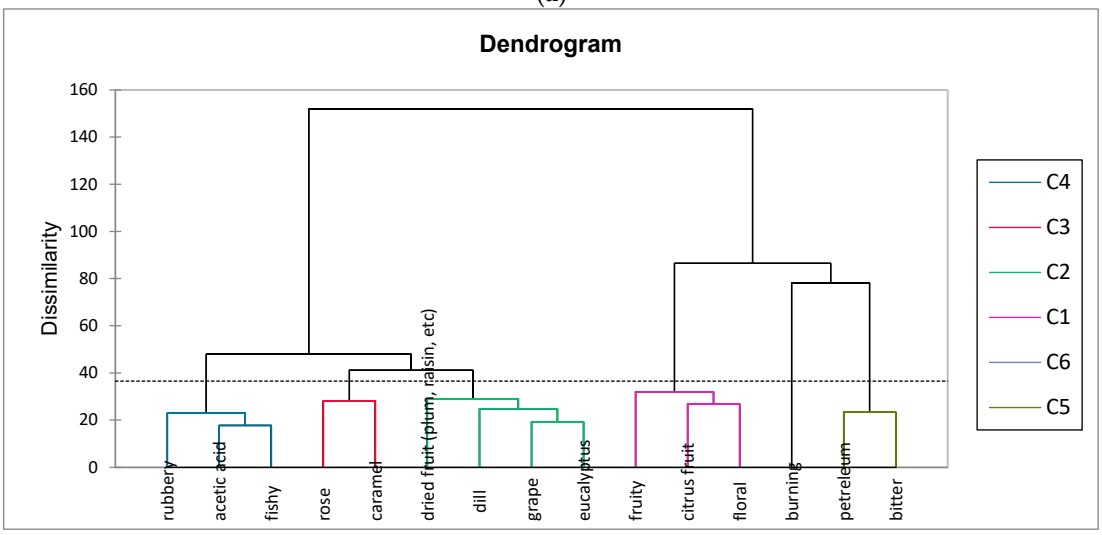
Figure 2. Correspondence analysis for CATA questions on forty-five (45) samples using the fifteen (15) terms with the most important *p*-values.

Subsequently, Principal Coordinates Analysis (PCoA) was applied to the correlation coefficients in the first two axes (F1 and F2) (Figure 3a), and Agglomerative Hierarchical Clustering (AHC) was also run on the data (Figure 3b) in order to detect the groups. To effectively visualize the various dimensions of the data, XLSTAT performed a Principal Coordinates Analysis (PCoA), applying the Lingoes correction when required. This approach was favored over traditional Multidimensional Scaling (MDS) because it automatically oriented the coordinate system so that the first axis captured the greatest amount of variance in the data. There, we observed that *burning* and *bitter* were outliers, highlighting their unique sensory impact. The clustering of *rubbery*, *acetic acid*, and *fishy* suggested a strong correlation, likely representing negative odors, while the pleasant descriptors (*floral*, *fruity*,

and *citrus fruit*) were consistently clustered together, indicating shared sensory profiles (Figure 3). These groupings not only reflected meaningful sensory relationships but also provided a robust framework for distinguishing between the samples. Their emergence through multivariate analysis underscored the potential of structured sensory profiling for characterizing and differentiating spirits within this category.



(**a**)



(**b**)

Figure 3. (**a**) Principal Coordinate Analysis applied to the attributes with the most important *p*-values from CATA questions. (**b**) Agglomerative Hierarchical Clustering. The colors of the attributes in the symmetric plot were grouped in the same way, with the colors of the clusters indicated by the Agglomerative Hierarchical Clustering. The dotted line represents the dissimilarity threshold used to define the six clusters.

3.3. Rate-All-That-Apply

As previously described, terms with a selection rate below 9% were excluded [23,26], resulting in a refined list of 45 descriptors. This threshold was chosen to balance descriptor diversity with statistical robustness in the subsequent RATA analysis. Regarding the reduction of samples, PCA was conducted for the samples and the fifty-nine terms across the first two axes (F1: 13.08%, F2: 7.65%) (Figure S1). When observing those plots, samples that had very similar counterparts or that did not contribute any differentiation to the aromatic profile of the distillates were removed. At this stage, only the Greek grape

