Journal of Sensory Studies

Journal of Sensory Studies ISSN 0887-8250

A COMPARISON OF TWO METHODS FOR GENERATING DESCRIPTIVE ATTRIBUTES WITH TRAINED ASSESSORS: CHECK-ALL-THAT-APPLY (CATA) VS. FREE CHOICE PROFILING (FCP)

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Accepted for Publication January 11, 2016

doi:10.1111/joss.12202

ABSTRACT

The quality and reliability of descriptive profiles are closely linked to an accurate selection of the attributes included therein. Descriptive profiles with trained assessors often face challenges stemming from consensual procedures and the risk of forgetting some relevant descriptors. To overcome these problems, the suitability of two nonconsensual methods performed by trained assessors, namely free choice profiling (FCP) and check-all-that-apply (CATA), are examined and compared when building a sensory profile for fish.

Eighteen trained panelists having similar training were randomly split into two groups of nine assessors each. One group evaluated different fish species using CATA and the other using FCP, with both groups adopting the same experimental design.

Although both methodologies generated an important number of sensory descriptors for the tested products, noticeable differences among methods were observed. CATA performed better than FCP in terms of the descriptive ability and slightly better regarding the discriminant capacity. Both methods provided similar product location in the multidimensional space. The RV coefficient was significantly different from zero for all the sensory modalities except for odor and texture. However, noticeable differences were observed in product description. The main limitations of the study were also discussed.

PRACTICAL APPLICATIONS

Sensory descriptive analysis is normally the first step in the characterization of a food product, thus providing valuable information for food companies when designing and/or improving a product. This study shows and compares the usefulness of two methods, namely CATA and FCP, to obtain descriptive profiles, thus avoiding some of the bias linked to consensual procedures. Both methods are suitable for product discrimination, although they provide different sensory characterization for the different samples. The use of trained assessors, both with CATA and FCP, might increase the quality of a descriptive profile by avoiding useless terms and, especially in the case of CATA, ensuring that the most relevant descriptors are included.

INTRODUCTION

Sensory descriptive analysis is normally the first step in the characterization of a food product. It provides valuable information for food companies when designing and/or improving a product throughout the different steps involved, from formulating a product to tracking its shelf life. Sensory descriptive analysis also helps researchers to better understand the sensory response resulting from the consumption or use of a product and the relationship between sensory and other physicochemical characteristics (Varela and Ares 2012).

Descriptive methods consist of different steps depending on the technique chosen; however, all methods include a step involving the selection of the most appropriate sensory descriptors to assess (Murray *et al.* 2001). The quality and reliability of a descriptive profile is closely linked to an accurate selection of the attributes included in it (Montouto *et al.* 2002). As stated by Stampanoni (1994), sensory terminology is a determinant factor in descriptive analysis because perceptions are greatly influenced by language.

Traditionally, the generation and selection of descriptors have been accomplished by means of trained assessors. Methods including flavor profile (Cairncross and Sjöström 1950), texture profile (Brandt *et al.* 1963), quantitative descriptive analysis (Stone *et al.* 1974) and the spectrum method (Meilgaard *et al.* 1991) have been used for this purpose; meanwhile, other techniques such as quantitative flavor profiling delegate this task to a reduced group of experts (Stampanoni *et al.* 1996). Although these techniques have proven to be both powerful and highly effective in sensory profiling (Guerrero 1996; Murray *et al.* 2001, Varela and Ares 2012), sometimes the assessors' lack of product-oriented expertise and training or time constraints constitute a handicap for obtaining a satisfactory list of sensory descriptors. In most traditional descriptive techniques, attribute elicitation can be affected by weaknesses such as time requirement and elevated costs, low product knowledge, and need for consensus.

To elaborate an appropriate descriptive profile, a good knowledge of the product is recommended. Normally, conceptual associations are founded on self-experiences (Stolzenbach *et al.* 2013); thus, familiarity with previous concepts and product definitions makes it easier for assessors to elicit attributes when writing descriptions (Tuorila *et al.* 1998). In addition, the ease with which a person draws an association between a stimulus and its defining concept is highly influenced by prior experience with the same stimulus (Giacalone *et al.* 2015).

