The sensory wheel of virgin olive oil

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SUMMARY

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During a 3-year FLAIR study extra virgin olive oils, varying in species, degree of ripeness and extraction method, were evaluated by 6 different institutes according to QDA or COI-methods in order to identify parameters related to the quality of extra virgin olive oil. The current COI-method yields a poor between-panel reproducibility. This could well be caused by a difference in the perception of positive quality aspects. Whereas the QDA-method is especially suitable for determining sensory profiles according to the perception of the consumer, the COI-method should be tailored to detect possible defects only.

In order to cluster all attributes to one condensed set of sensory attributes for describing virgin olive oil, the COI and QDA data of all panels were pooled and analyzed separately for appearance, texture and flavour. This approach resulted in a set of 3 appearance, 3 texture and 12 flavour descriptors which can be conveniently represented graphically in the form of a "sensory wheel".

On the basis of the findings it is recommended to base the "extra virgin" qualification for olive oils solely on the absence of defects. The between-panel reproducibility of such a simplified COI-test can be assessed by means of ring tests and improved by training with reference products. When an oil passes this screening it can be profiled subsequently using the attributes of the sensory wheel. Such a profile can be linked to preferential profiles derived from consumer studies enabling the production of most preferred olive oils.

KEY-WORDS: COI method - QDA method - Sensory analysis - Sensory wheel - Virgin olive oil.

1. INTRODUCTION

A key objective of the Virgin Olive Oil project under the EC FLAIR-programme was to establish a standardized terminology for describing virgin olive oil. The development of such a standard reference of virgin olive oil sensory evaluation is important because it allows the same objective evaluation of the sensory characteristics of (virgin) olive oils to be used throughout the industry. In the sensory study under the Virgin Olive Oil-project data was obtained for olive oils from two harvests using panels from six participating institutes. Two sensory testing methodologies were applied: QDA and the COI test. All data was pooled together and analyzed, searching for a reduced set of descriptive attributes that adequately summarizes the different characteristics of the olive oils encountered in the study. Having data of three different COI panels on the same set of olive oils we have also taken the opportunity to test the reproducibility of this test method.

2. EXPERIMENTAL

2.1 Olive Oil Samples

Olive oil samples were collected from two harvests (1992 and 1993). In each harvest 16 samples were obtained of different varieties, different degrees of ripeness, and different extraction technologies. A full description of the 16 samples is given in Table I.

2.2. Sensory Panel Testing

The olive oils were tested in sensory panels which used either the COI or the QDA-method.

2.2.1. COI testing

The COI method has been described in detail (C.O.I., 1991). In this panel testing method each oil is scored on a fixed set of 16 predefined sensory attributes and an overall-grading. Three panels, at Instituto de la Grasa y sus Derivados (Sevilla, Spain), Stazione Sperimentale Oli e Grassi (Milan, Italy), and Eleourgiki (Athens, Greece), used the COI method.

2.2.2. QDA testing

The general QDA methodology is described by Stone et al (1974) and by Lyon (1994). QDA-methodology was applied in three institutes: Biagini (Milan, Italy), Campden Food and Drinks Research Association (Chipping-Campden, United Kingdom), and Unilever Research Laboratorium (Vlaardingen, The Netherlands). The number of panelists was 10 (Biagini), 9 (CFDRA), 8-11 (Unilever). The panellists were carefully selected and trained during the first year of the project. Each of the three panels generated a different set of attributes, which we have assigned to three categories: Appearance, Texture and Flavour. A few attributes related to the overall strength or intensity of smell, taste or aftertaste were omitted. The total number of attributes (and the number of attributes per category) used in the analysis are: Biagini 18 (2+2+14), Campden 21 (5+2+14), and Unilever 68 (7+8+53). All attributes used in the study are listed in Table II.