marc spirit samples were removed, while all Grappa and Zivania samples were retained. Specifically, the following nine samples were excluded: T19, T25, T12, T15, T7, T21, T23, and T1. The remaining samples (36 out of 45) used for the RATA assessment are indicated in Table 1. A five-point applicability scale (not applicable at all, slightly applicable, moderately applicable, very applicable, and extremely applicable) was used for the RATA test. ANOVA results for the attributes showed that twenty-five (25) out of forty-five (45) attributes were significant at the 95% confidence level and, therefore, those attributes were discriminating (Table 3). Nevertheless, the primary objective here was not the categorization of the samples but the development of a lexicon capable of accurately describing grape marc distillates. According to the CA, the first two axes explained 43.25% of the total variance in the sensory data (Figure 4). While the biplot provided a visual overview of the relationships between products and attributes, the moderate level of explained variance and the lack of clear sample separation limited the strength of conclusions regarding the discriminative power of specific terms. Nevertheless, several attributes—such as *floral*, *fruity*, *herbal*, and *off-odor*—appeared in proximity to multiple product points and were frequently selected by assessors across samples. To further support the identification of relevant descriptors, ANOVA results were considered (Table 3). Attributes such as *citrus fruit* ($p = 0.001$), *grape* ($p = 0.008$), *fruity* ($p = 0.011$), *dill* ($p = 0.017$), and *dried* (*hay*, *straw*, *tea*) ($p = 0.009$) showed statistically significant differences among products (Table 3), indicating their potential role in product discrimination. Importantly, our aim was not limited to identifying discriminative attributes but also included highlighting those most frequently perceived across the product set, as these were essential for the development of a comprehensive flavor wheel.

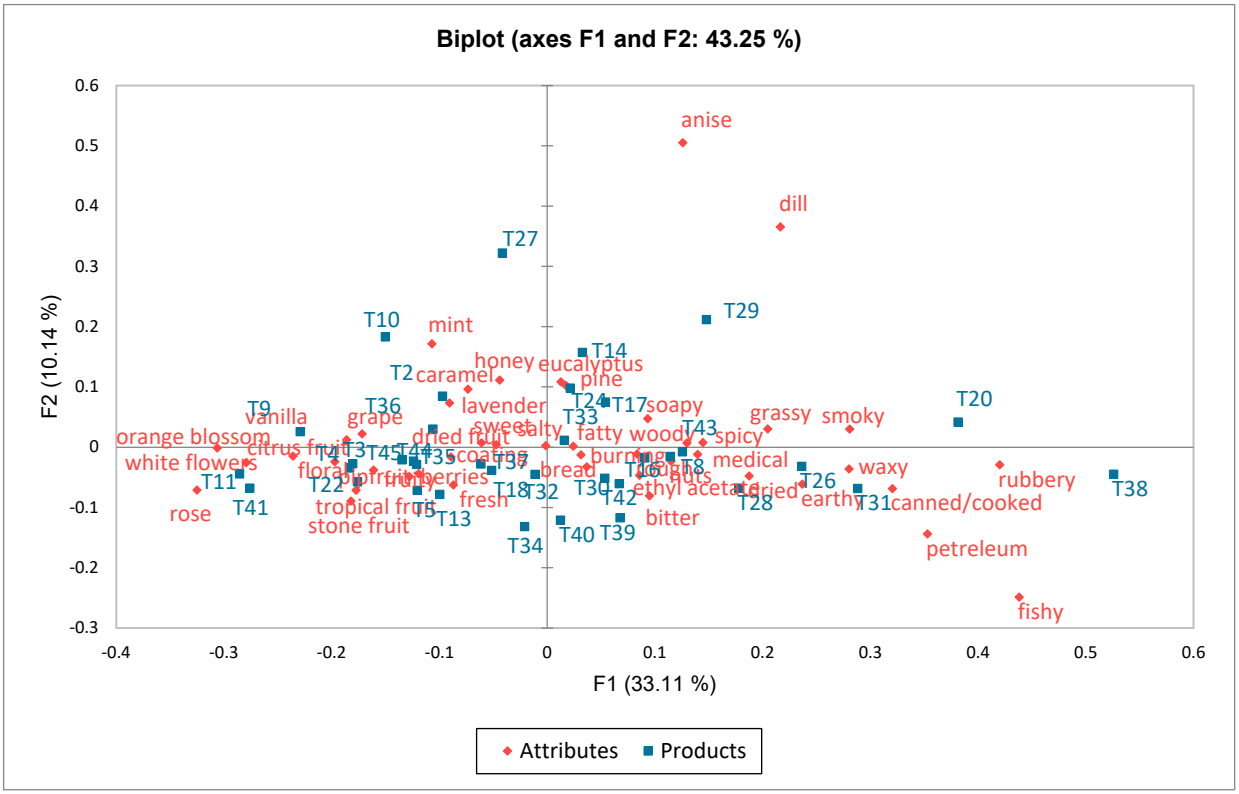


Figure 4. Correspondence analysis for RATA questions for thirty-six (36) samples using forty-five (45) terms.