Sensory consensual methods may run the risk of producing unreliable results, often in situations involving a panel leader with a dominant personality (Walker 2004; Lawless and Heymann 2010). In addition, assessors could make mistakes such as sensitivity errors, which occur when some panelists are more sensitive than others to a determined attribute, thus, affecting the panel consensus (Meullenet 2008a). The selection of attributes to be included in a final profile by consensus procedure could be prone to different biases originating within the group dynamic itself. Factors such as a lack of agreement on which attributes to select (Murray *et al.* 2001) or the existence of disagreements regarding the individual meaning of some sensory characteristics (Delarue and Sieffermann 2004) might influence the validity of the final consensus. In fact, even after extensive panel training aimed to obtain agreement over attribute meaning, small differences between assessors are unavoidable (Lea *et al.* 2001, Martens and Martens 2001, Granitto *et al.* 2008). On occasion, even trained panelists seem to hold different conceptions of the same stimulus (Moskowitz 2003), thus, implying a certain communication deficiency related to vocabulary (Fichet *et al.* 2011). As stated by Lawless (1999), a stimulus may elicit responses that are quantitatively and qualitatively different from one subject to another, especially when chemical senses are involved. The risk of forgetting one or several important descriptors might also be an additional inconvenience in these consensual methods (Perrin and Pagès 2009).

One possible solution to solve some of these problems is to encourage the personal generation of descriptors, as free as possible, by means of techniques such as free choice profiling (FCP) (Williams and Langron 1984), wherein panelists are not expected to agree on the number, type or interpretation of elicited attributes. This method is even faster and more economical than traditional procedures (Jack and Piggott 1991; Reinbach *et al.* 2014), although, it has some disadvantages when performed with consumers using terms that are too personal or difficult to interpret because of their quantity or diversity (Piggott and Watson 1992). A majority of those terms elicited from consumers are usually not linked with any specific definitions or references, thus, making it difficult to deduce a consensual use of terms (Sieffermann 2000). In addition, some terms could be related to benefits that are consequences of consuming the product (e.g., thirst quenching, filling up) and that seem to be linked to hedonic issues (Veinand *et al.* 2011). Consequently, the use of this technique, usually reserved for naïve individuals, could be enhanced when used with trained panelists (Guerrero *et al.* 2001). The use of FCP among trained panelists offers the advantages of both traditional descriptive techniques and free eliciting techniques, thus eliminating a number of extant inconveniences linked to consensual procedures.

Another method that might be useful in overcoming some of the biases previously mentioned is CATA or the Check-All-That-Apply test (Adams *et al.* 2007; Meullenet *et al.* 2008b, Varela and Ares 2012). The CATA method is a form of multiple choice survey wherein a list of answer alternatives is presented and respondents tick the options that they consider applicable to the product. The CATA method requires minimal instruction, is relatively easy to perform and is completed quickly (Dooley *et al.* 2010). CATA's

TABLE 1. FISH SPECIES USED FOR DIFFERENT DESCRIPTIVE ANALYSES

Scientific Name	Commercial name	Free attribute generation	CATA test	FCP test
Salmo salar	Salmon	X	X	X
Argyosomus regius	Meagre	X	X	X
Perca fluviatilis	Eurasian perch	X	X	
Xiphias gladius	Swordfish	X	X	
Merluccius merluccius	European hake	X	X	
Lophius piscatorius	Anglerfish (monkfish)	X	X	X
Scomber scombrus	Atlantic mackerel	X	X	
Gadus morhua	Atlantic cod	X	X	X
Sparus auratus	Gilthead seabream	X	X	
Pangasius hypophthalmus	Iridescent shark	X	X	
Hippoglossus hippoglossus	Atlantic Halibut	X	X	X
Zeus faber	John Dory or Peters fish	X	X	
Pagrus pagrus	Red porgy	X		
Sanders lucioperca	Pikeperch	X	X	X
Lithognathus Mormyrus	Sand steenbras	X		
Etmopterus pusillus	Smooth lanternshark	X		
Psetta maxima	Turbot	X	X	X
Dicentrarchus labrax	European seabass	X	X	
Diplodus sargus sargus)	White seabream	X		
Conger conger	Conger Eel	X	X	
Solea solea	Sole	X	X	
Lepidorhombus boscii	Four spot megrim	X	X	
Salmo trutta	Brown trout	X	X	X