Table I
Sensory attributes used for the characterization of virgin olive oils in the three QDA panels

	Code	Name	Ripeness	Country	Treatment
1	G-01-01-CE	Coroneiki	Unripe	Greece	Centrifugation
2	G-01-02-CE	Coroneiki	Normal	Greece	Centrifugation
3	G-01-03-CE	Coroneiki	Over-ripe	Greece	Centrifugation
4	G-01-02-PE	Coroneiki	Normal	Greece	Percolation
5	G-02-02-CE	Tzunnati	Normal	Greece	Centrifugation
6	I-03-01-CE	Coratina	Unripe	Italy	Centrifugation
7	I-03-02-CE	Coratina	Normal	Italy	Centrifugation
8	I-03-03-CE	Coratina	Over-ripe	Italy	Centrifugation
9	I-03-02-PR	Coratina	Normal	Italy	Expression
10	I-04-02-CE	C. di Bit.	Normal	Italy	Centrifugation
11	S-05-01-CE	Picual	Unripe	Spain	Centrifugation
12	S-05-02-CE	Picual	Normal	Spain	Centrifugation
13	S-05-03-CE	Picual	Over-ripe	Spain	Centrifugation
14	S-06-01-CE	Arbequina	Unripe	Spain	Centrifugation
15	S-06-02-CE	Arbequina	Normal	Spain	Centrifugation
16	S-06-03-CE	Arbequina	Over-ripe	Spain	Centrifugation

Assessment Procedure

Here we describe the procedure of testing as applied in our laboratory in some detail. The procedure used in the other laboratories is very similar. The samples were presented in a balanced order. For assessing the samples the oils were offered in small 50 ml glasses. At first 30 ml was given to evaluate the smell, taste, mouthfeel, aftertaste and after mouthfeel under red lightning conditions. At the end of the session 10 ml of oil was presented to evaluate the appearance under artificial daylight conditions. The samples were presented at room temperature and were evaluated two (1992 harvest) or three (1993 harvest) times.

The panellists were instructed to swallow what was left after spitting out. After evaluating one sample each panellist ate a piece of an unsalted cracker to absorb the oil in the mouth. Then the panellist rinsed her mouth with slightly soured water (0.5 g/l citric acid) to cleanse the palate. Quantitative evaluation of the samples was carried out by the sensory panel using the PSA system with a 130 mm unstructured line scale for registration of the data. There were two anchors on the scale: at 10% very weak and at 90% very strong.

2.3 Data analysis

All statistical analysis of the data was carried out using procedures from the SAS package version 6.08 (SAS Institute, 1989).

3. REPRODUCIBILITY OF COI TEST

The COI-method has been in use in oil producing companies throughout the European Community since it acquired legal status in 1992 as a tool for assessing the extra-virgin character of olive oil . According to the COI-method the qualification 'extra virgin' is given if the overall-grading exceeds a critical limit, which currently is set at 6.5. Because of the economic consequence of false decisions with regard to the quality of an oil it is clear that the overall-grading as given by the COI-test should be objective and have no systematic bias for any participating institute. We have therefore compared the results from the three institutes which applied the COI -method to the same set of olive oils.

In Figure 1 we sumarize the results for the three institutes for the harvest of 1992. The so-called box plots (Tukey, 1977) in Figure 1 give a compact graphical summary of the distribution of data. The middle bar indicates the median (50th percentile), the 'box' spans the middle part of the distribution (25th and 75th percentile), and the outer quartiles and, occasionally, a few outlying observations. It is quite clear that there is a systematic difference between the Italian (Biagini) and Greek (Eleourgiki) panels on the one hand and the Spanish (Inst. de la Grasa) panel on the other hand. The difference amounts to almost a full point, which in view of the large number of observations (1192 for the three panels) is highly significant. Stated differently, the probability of a sample being accepted is much higher for the Spanish panel (83 % above 6) than for the other two panels (51-52 %). The same picture emerges for the 1993 harvest.

Table II
Sensory attributes for characterizing virgin olive oil, according to the three main categories Appearance, Texture and Flavour, used by three QDA panels (Biagini, IT; CFDRA,UK; Unilever, NL).

	IT:	yellow	green			
Appearance	UK:	depth	bright	yellow	green	brown
	NL:	yellow	green	brown	glossy	transparent
		particles	syrup			
	IT:	pungent	astringent			
Texture	UK:	thickness	throatcatching			
	NL:	velvet	sticky	astringent	cooling	rough
		dry	sharp	pungent		
	IT:	tomato	gr.olive	r.bl.olive	cutty.grassy	artichoke
		apple	yeast	bitter	tomato	gr.olive
		r.bl.olive	cutty.grassy	artichoke	apple	
	UK:	grassy/o	almond/o	banana/o	pungent/o	tomato/o
		hay/o	perfumy/o	grassy/f	almond/f	banana/f
		hay/f	perfumy/f	tomato/f		
Flavour	NL:	seabreez	prickly	apple	twig	harshy
		drywood	lemon	orange	soft_fruit	candies
		wild_flower	ferment	farm	salad_oil	tallow
		rancid	codliver	nuts	medicin	earthy
		sweet	salty	sour.vinegar	olives	gr.leaf
		grass	gr.banana	herbes	gr.pepper	chili.pepper
		butter	rancid	coconut	caramel	grotty
		roasted	ashtray	velpon.glue	refinery	metallic
		bitter	green	fruity	velpon.glue	white.choc
		putty	fry.oil	trainy	dry.wood	dusty