Table 3. ANOVA summaries for each attribute in relation to the products according to RATA results.

Attribute	*p*-Value	Attribute	*p*-Value	Attribute	*p*-Value	Attribute	*p*-Value
anise	<0.0001	ethyl acetate	0.013	mint	0.099	smoky	0.006
berries	0.405	eucalyptus	0.442	nuts	0.253	soapy	0.543
bitter	0.121	fatty	0.634	orange blossom	0.0001	spicy	0.006
bread	0.270	fishy	0.006	petroleum	<0.0001	stone fruit	0.006
burning	<0.0001	floral	0.0003	pine	0.327	sweet	0.673
canned/cooked	0.022	fresh	0.112	pip fruit (apple/pear)	0.071	tropical fruit	0.197
caramel	0.377	fruity	0.011	rose	0.019	vanilla	0.002
citrus fruit	0.001	grape	0.008	rough	0.001	waxy	0.0004
coating	0.001	grassy	0.003	rubbery	0.001	white flowers	0.007
dill	0.017	honey	0.648	salty	0.819	woody	0.297
dried (hay, straw, tea)	0.009	lavender	0.291				
dried fruit	0.490	medical	0.161				
earthy	0.083						

A comparative analysis between the CATA and RATA methods was conducted to explore the consistency and complementarity of the two sensory techniques. Figure S3 presents a scatter plot, where each point represents a sensory attribute, plotted according to its frequency of selection in CATA (% CATA) and its mean intensity rating in RATA. It is important to note that the two methods were applied to different sets of samples and involved partially different sets of sensory terms, which limits the possibility of a direct statistical comparison. However, for the overlapping attributes, the visualization reveals a general trend of agreement between the two methods. Attributes such as *burning*, *sweet*, and *coating* showed both high selection frequency and high intensity, and were also statistically significant (p-value < 0.05), supporting their discriminative power across samples. This analysis reinforces the robustness of the sensory profiling and highlights the value of combining CATA and RATA for complementary insights.

3.4. Flavor Wheel

The terms that were finally selected for the wheel, based on the collective results of UFP, CATA, and RATA and the respective data analyses, were organized into a flavor wheel, as shown in Figure 4. Therefore, the grape marc spirit flavor wheel that we suggest in this study is split into three tiers, with 2 first-, 12 second-, and 45 third-tier descriptors (Figure 4). The innermost tier represents two primary sensory modalities, whereas the outer tier refines these categories with more specific descriptors. This means that the primary descriptors located in the inner and second tiers represent broad, generic terms that encompass specific groups of related adjectives, whereas the more detailed attributes are positioned in the third tier. All second-tier descriptors included in this study were previously used in sensory lexicons for alcoholic beverages, chocolate, milk, and herbal products [7,9,14,15,17,23,27–29]. While these categories differ in product matrices, the recurrence of certain sensory terms across them supports their relevance and robustness. This cross-referencing is particularly valuable in the context of constructing a sensory wheel, where the goal is to capture a broad and representative vocabulary of perceived attributes. The descriptors included in our suggested flavor wheel are derived solely from the analysis of 45 samples representing three countries where those products are traditionally made. It is anticipated that adjustments and refinements may be necessary over time in this suggested sensory wheel, especially if adopted and utilized by the industry. It should also be clarified here that the suggested flavor wheel is recommended for flavor descriptions of any grape marc spirit originating from the Mediterranean, even though we did not include samples

from Spain (Orujo) or France (Eau de Vie de Marc). It is, however, not recommended for usage for the flavor description of spirits that have undergone anise or other spice additions or any kind of aging with wood.

4. Discussion

The construction of flavor lexicons or sensory wheels has been applied to many beverages and foods, including Raki [1], Ouzo and aniseed-flavored Tsipouro [19], Pisco [30], coffee [7], rooibos tea [17], and other foods ranging from chocolate [23] to marine oils [29] and human milk [28]. The development of a sensory wheel requires a sample set that reflects diverse sources of variability and encompasses an extensive array of sensory descriptors [29]. In this study, 45 different grape marc spirit samples from three Mediterranean countries (Greece, Italy, and Cyprus) were selected to represent a wide range of those spirits (Table 1). A similar methodology was applied by Koch et al. (2012) [17], who used 69 rooibos tea samples from 64 producers. Sample selection aimed to capture variation in grape variety, region, and distillation method, ensuring a representative sensory space (Table 1).