potential for eliciting reliable product characterizations has come mostly from consumers (Ares *et al.* 2014, Ares *et al.* 2015), with a similar procedure having reportedly been used with trained assessors (Campo *et al.* 2010). To our knowledge, this technique has not been previously used when performing free selection of descriptive terms by trained panelists. Theoretically, the use of CATA should allow tasters to select the most appropriate terms to describe a product without a consensus bias, thus reducing the risk of forgetting relevant attributes if the selected terms included in the test have been chosen based on an extensive bibliographic search when available. When little previous descriptive information exists, the initial list of descriptors can be freely generated by means of trained assessors, similarly to the procedure used in the first stage of a FCP (individual free generation of descriptors).

The aim of this study is to verify and compare the ability of two nonconsensual methods, namely CATA and FCP, to elicit sensory descriptive attributes in terms of the quantity and quality (i.e., assessed by their discriminant power) of descriptors generated by trained assessors.

MATERIALS AND METHODS

Sampling and Cooking Procedure

Twenty-three different fish species were selected at the fish market based on visual differences (size, color, shape), expected mouth characteristics (texture and flavor) and availability throughout the duration of this study (Table 1).

Fresh samples were acquired in fillet presentation (boneless and without the skin). Each fillet was vacuum-packed and stored frozen (−20C) until evaluation for a maximum of 15 days. Twenty-four hours before analysis, samples were thawed at 4C.

In all cases, samples were cooked in a convection oven at 115C for 20 min in individual transparent glass jars designed to make samples easy to visualize. Jar lids were used to keep the samples' odor from disappearing (Model B-250, Juvasa, Spain). Jars were then placed inside electrical heaters at 60C to keep them warm while being tasted.

Elicitation of Descriptive Terms

The descriptive terms to be analyzed and compared were obtained by means of two different methodologies: CATA and FCP.

CATA Test. To select the attributes to be included in the checklist, an extensive bibliographical review was conducted, creating a list of potential fish descriptors (Table 2). Then, panelists assessed the 23 different species (Table 1) in four different sessions (one for odor, one for appearance, one for flavor and one for texture), where they were asked to individually elicit as many sensory attributes as possible to describe those fish samples provided. In each session or for each sensory modality panelists evaluated five sets of four