The reason for this difference in results cannot be extracted from the data. It may be conjectured, however, that it may be related to a differential appreciation of oils from local regions. If that would be the case the mean difference found between the three panels might be an average result of distinct patterns of differences between the Spanish, Greek or Italian oils for the three panels. In statistical jargon: there may be an interaction between the origin of the panellists and the origin of the olive oil.

In order to examine if the panels were biased by a preference for the oils they are familiar to, the grading of the oils from different countries is compared (Figure 2). The Greek oil was graded higher than the Italian oils by all three panels. The Spanish oils were considered equal in grading to the Italian oils by the Greek and Italian panel. However, the Spanish panel graded the Spanish oils even half a point higher than the Greek oils, i.e. 2 points higher than the grade given by the other panels to these Spanish oils. These results illustrate that the current COI-method yields a poor between-panel reproducibility of the overall-grading scores. This could well be caused by a difference in the perception of the positive quality attributes.

In a comparitive study of COI test results for 6 olive oils Ranzani (1994) also noticed a considerable lack of agreement among 17 different panels.

4. DESIGN OF A SENSORY WHEEL

One of the objectives of the sensory study in the FLAIR-project was to establish a standardized terminology to describe virgin olive oil. For that aim the sensory data for

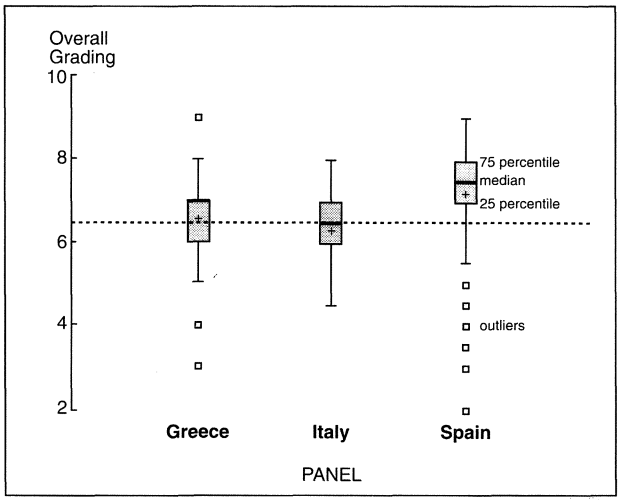

Figure 1
Distribution of the overall grading scores of virgin olive oils according to three COI panels (1992 harvest, all regions).

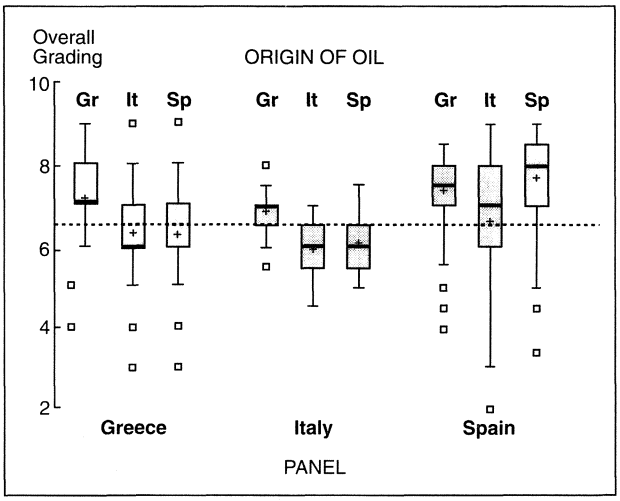

Figure 2
Distribution of overall grading scores of virgin olive oils per region according to three COI panels (harvest 1992).

1992 and 1993 of all six participants of the sensory study in the FLAIR project was pooled, in order to find the main descriptors.