The number of descriptors in published flavor wheels typically ranges from 40 to 80. For example, Tura et al. (2023) [26] identified 44 attributes for hemp seed oil, while Yu et al. (2022) [28] structured 53 descriptors for human milk Specifically in the work of Tura and coworkers [26], a trained sensory panel conducted an evaluation using a conventional descriptive analysis methodology to generate a sensory lexicon, which categorized 44 attributes into positive (e.g., nutty, hay, bitter) and negative (e.g., rancid, fishy) [26] descriptors, while Yu and coworkers [28] used the ISO standard [31] to organize the sensory descriptors of human milk; a hierarchical framework was applied, categorizing them into three primary sensory modalities: aroma, flavor, and mouthfeel. By performing multivariate analyses, 53 sensory descriptors were identified, narrowed down through statistical screening based on significance (M-values), thereby constructing a three-tiered flavor wheel with specific layers for aroma, flavor, and texture nuances [28]. Finally, in the work of Darici et al. (2021) [1], 76 specific attributes were identified for Raki spirits, including 8 terms for appearance, 55 for aroma, and 13 for taste and mouthfeel.

Most studies employing CATA questions have used lists containing between 10 and 40 terms [8,32,33]. Shorter lists may prompt consumers to select all available terms, reducing their ability to distinguish between samples. Longer attribute lists can induce heuristic decision-making, where consumers opt for initial choices rather than fully processing the sensory profile of the product [34,35]. However, research indicates that the length of the list, when between 12 and 30 terms, does not significantly impact the results [36]. The long list of attributes risk was also present in our study, as the experimental design initially included 59 terms for the CATA questions and a correspondingly large number of samples. However, first, we knew we were going to work with a trained panel of assessors rather than naïve consumers who would be able to manage more demanding sensory tasks, and, most importantly, it was part of our plan to further reduce the terms in order to employ RATA questions subsequently in our last experiment. Therefore, despite the initial complexity, our aim was to reduce both the number of terms and samples and then reassess the most significant terms using the RATA questions. Following UFP, 59 attributes were selected for CATA evaluation, forming the basis for subsequent refinement through RATA.

According to Delarue and Lawlor (2022) [37], terms included in the CATA questions should be familiar and easily understood by assessors. For this reason, we employed the UFP to generate vocabulary grounded in the assessors' own language. The UFP method, following the free vocabulary approach as described in Free Choice Profiling (FCP) [38], allowed each judge independently to describe the most salient sensory differences among

the spirits. This method was particularly suitable for our objective, as it enabled the inclusion of diverse sensory perspectives and expanded the lexicon with terms relevant across all samples. Furthermore, the incorporation of individual descriptors facilitated the integration of multiple perspectives within each evaluation. For example, one judge may prioritize taste, another may concentrate on mouthfeel properties, and a third may highlight specific aroma notes. Similar approaches have been used in the development of sensory lexicons for apple juice [39] and barrel-aged beer [9], where UFP replaced traditional Quantitative Descriptive Analysis (QDA), allowing assessors to freely describe products without formal training. In our study, the UFP results aligned with previous findings on Greek marc distillates [3], in which Greek marc distillates were similarly categorized using combined UFP with Polarized Projective Mapping, using the same flavor notes that were statistically important in the F1 axis (Figure 2). In addition, aroma, taste, and mouthfeel attributes were all important in the differentiation of the 45 products used (Tables 2 and 3).

Alternatively, rapid methods such as single free sorting [7], UFP with Napping [9], and free sorting with CATA analysis [8] have also been utilized for coffee, barrel-aged beer, and Virginia hard alcoholic ciders, respectively. For example, in a study by Spencer et al. (2016) [7], participants performed a modified, non-tasting sorting task using the 99 coffee flavor attributes from the World Coffee Research (WCR) sensory lexicon. They grouped the flavor attributes based on perceived similarities and differences, using their knowledge and experience rather than tasting samples. Other studies used 18 [8] and 4 [9] samples, respectively. In contrast, our methodology incorporated a larger number of samples, allowing for broader term generation and better category coverage. Our RATA results revealed that all selected terms had 23–97% occurrence across all samples representing the three different countries of origin (Greece, Cyprus, and Italy with tsipouro, zivania, and Grappa, respectively) (Table 4). In this way, we could ensure that the terms included in the sensory wheel had important relevance across all grape marc distillates analyzed in this study.