TABLE 2. SENSORY ATTRIBUTES OBTAINED FROM THE BIBLIOGRAPHY

Attribute	Specie tested	Description	Reference	Country
Odor				
Acetic	Atlantic cod	Acetic acid	Sveinsdottir *et al*. (2009)	Iceland
Ammonia	Cod	TMA concentrated	Cardenas *et al*. (2007)	Iceland
Butter	Atlantic cod	Popcorn	Sveinsdottir *et al*. (2009)	Iceland
Dairy	Sea bream	Boiled milk	Cardinal *et al*. (2011)	France
Earthy	Sea bream	Intense odor	Cardinal *et al*. (2011)	France
Manure	Salmon	Barn cow manure	Farmer *et al*. (2000)	Ireland
Meat	Cod	Boiled meat	Sveinsdottir *et al*. (2009)	Iceland
Metallic	Salmon	Iron, blood sulfate	Rødbotten *et al*. (2009)	Norway
Potato	Cod	Cooked potato	Sveinsdottir *et al*. (2010)	Iceland
Rancid	Meagre	Oxidized fat	Hernández *et al*. (2009)	Spain
Rotten	Cod	Old fish	Cardenas *et al*. (2007)	Iceland
Sea water	Salmon	Fresh salty ocean	Rødbotten *et al*. (2009)	Norway
Sea weed	Cod	Seafood, alga	Sveinsdottir *et al*. (2010)	Iceland
Sour	Salmon	Organic acids	Rødbotten *et al*. (2009)	Norway
Stagnant water	Salmon	Intensity of the attribute	Farmer *et al*. (2000)	Ireland
Sulfur	Cod	Phosphorus Sulfur	Sveinsdottir *et al*. (2009)	Iceland
Vanilla	Cod	Milky vanilla	Sveinsdottir *et al*. (2010)	Iceland
Appearance				
Black veins	Sea bream	Black grooves	Cardinal *et al*. (2011)	France
Coagulated proteins	Sea bream	Brown spots	Cardinal *et al*. (2011)	France
Color ivory	Salmon	Yellow notes	Rødbotten *et al*. (2009)	Norway
Color white	Halibut	Intensity pure color	Olsson *et al*. (2003)	Norway
Color homogeneity	Cod	Color uniformity	Sveinsdottir *et al*. (2009)	Iceland
Exudates presence	Salmon	Released liquid	Farmer *et al*. (2000)	Ireland
Fat droplets in exudates	Salmon	Fat released in fish exudates	Farmer *et al*. (2000)	Ireland
Laminar structure	Salmon	Visual flake openings	Veiseth-Kent *et al*. (2010)	Norway
Shine	Sea bream	Bright surface	Orban *et al*. (1997)	Italy
Suspended particles	Cod	Precipitation of meat	Sveinsdottir *et al*. (2010)	Iceland
Flavor				
Acid	Cod	Flavor intensity	Rødbotten *et al*. (2009)	Norway
Ammonia	Cod	Amine flavor	Sveinsdottir *et al*. (2009)	Iceland
Bitter	Salmon	Intensity quinine	Rødbotten *et al*. (2009)	Norway
Butter	Cod	Popcorn like	Sveinsdottir *et al*. (2009)	Iceland
Earthy	Sea bream	Flavor Intensity	Cardinal *et al*. (2011)	France
Fish oil	Salmon	Oily Intensity	Farmer *et al*. (2000)	Ireland
Meat	Cod	Boiled meat	Sveinsdottir *et al*. (2009)	Iceland
Manure	Salmon	Intensity barn	Farmer *et al*. (2000)	Ireland
Metallic	Sea bream	Flavor Intensity	Cardinal *et al*. (2011)	France
Nutty	Salmon	Almond hazelnut	Veiseth-Kent *et al*. (2010)	Norway
Old	Salmon	Not fresh	Rødbotten *et al*. (2009)	Norway
Potato	Sea bream	Flavor Intensity	Cardinal *et al*. (2011)	France
Pungent	Cod	Intense	Cardenas *et al*. (2007)	Iceland
Rancid	Salmon	Oxidized fat	Bencze *et al*. (1998)	Norway
Rotten	Cod	Putrid	Sveinsdottir *et al*. (2009)	Iceland
Salty	Salmon	Intensity	Farmer *et al*. (2000)	Ireland
Sea water	Salmon	Fresh, ocean	Rødbotten *et al*. (2009)	Norway
Sour	Cod	Deteriorated	Sveinsdottir *et al*. (2009)	Iceland
Smoked	Salmon	Intensity	Bencze *et al*. (1998)	Norway
Sweet	Cod	Intensity	Cardenas *et al*. (2007)	Iceland
Texture				
Chewiness	Meager	Number of chews before swallowing	Hernández *et al*. (2009)	Spain
Cohesiveness	Meager	Fish structure	Giogios *et al*. (2013)	Greece
Elastic	Salmon Perch	Degree of recovery when applying Biting force	Veiseth-Kent *et al*. (2010)	Norway

