MADEIRA WINES:
SENSORY DESCRIPTIVE ANALYSIS OF TRADITIONAL WINES AND WINES WITH ADDED SOTOLON

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INTRODUCTION

Traditional Madeira wines are "baked" and aged. One of the aging volatiles is sotolon (4,5-dimethyl-3-hydroxy-2 (5H)-furanone), which imparts an aroma usually described as caramel, burnt sugar, "madeirised", "rancio", nutty and curry-like, and which increases in concentration with age [1]. The sensory effect of sotolon on the "perceived age" of Madeiras was evaluated by comparing unbaked wines with added sotolon to traditional baked wines. Six traditional Madeiras made with Bual grapes (vintage 1961, 1968, 1980, 1993, 1996, and 1999), and 3 young, unbaked Bual wines with 0 ppb, 10 ppb and 19 ppb added sotolon, respectively, were compared by sensory descriptive analysis.

GOAL:

Evaluate the sensory impact of sotolon on the "perceived age" of Madeira Wine

Madeira ⟷ Madeira +Sotolon

1st STEP: Establish the sensory profile of Madeiras

2nd STEP: Training Sessions

Descriptive Analysis Panel Training and Selection. Twelve University of California, Davis, graduate students were selected from a group of 32 persons on the basis of their sensory performances [2].
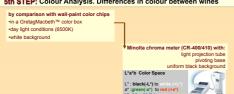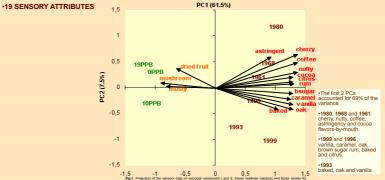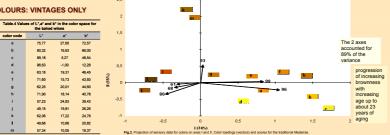
Table 2. Attributes used for the Descriptive Analysis by the 12-Judge panel and Composition of reference standards

Aroma*	Composition
dried fruit	mixed dried fruit (raisins+prunes+apricots+figs)
nutty	mixed nuts (pecan + walnuts + almonds)
musty	verbally defined as "a damp basement"
baked	baked pie crust
oak	oak chips with some drops of oak oil
mushroom	fresh mushrooms
vinyl	vinyl glove
brown sugar	burnt brown sugar

Flavor by mouth*	
caramel	hard caramel candy
sweet	100g/L sucrose-water solution
bitter	0.15% caffeine-water solution
alcohol	10% ethanol/water solution
astringent	pecan skin
cocoa	cocoa flavor (Hershey's syrup, genuine chocolate flavor)
vanilla	artificial vanilla flavor (with vinyl vanilla)
cherry	cherry preserves
citrus	teaspoon of a mixture of orange/lemon natural extracts and grapefruit juice
coffee	fresh brewed coffee
rum	dark rum

3rd STEP: Descriptive Analysis

Wine.
The wines used in this study were 6 traditional Madeiras made with Bual grapes that were 5, 8, 11, 24, 38 and 43 years-old (vintages 2004-1999, 1996, 1993, 1980, 1968, 1961) and 3 young, unbaked Bual wines, from 2003, with 0 ppb, 10 ppb and 19 ppb added sotolon (Table.1). All wines were donated by The Madeira Wine Company, Funchal, Madeira, Portugal.

Table 1. Details of Madeira Wines evaluated

Code	Type	Sotolon added	Vintage
1961	baked	-	1961
1968	baked	-	1968
1980	baked	-	1980
1993	baked	-	1993
1996	baked	-	1996
1999	baked	-	1999
0PPB	unbaked	0ppb	2003
10PPB	unbaked	10ppb	2003
19PPB	unbaked	19ppb	2003

All the wines were made from Bual grapes donated by The Madeira Wine Company

Sotolon was donated by International Flavors & Fragrances, Inc.(150 Docks Corner Road, Dayton, N.J. 08810 USA).

5th STEP: Colour Analysis. Differences in colour between wines

by comparison with wall-paint color chips
•in a GretagMacbeth™ color box
•day light conditions (6500K)
•white background

Minolta chroma meter (CR-400/410) with:
light projection tube
pivoting base
uniform black background

L*a*b Color Space

L* : black(-L*) to white (+L*)
a* :green(-a*) to red (+a*)
b* : blue (-b*) to yellow (+b*)

6th STEP: Data Analysis

Data Analysis: All statistical analyzes were performed using SAS (SAS Institutes, Cary, NC). The results of all the descriptive analysis sessions were analyzed by analysis of variance and multivariate analysis of variance (proc glm, with judges as a random factor), to test if the 19 flavor attributes generated by the trained panel, discriminated significantly among the wines. Calculations of the least significant difference (LSD) [3] were applied for validation of the comparison of the different wines for each significant attribute. Principal component analysis was applied to disclose the interrelationship among the wines.

A plot produced from the frequency data associated with each wine and color chips by correspondence analysis (proc corresp) graphically showed the relationship among the colors of the different wines.