Existing flavor wheels across diverse products (e.g., tea, chocolate, rum) consistently employ tiered structures and 40–60 descriptors, supporting the structure adopted in our study. The rooibos tea flavor wheel in the research of Koch et al. (2012) [17], developed from a descriptive analysis of 69 samples collected across various regions and grades, reflects the complexity of this herbal tea by identifying 17 attributes (e.g., herbal–floral, woody, honey, hay). These attributes are organized into a two-tier structure, enabling the clear differentiation of high-quality tea (e.g., sweet, honey, caramel) from lower-quality batches with undesirable notes (e.g., green, hay, musty). Similarly, for chocolate, consumer-generated sensory descriptors were used for the construction of the wheel, emphasizing relevance to consumer preferences. Focus groups contributed 2.199 terms, later refined to a three-tiered wheel with 61 attributes across appearance, aroma, texture, and flavor for chocolate [23]. In contrast, the cold-pressed hemp seed oils flavor wheel in the research of Tura et al. (2023) [26] prioritized the natural complexity of the oil and its quality markers. A trained panel generated a vocabulary of 44 descriptors through descriptive analysis, grouping them into clusters such as color, aroma, flavor, and mouthfeel. This wheel also highlights both positive attributes (e.g., nutty, herbal) and defects (e.g., rancid, fishy) [26]. In another approach, a flavor wheel for rum was created using web-based material instead of traditional sensory panels, highlighting the diversity of this alcoholic beverage category. By analyzing over 1000 reviews, the developers categorized 147 sensory terms into 22 categories, such as fruity, woody, and sweet. For the construction of the brandy aroma wheel, as detailed in the paper by Jolly and Hattingh (2001) [15], a standardization of the descriptive terminology took place, and a list of 61 descriptors was compiled from the existing literature and expert consultations. The wheel was refined through industry feedback and expert

panel evaluations and the final version includes 18 first-tier attributes and 75 second-tier attributes, providing a detailed standardized vocabulary for brandy aroma evaluation. According to the literature, all wheels employ a tiered structure, typically progressing from broad sensory modalities (e.g., aroma, taste, mouthfeel) to specific descriptors. It is observed that in almost all the mentioned studies, the sensory wheels consisted of three levels, and the number of terms used ranged from approximately 40 to 60.

Table 4. Identified percentages of occurrence of descriptions across all samples from RATA results.

Sensory Modality	Descriptions	Occurrence (%)	Sensory Modality	Descriptions	Occurrence (%)
Odor (ortho and retronasal)	Citrus fruit	88.89	Odor (ortho and retronasal)	Mint	60
	Floral	88.89		Medical	55.56
	Eucalyptus	86.67		Earthy	55.56
	Grassy	84.44		Pine	53.33
	Anise	84.44		Dill	53.33
	Fresh	82.22		Smoky	53.33
	Dried (hay, straw, tea)	82.22		Grape	51.11
	Ethyl acetate	82.22		Waxy	51.11
	Stone fruit	77.78		Nuts	51.11
	Fruity	75.56		Berries	46.67
	Canned/cooked	75.56		Rose	44.44
	Tropical fruit	73.33		Lavender	44.44
	Vanilla	73.33		Rubbery	44.44
	Honey	73.33		Fishy	33.33
	White flowers	71.11	Mouthfeel	Burning	93.33
	Orange blossom	68.89		Coating	91.11
	Soapy	68.89		Fatty	75.56
	Petroleum	68.89		Rough	64.44
	Woody	68.89		Dry	44.44
	Bread	66.67	Basic tastes	Sweet	97.78
	Caramel	66.67		Bitter	95.56
	Pip fruit (apple/pear)	64.44		Salty	64.44
	Spicy	62.22			
	Dried fruit (plum, raisin, etc.)	60			

The final wheel included two sensory modalities, 12 intermediate categories, and 44 specific descriptors derived from RATA. Specifically, the third tier encompassed all terms utilized in RATA analyses, whereas the first tier clearly grouped terms based on their modality. The second tier included groups categorized by modality, such as mouthfeel and taste, as well as groups with highly similar descriptions, like the fruity group. The organization of certain groups was also conducted by considering existing flavor wheels of other high-alcohol-containing beverages: spirits [1,14,19,27]. It is important to note that the samples were non-aged; however, there were terms that could be classified as aging aromas, such as honey, vanilla, and caramel. For those notes, the positioning of the terms was evaluated based on the tasters' assessments. For instance, the honey note was predominantly used in samples that also contained other floral aromas, while the vanilla note was mainly associated with spicy notes. A comparison of sensory attributes with the previously mentioned aromatic wheels is challenging as even when limited to those of alcoholic beverages (e.g., brandy, rum), those products undergo an additional production step—aging—during which tertiary aromas develop, which were absent in our samples.

To our knowledge, there are to date no published flavor wheels on non-aniseed flavored grape marc spirits, apart from a work performed specifically on Grappa products [40]. However, even though the wheel appears in the respective Swiss site, it is not mentioned how that wheel was constructed; how many products were employed, if any; or what the overall development process was. Still, in that Grappa wheel, 68 descriptors are fea-

tured, and we observe significant overlap with the attributes identified in the present study. Specifically, for example, in the fruity category, the general subcategories at the second level are very similar, as both wheels include citrus, pip fruit, stone fruit, and dried fruit. However, in our wheel, an additional subcategory, tropical fruit, is introduced (Figure 5).