4.1. Data Analysis

A separate Cluster Analysis of the combined attributes from the COI and QDA panels was carried out for the categories 'appearance', 'texture' and 'flavour'. The analysis aims to cluster highly correlated variables into nonoverlapping clusters in such a way that each cluster can be interpreted as essentially unidimensional. The clusters are chosen in such a way that their first principal components taken together account for the maximum possible proportion of the total variance of all variables. The analysis uses the correlation matrix of the relevant attributes computed from average scores (by year and by panel) over panellists and tasting sessions. Usage of the covariance matrix, i.e. giving different weights to the individual attributes, resulted in nearly the same clustering. Also an overall-scaling of the data from each laboratory such that their contribution to the total variance of the pooled data was equal had little effect on the results. A Principal Component Analysis based on the correlation matrix was also performed to visualize the grouping of the attribute loadings in rotating 3D-spaces.

4.2. Wheel synthesis

On the basis of the cluster analysis and the inspection of the principal component loadings a Sensory Wheel for Virgin Olive Oil was constructed (Figure 3). The sensory wheel has three concentric circles:

- In the centre are the chemical senses: look, feel, smell and taste, which are used to evaluate the characteristics of appearance, texture and flavour.
- In the inner ring 18 clusters are represented by their main attributes. These attributes can be used to describe an olive oil in terms of a basic sensory profile. They will provide the neccesary information about the underlying sensory dimensions.
- In the outer ring additional attributes from the same clusters are shown. One or more of these attributes can be *added* in the evaluation of olive oil in order to obtain more detailed information. However, they cannot *replace* the attributes of the inner ring without losing essential information.

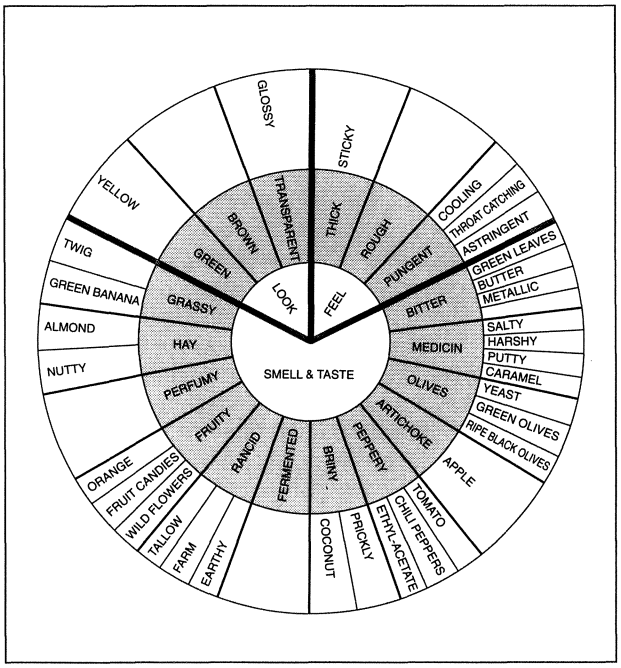

Figure 3
The Sensory Wheel of Virgin Olive Oil

The construction of the wheel can be demonstrated by taking one cluster, the fruity cluster, as an example (Table III). All attributes in this cluster have more or less to do with various fruits. Two ways to label this cluster are possible, either to pick one of the attributes with a high correlation to the own cluster, meaning it lies in the hart of the cluster, or to label this cluster by a more common name. In this case the name fruity is chosen, referring to all kind of fruits other than olive fruit. To be more in line with the COI labelling, this cluster could also named: other fruit.

Table III
Attributes from various panels in the fruity cluster and their correlation with the cluster component (first PC).

Name	Panel	Correlation
tomato (taste)	QDA-IT	0.69
tomato (flavour)	QDA-IT	0.71
apple	QDA-IT	0.55
apple	QDA-NL	0.92
lemon	QDA-NL	0.81
orange	QDA-NL	0.88
soft fruit	QDA-NL	0.91
candies	QDA-NL	0.73
wild flowers	QDA-NL	0.92
other ripe fruit	COI-IT	0.29
unpleasant	COI-IT	-0.52
fruity	COI-SP	0.65
fusty	COI-SP	-0.29

An example of the grouping of attributes in inner and outer ring is shown in Figure 4. Fruity, soft fruit and other ripe fruit form together one group; orange, lemon and apple another group. Fruit candies and wild flowers stand on their own. Tomato, from the Biagini panel, forms a separate group. This attribute is not shown in the outer ring of the Sensory Wheel, while it can be covered by fruity in this place, and also because the tomato attribute from the CFDRA panel was found in a different cluster and is shown over there. The negatively correlated attributes unpleasant and fusty are not included in the Sensory Wheel. In this fruity cluster one fusty attribute was found from the Spanish COI panel. The other two fusty attributes, from the Italian or Greek panel were found in different clusters. It was frequently found that the same COI-attribute from the different panels was found scattered over different segments of the wheel.