REFERENCES

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2. Lesachaene, I.; Issanchou, S. Olfactory Memory Performance Effects of Sensory Experience, Familiarity and Label Use Consistency Chemical Senses 1995, 20, 114-115.
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RESULTS

•ANOVA:

Table 3. Means and LSD for all the wines and the attributes

Wine code	dried fruit**	nutty*	musty***	baked*	oak**	mushroom**	brown sugar**	caramel***	vinyl	sweet	astringent**	cocoa**	vanilla**	cherry**	citrus**	coffee**	rum***	alcohol***
1961	4.5694	2.825	1.0389	1.6444	1.7167	0.2722	2.1028	3.7417	3.6306	3.5556	1.9611	2.175	1.6583	3.6389	3.5306	1.7611	2.9111	4.4389
1968	4.8417	3.0556	0.9278	1.8528	2.6806	0.2667	2.4833	3.9722	3.2972	3.3139	2.1472	1.8667	1.9967	2.4444	3.5361	3.3472	1.8444	3.1861	4.4556
1980	5.0167	2.8583	0.6139	2.1556	2.2472	0.3333	2.8194	3.5778	3.1083	4.0556	2.1083	2.1	1.6639	2.2639	3.8194	3.875	1.7056	3.4083	4.7139
1993	3.8833	2.175	0.9389	1.7083	2.0472	0.4417	2.2694	2.7778	3.1889	3.9583	1.3583	1.0583	1.1583	1.85	3.7361	3.5556	1.275	2.4611	3.1833
1996	4.8333	2.8194	1.0306	1.9889	2.9889	0.3694	2.5056	4.0694	3.6278	4.6778	1.475	1.2889	1.7972	2.5778	3.3639	3.0306	1.8556	3.5606	4.1889
1999	4.5694	2.9694	1.3528	2.425	2.325	0.4	1.8583	3.5639	3.8889	4.0889	1.525	1.7083	2.0556	2.45	3.375	3.2333	1.6556	3.0694	4.1278
0PPB	6.3472	2.0194	2.2111	0.9694	1.5833	1.5111	2.1833	1.6722	1.5028	4.3861	1.475	0.975	1.3028	1.0333	2.8222	2.7111	1.0806	1.5833	2.4222
10PPB	5.9222	1.75	2.5056	1.35	1.35	1.4222	2.3972	1.9694	1.525	4.1194	1.8194	1.0389	0.9472	1.4539	2.3139	2.3528	0.9667	1.4444	2.3917
19PPB	6.0944	1.5417	2.5889	1.0167	1.4589	1.4611	2.3944	1.5944	1.4972	4.2139	1.7694	1.4222	0.7389	0.9083	2.7111	2.3972	0.95	1.2472	2.3139
LSD	0.7900	0.7587	0.5751	0.6412	0.6507	0.3670	-	0.6966	-	0.7154	-	0.5790	0.5588	0.8076	0.6450	0.6027	0.5268	0.6453	0.7376

indicate non significance at p > 0.05
*,**,***indicate significance at p < 0.05, p < 0.01, p < 0.001, respectively.

wines were significantly different across 16 of the 19 flavor attributes generated by the trained panel.

Only the vinyl*, sweet* and bitter* attributes did not discriminate significantly among the wines using for error the wine*judge interactions.

•19 SENSORY ATTRIBUTES

Fig.1. Projection of the sensory data on principal component I and II. Flavor loadings (vectors) and factor scores for each one of the wines used in the study. In green the unbaked wines, in blue the traditional Madeiras averaged across the 3 replications. The attributes which were found to not significant discriminate among the wines such as vinyl; sweet and bitter were not projected.

•The first 2 PCs accounted for 69% of the variance
•**1980**, **1968** and **1961** cherry, nutty, coffee, astringency and cocoa flavors-by-mouth.
•**1999** and **1996** vanilla, caramel, oak, brown sugar rum, baked and citrus
•**1993** baked, oak and vanilla

•COLOURS: VINTAGES ONLY

Table.4 Values of L*,a* and b* in the color space for the baked wines

color code	L*	a*	b*
a	75,77	27,65	72,57
b	80,32	16,63	66,00
c	89,18	5,27	48,54
d	96,63	-1,00	12,28
e	63,18	19,31	46,45
f	71,60	15,73	43,93
g	62,25	20,01	44,60
h	71,90	18,14	40,78
i	57,23	24,83	39,43
j	49,15	19,81	26,26
k	62,06	17,22	24,78
l	49,66	10,66	20,82
m	57,34	10,05	19,37

The 2 axes accounted for 89% of the variance

progression of increasing brownness with increasing age up to about 23 years of aging

Fig.2. Projection of sensory data for colors on axes I and II. Color loadings (vectors) and scores for the traditional Madeiras.

CONCLUSION

The ANOVA results showed that the wines were significantly different across 16 of the 19 flavor attributes generated by the trained panel.

PCA, results (Fig 1) showed that the baked and the unbaked wines were located on opposite ends of PC1. The unbaked wines were higher in musty, mushroom and dried fruit flavor-by-mouth, while the baked wines had more complexity in flavor and were higher in multiple attributes.
The older vintages from were characterized by higher intensities of cherry, nutty, coffee, astringency and cocoa flavors-by-mouth. The younger vintages were higher in vanilla, caramel, oak, brown sugar rum, baked and citrus flavors-by-mouth.

Correspondence analysis was used to analyze the color data for all the wines. Using only the traditional Madeira wines results showed that the first 2 axes accounted for 89% of the variance. In Fig 2, the results show a progression of increasing brownness with increasing age up to about 23 years of aging.

Although the two unbaked wines with added sotolon seemed to be more complex in flavor than the one without, this compound alone did not make them similar to the traditional Madeiras.

The baking process is important to the flavors of traditional Madeiras. A future modification of this study would be to add the sotolon after baking but before aging and to use a trained panel of connoisseurs of aged dessert wines, because the majority of persons in the panel were not familiar with the characteristics of old vintages.