Figure 5. A flavor wheel for non-flavored and non-aged grape marc spirits with the terms that were finally selected for the lexicon based on the collective results of UFP, CATA, and RATA.

This process enabled the reduction from 205 to 45 descriptors, 25 of which were highly discriminating across products (Table 3), forming the basis of the proposed sensory wheel. The whole process helped us construct a flavor wheel of 12 broad and 45 specific descriptors covering the flavor of the category in question.

5. Conclusions

Flavor wheels are important sensory tools with broad applications in industry, quality assurance, and research. Despite the significance of grape marc spirits in the alcoholic beverage sector, no published flavor wheel has been available for this category to date, with the sole exception of an online Grappa wheel from a Swiss source in 2023 [40]. The aim of our study was to construct a flavor wheel for the category of non-flavored and non-wood-aged grape marc spirits. A parallel objective was to explore an alternative methodological pathway for flavor wheel development using a combination of rapid sensory evaluation techniques. The sequential use of UFP, CATA, and RATA allowed us to first generate a wide range of descriptors, then screen for relevance and frequency, and, finally, quantify their discriminative power. This approach offers a time-efficient and scalable alternative to traditional descriptive analysis, which may be particularly useful for under-characterized or emerging product categories. The panelists' familiarity with the sensory space of such products ensured the reliability of the data, even though they were not specifically trained for this particular spirit category. The final flavor wheel comprises

12 broad and 45 specific descriptors, selected based on their frequency of occurrence across samples (33.3–97.7%). For example, sweet and bitter were among the most frequently cited taste attributes (97.7% and 95.5%, respectively), while fishy was the least frequent (33.3%, $p = 0.005$). This dual focus—on both discriminative and commonly shared descriptors—ensures that the wheel is both representative and practical (Tables 3 and 4). Beyond its immediate application, the proposed methodology could be adapted for other traditional or region-specific beverages, offering a flexible framework for lexicon development. Further validation of the wheel using Mediterranean grape marc spirits such as Spanish Orujo would enhance its generalizability and industry relevance.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/beverages11040101/s1: Figure S1: Principal Component Analysis in for CATA results, of fifty-nine (59) terms in forty-five (45) spirits, in order to remove the samples that had similar counterparts or did not contribute to the differentiation of the aromatic profile. The samples with yellow font were are the removed ones; Figure S2: Principal Component Analysis of UFP data results on two hundred and five (205) terms from forty-five spirits (45) in the first two axes; Figure S3: Scatter plot comparing the percentage of selection in Check-All-That-Apply (CATA) and the mean intensity ratings in Rate-All-That-Apply (RATA) for common sensory attributes. Attributes are color-coded based on statistical significance (blue = significant, red = not significant; p-value threshold = 0.05). Note: CATA and RATA were applied to different sample sets and used partially different sensory terms.

Author Contributions: E.A.T.: investigation, methodology, software, data curation, formal analysis, writing—original draft, Visualization. P.I.: investigation, data curation. M.Z.: investigation, data curation. E.K.: conceptualization, methodology, validation, writing—review and editing, visualization, supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of West Attica (protocol code 97565, 24 October 2024).

Informed Consent Statement: Informed consent for participation was obtained from all subjects involved in this study.

Data Availability Statement: The original contributions presented in this study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors have no competing interests to declare.

References

1. Darıcı, M.; Özcan, K.; Beypınar, D.; Cabaroglu, T. Sensory lexicon and major volatiles of rakı using descriptive analysis and GC-FID/MS. *Foods* **2021**, *10*, 1494. [CrossRef] [PubMed]
2. Bovo, B.; Carlot, M.; Lombardi, A.; Lomolino, G.; Lante, A.; Giacomini, A.; Corich, V. Exploring the use of Saccharomyces cerevisiae commercial strain and Saccharomycodes ludwigii natural isolate for grape marc fermentation to improve sensory properties of spirits. *Food Microbiol.* **2014**, *41*, 33–41. [CrossRef]
3. Tsapou, E.A.; Tzortzis, P.M.; Koussissi, E. Application of Polarized Projective Mapping combined with Ultra Flash Profiling to a complex− high fatigue product category: The case of Greek grape marc spirits. *Food Qual. Prefer.* **2024**, *118*, 105182. [CrossRef]
4. Soufleros, E.H. *Wine and Distillates*; Papageorgiou Pub: Thessaloniki, Greece, 1987.
5. Rodríguez-Solana, R.; Rodríguez, N.; Dominguez, J.M.; Cortés, S. Characterization by chemical and sensory analysis of commercial grape marc distillate (Orujo) aged in oak wood. *J. Inst. Brew.* **2012**, *118*, 205–212. [CrossRef]
6. Tsapou, E.A.; Dourtoglou, V.; Dourtoglou, T.; Sinanoglou, V.; Koussissi, E. Volatile Profile in Greek Grape Marc Spirits with HS-SPME-GC-MS and Chemometrics: Evaluation of Terroir Impact. *ACS Omega* **2023**, *8*, 42803–42814. [CrossRef]
7. Spencer, M.; Sage, E.; Velez, M.; Guinard, J.X. Using Single Free Sorting and Multivariate Explor-atory Methods to Design a New Coffee Taster's Flavor Wheel. *J. Food Sci.* **2016**, *81*, 12. [CrossRef] [PubMed]