TABLE 2. CONTINUED

Attribute	Specie tested	Description	Reference	Country
Flakes	Cod	Fish breaks in flakes when pressing	Sveinsdottir *et al*. (2009)	Iceland
Film palate	Salmon	Degree in which fish sticks to mouth	Farmer *et al*. (2000)	Ireland
Firmness	Halibut	Hardness in the first bite	Olsson *et al*. (2003)	Norway
Gummy	Perch	Like chewing gum	Stejskal *et al*. (2011)	Czech Republic
T-Juicy	Salmon Halibut	Water released after chewing	Veiseth-Kent *et al*. (2010)	Norway
Mouth residue	Salmon	Intensity	Farmer *et al*. (2000)	Ireland
Stringiness	Meager Sea bream Cod	Fibred tissue	Giogios *et al*. (2013)	Greece
Teeth adherence	Salmon Cod Sea bream	Degree in which fish sticks to teeth	Farmer *et al*. (2000)	Ireland

samples and one set of three samples. Assessors had a short break of 5 min between each set of samples. Finally, a list of attributes was revealed to the panelists. This list included the attributes from the bibliographical review and some additional attributes that had been obtained from the previous four different sessions after removing those terms considered redundant by means of a triangulation process (Guerrero *et al.* 2010). CATA analysis was carried out over this final checklist, which had a total of 103 descriptors that included odor, appearance, flavor and texture attributes. To reduce the number of samples requiring assessment, and based on the previous descriptive task (the four different sessions mentioned above), 19 fish species (those presenting the highest sensory diversity) were evaluated in one session (in four sets of four samples each and one set of three samples, thus allowing assessors to have a short break of 5 min between each set of samples). Due to the large amount of attributes to evaluate, they were grouped by sensory modality and presented to the assessors in separated paper sheets. To make the task easier, the order of the descriptors was always the same for all the assessors and for the five sets of samples in order to reduce the effort spent on locating and checking the attributes on the ballot. Panelists were asked to smell samples at the beginning of the test so that the odor would not disappear before they completed the task. For every sample, panelists were instructed to mark in the checklist only those attributes that were clearly perceived to more effectively capture the relevant differences among selected fish species. This procedure was performed species by species within each set of sample, so for each assessor each specific attribute could be ticked up to a maximum of 19 times. Panelists also had the opportunity to add new descriptors if they considered it necessary.

FCP. Eight fish species were selected from among the previous 19 species assessed in the CATA sessions. Selection was designed to choose those that were most different from each other from a sensory point of view in the CATA test. Species selected for this technique were salmon, meager, angler fish, Atlantic cod, halibut, turbot, pikeperch and brown trout (sea trout). The FCP technique was performed in three sessions. In the first session, panelists evaluated the eight samples to generate the personal attributes they could perceive as relevant when describing each fish species. In the next two sessions, panelists had to rate the same eight samples in each of them using their own attributes in a lineal scale from 0 to 10, anchored with the words low intensity/absence (0) and high intensity (10).

Panelists and Procedure

Eighteen panelists with more than 4 years of experience in the sensory profiling of food products (previously selected and trained according to ISO regulations) were recruited for this study. Nine panelists were randomly selected to participate in the CATA analysis and the other nine in the FCP method. All of them had similar descriptive and quantitative sensory performance and were between 31–52 years old.

In each session, the order of sample presentation and the first order and carry-over effects (Macfie *et al.* 1989) were blocked. In all cases, the generation of descriptors was performed in isolated sensory testing booths (ISO, 2007). All assessors were provided with mineral water to cleanse their palates between samples.

Data Analysis

To analyze and visualize the CATA data, a Factorial Correspondence analysis was performed over the contingency matrix obtained (frequency of each selected term for each species). Previously, only those descriptors being cited eight or more times (taking into account all assessors and the 19 products) were kept. FCP data were analyzed using the Generalized Procrustes Analysis (GPA) (Gower 1975). In this case, only discriminant descriptors after performing a twoway ANOVA (fish species and tasting session) for each assessor ($P < 0.25$) were retained. The mean value of the two replicates performed was submitted to the GPA analysis. Using these two selecting criteria (frequency of elicitation equal or higher than 8 for CATA and discriminant ability of $P < 0.25$) a similar reduction of the initial number of descriptors were obtained (70.9% for CATA and 70.0% for FCP), thus, being both methods easier to compare.