This "fruity" part forms one segment of the wheel. Together with the other segments, formed by other clusters, they form the Sensory Wheel for Virgin Olive Oil. The other segments are built up in a comparable way. There are 3 segments for appearance, 3 for texture, and 12 for flavour and adding up to the 18 attributes of the inner ring.

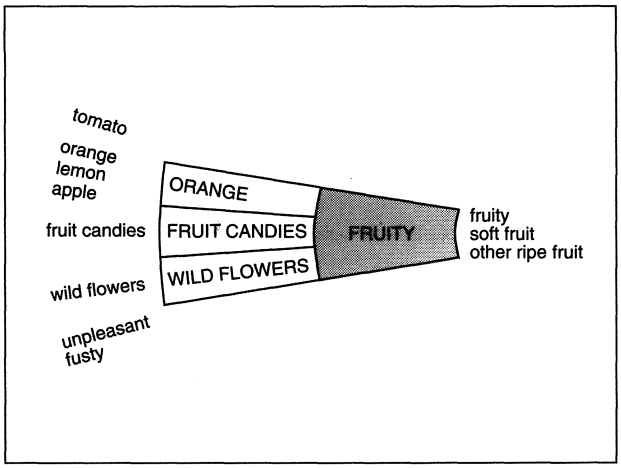

Figure 4
The fruity segment of the sensory wheel showing the allocation of the main (central) attributes and additional (peripheral) attributes from the fruity cluster.

It should be emphasized that the sensory wheel is constructed on the basis of only 16 extra virgin olive oils and only two harvests. Evaluating a wider spectrum of olive oils over a longer period of time should help to decide if the wheel has to be adjusted.

4.3. Usage

With the 18 main attributes a score form can be designed, either with a simple 0 to 5 scale, or an unstructured line scale. The definition of the attributes should be defined and written on a list. The panellists performing the evaluation should be screened for at least normal tasting abilities and a more than average ability for smell. Other aspects should be considered in addition, like health, absence of colour blindness, motivation and ability to work in a group. The panellists should be trained properly. They should interpret the attributes in the same way, should score consistently and use the scale to score in the same way. The evaluation should be carried out under controlled circumstances according to standardized procedures.

5. CONCLUSIONS

The COI-method has been show to give a poor reproducibility. We recommend that it should be used for quality control only. Quality must then be defined as the *absence of defects* due to maltreatment, according to technical specifications. In addition to physical and chemical specifications, the very sensitive human nose should be used. For quality control the procedure for qualification of

extra virgin olive oil can be simplified, by using solely the 'negative' attributes. Therefore, it is recommended that the COI-method should be tailored to detect possible defects solely. The final verdict should then be a simple: YES or NO extra virgin.

name: _____date: _____sample code: __

OLIVE OIL QUESTIONNAIRE

	0	1	2	3	4	5
green						
brown						
transparant						
thick						
rough						
pungent						
grassy						
hay						
perfumy						
fruity						
rancid						
fermented						
briny						
peppery						
artichoke						
olives						
medicin						
bitter						

Figure 5
Example of Olive Oil Questionnaire using the central attributes from the sensory wheel.

An example of a quality control scoring form is shown in Figure 5. The poor between-panel reproducibility can be improved by training, while using reference products showing defects that may occur. The quality of the COI-panel should be checked and maintained by means of ring testing. In ring testing, samples from the same oils will be sent to all panels. The results can be compared to evaluate the performance of the panels.

We have developed a Sensory Wheel comprising 3 appearance, 3 texture and 12 flavour descriptors. This Sensory Wheel can be a valuable tool in describing virgin olive oil and in establishing the relative importance of the attributes for the perceived quality of the oils. Profiles of virgin olive oils can be linked to consumer preference or acceptance judgements of the same oils, in order to make a prediction model for a certain consumer group. For a basic food such as olive oil, the sensory aspects are very important, though other factors like brand name, price and availability, are involved in the perception of quality by consumers. Using the same terminology by panels worldwide would greatly enhance the communication about olive oil quality.

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