8. Phetxumphou, K.; Cox, A.N.; Lahne, J. Development and characterization of a check-all-that-apply (CATA) lexicon for Virginia hard (alcoholic) ciders. *J. Am. Soc. Brew. Chem.* **2020**, *78*, 299–307. [CrossRef]
9. Silvello, G.C.; Bortoletto, A.M.; Alcarde, A.R. The barrel aged beer wheel: A tool for sensory assessment. *J. Inst. Brew.* **2020**, *126*, 382–393. [CrossRef]
10. Asih, N.E.; Ramadhanty, K.P.; Ramandias, J.; Azkarama, F.; Sunarharum, W.B. Lexicon, sensory wheel and kit as sensory communication tools: A review. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2021; Volume 924, p. 012027. [CrossRef]
11. Meilgaard, M.C.; Dalgliesh, C.E.; Clapperton, J.F. Beer flavor terminology. *J. Am. Soc. Brew. Chem.* **1979**, *37*, 47–52. [CrossRef]
12. Noble, A.C.; Arnold, R.A.; Masuda, B.M.; Pecore, S.D.; Schmidt, J.O.; Stern, P.M. Progress towards a standardized system of wine aroma terminology. *Am. J. Enol. Vitic.* **1984**, *35*, 107–109. [CrossRef]
13. Noble, A.C.; Arnold, R.A.; Buechsenstein, J.; Leach, E.J.; Schmidt, J.O.; Stern, P.M. Modification of a standardized system of wine aroma terminology. *Am. J. Enol. Vitic.* **1987**, *38*, 143–146. [CrossRef]
14. Lee, K.Y.M.; Paterson, A.; Piggott, J.R.; Richardson, G.D. Origins of flavour in whiskies and a revised flavour wheel: A review. *J. Inst. Brew.* **2001**, *107*, 287–313. [CrossRef]
15. Jolly, N.P.; Hattingh, S. A brandy aroma wheel for South African brandy. *S. Afr. J. Enol. Vitic.* **2001**, *22*, 16–21. [CrossRef]
16. Monteiro, B.; Vilela, A.; Correia, E. Sensory profile of pink port wines: Development of a flavour lexicon. *Flavour Fragr. J.* **2014**, *29*, 50–58. [CrossRef]
17. Koch, I.S.; Muller, M.; Joubert, E.; Van der Rijst, M.; Næs, T. Sensory characterization of rooibos tea and the development of a rooibos sensory wheel and lexicon. *Food Res. Int.* **2012**, *46*, 217–228. [CrossRef]
18. Donnell, E.M.; Hulin-Bertaud, S.; Sheehan, E.M.; Delahunty, C.M. Development and learning process of a sensory vocabulary for the odor evaluation of selected distilled beverages using descriptive analysis. *J. Sens. Stud.* **2001**, *16*, 425–445. [CrossRef]
19. Tsachaki, M.; Arnaoutopoulou, A.P.; Margomenou, L.; Roubedakis, S.C.; Zabetakis, I. Develop-ment of a suitable lexicon for sensory studies of the anise-flavoured spirits ouzo and tsipouro. *Flavour Fragr. J.* **2010**, *25*, 468–474. [CrossRef]
20. Ares, G.; Jaeger, S.R. Check-all-that-apply questions: Influence of attribute order on sensory product characterization. *Food Qual. Prefer.* **2013**, *28*, 141–153. [CrossRef]
21. Ares, G.; Bruzzone, F.; Vidal, L.; Cadena, R.S.; Giménez, A.; Pineau, B.; Hunter, D.C.; Paisley, A.G.; Jaeger, S.R. Evalua-tion of a rating-based variant of check-all-that-apply questions: Rate-all-that-apply (RATA). *Food Qual. Prefer.* **2014**, *36*, 87–95. [CrossRef]
22. *ISO8589: 2007*; Sensory Analysis—General Guidance for the Design of Test Rooms. International Organization of Standardization: Geneva, Switzerland, 2007; 2nd ed.
23. De Pelsmaeker, S.; De Clercq, G.; Gellynck, X.; Schouteten, J.J. Development of a Sensory Wheel and Lexi-con for Chocolate. *Food Res. Int.* **2019**, *116*, 1183–1191. [CrossRef]
24. Meyners, M.; Castura, J.C. Randomization of CATA attributes: Should attribute lists be allocated to assessors or to samples? *Food Qual. Prefer.* **2016**, *48*, 210–215. [CrossRef]
25. Lumivero. XLSTAT Statistical and Data Analysis Solution. 2025. Available online: https://www.xlstat.com/ (accessed on 31 July 2024).
26. Tura, M.; Mandrioli, M.; Valli, E.; Dinnella, C.; Gallina Toschi, T. Sensory wheel and lexicon for the description of cold-pressed hemp seed oil. *Foods* **2023**, *12*, 661. [CrossRef]
27. Ickes, C.M.; Lee, S.Y.; Cadwallader, K.R. Novel creation of a rum flavor lexicon through the use of web-based material. *J. Food Sci.* **2017**, *82*, 1216–1223. [CrossRef] [PubMed]
28. Yu, M.; Zheng, C.; Xie, Q.; Tang, Y.; Wang, Y.; Wang, B.; Song, H.; Zhou, Y.; Xu, Y.; Yang, R. Flavor wheel construction and sensory profile description of human milk. *Nutrients* **2022**, *14*, 5387. [CrossRef] [PubMed]
29. Larssen, W.E.; Monteleone, E.; Hersleth, M. Sensory description of marine oils through develop-ment of a sensory wheel and vocabulary. *Food Res. Int.* **2018**, *106*, 45–53. [CrossRef]
30. Bordeu, E.; Formas, G.; Agosin, E. Proposal for a standardized set of sensory terms for pisco, a young muscat wine distillate. *Am. J. Enol. Vitic.* **2004**, *55*, 104–107. [CrossRef]
31. *ISO 11035:1994*; Sensory Analysis—Identification and Selection of Descriptors for Establishing a Sensory Profile by a Multidimensional Approach. International Organization of Standardization: Geneva, Switzerland, 1994; 1st ed.
32. .Bruzzone, F.; Vidal, L.; Antúnez, L.; Giménez, A.; Deliza, R.; Ares, G. Comparison of intensity scales and CATA questions in new product development: Sensory characterisation and directions for product reformulation of milk desserts. *Food Qual. Prefer.* **2015**, *44*, 183–193. [CrossRef]
33. Vidal, L.; Tárrega, A.; Antúnez, L.; Ares, G.; Jaeger, S.R. Comparison of correspondence analysis based on Hellinger and chi-square distances to obtain sensory spaces from check-all-that-apply (CATA) questions. *Food Qual. Prefer.* **2015**, *43*, 106–112. [CrossRef]
34. Krosnick, J.A.; Alwin, D.F. An evaluation of a cognitive theory of response-order effects in survey measurement. *Public Opin. Q.* **1987**, *51*, 201–219. [CrossRef]

35. Rasinski, K.A.; Mingay, D.; Bradburn, N.M. Do respondents really "mark all that apply" on self-administered questions? *Public Opin. Q.* **1994**, *58*, 400–408. [CrossRef]
36. Jaeger, S.R.; Beresford, M.K.; Paisley, A.G.; Antúnez, L.; Vidal, L.; Cadena, R.S.; Giménez, A.; Ares, G. Check-all-that-apply (CATA) questions for sensory product characterization by consumers: Investigations into the number of terms used in CATA questions. *Food Qual. Prefer.* **2015**, *42*, 154–164. [CrossRef]
37. Delarue, J.; Lawlor, J.B. (Eds.) *Rapid Sensory Profiling Techniques: Applications in New Product Development and Consumer Research*; Woodhead Publishing: Sawston, UK, 2022.
38. Williams, A.A.; Langron, S.P. The use of free-choice profiling for the evaluation of commercial ports. *J. Sci. Food Agric.* **1984**, *35*, 558–568. [CrossRef]
39. Mendes da Silva, T.; Torello Marinoni, D.; Peano, C.; Roberta Giuggioli, N. A new sensory approach combined with a text-mining tool to create a sensory lexicon and profile of monovarietal apple juices. *Foods* **2019**, *8*, 608. [CrossRef] [PubMed]
40. Agroscope. 2023. Available online: https://www.agroscope.admin.ch/agroscope/en/home/news/newsroom/2023/06-27_aromarad-grappa-marc.html (accessed on 20 November 2024).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.