A comparison between the CATA and FCP techniques was drawn by calculating the overall number of attributes elicited in each method and sensory modality (appearance, odor, flavor and texture attributes). Differences between the 8 fish samples were examined to check the discriminant ability of each method, thus, involving all the selected descriptors in each of them. In the case of FCP the consensual coordinates for each assessor and for all the samples, after performing the corrections done by the GPA (translation, scaling and rotation), were kept, thus obtaining the consensual results for each individual. For CATA data a Multiple Factorial Analysis was performed and again the consensual coordinates for each assessor and for all the samples were kept. In both cases, all the factors obtained were retained to cover 100% of the variability. Consensual configurations were always compared for the two methods. The consensual coordinates obtained in each method for the 8 fish species were submitted to an Analysis of Variance, a Discriminant analysis and a RV coefficient test for each sensory modality.

All statistical analyses were performed using XLSTAT software (2014).

RESULTS AND DISCUSSION

The results and discussion are presented in two differentiated parts. In the first section, the differences between the CATA and FCP methods are discussed, with a focus on the number of descriptors selected in general and by sensory modality. The second section examines and compares the discriminant ability of these two methods.

Attributes Selected

Both CATA questions and the FCP technique proved to be effective in generating an important number of sensory attributes for the products tested. As shown in Table 3, trained panelists selected, on average, 22 terms to describe the samples provided using the FCP technique, whereas the average number of selected terms was 50 when dealing with the CATA procedure. The differences observed regarding the final number of retained attributes between both methods are probably due to the greater ease and simplicity with which panelists selected relevant terms when using the CATA procedure, compared with the FCP test wherein panelists had to generate their own descriptors. According to Budiu (2014), showing panelists stimuli that they recognize improves their ability to select and use terminology, whereas panelists not prompted by stimuli must recall items from scratch. This phenomenon can be explained by looking at human memory processing. Neural activity can be activated

TABLE 3. FREQUENCY OF DIFFERENT SELECTED ATTRIBUTES IN CHECK-ALL-THAT-APPLY (CATA) AND IN FREE CHOICE PROFILING (FCP) METHODS FOR THE SAME EIGHT SPECIES

Sensory modality	Panelist ID	CATA	FCP
Appearance	P1	18	5
	P2	18	5
	P3	14	6
	P4	17	10
	P5	15	8
	P6	14	3
	P7	17	9
	P8	11	4
	P9	14	10
Average		15 (30%)	7 (32%)
		CV = 15.29%*	CV=39.69%*
Odor	P1	9	5
	P2	11	1
	P3	13	6
	P4	8	5
	P5	9	4
	P6	9	6
	P7	13	5
	P8	13	4
	P9	9	4
Average		10 (20%)	4 (18%)
		CV = 19.80%*	CV = 33.96%*
Flavor	P1	14	1
	P2	14	2
	P3	14	5
	P4	9	5
	P5	10	6
	P6	17	4
	P7	11	9
	P8	11	3
	P9	11	9
Average		12 (24%)	5 (23%)
		CV = 20.67%*	CV = 57.35%*
Texture	P1	11	5
	P2	14	6
	P3	13	9
	P4	14	6
	P5	15	6
	P6	11	5
	P7	15	9
	P8	12	2
	P9	13	6
Average		13 (26%)	6 (27%)
		CV = 11.72%*	CV = 35.36%*
Total Average		50 (100%)	22 (100%)

* CV, coefficient of variation (%) for each sensory modality and method.

in two ways: through recognition and through recall processes (Johnson 2010). In recognition activities, the information to be analyzed is already available along with options to choose from, and individuals select an answer from different alternatives, thus mirroring the CATA method. In recall processes, no answers are available to choose from and respondents must generate terms from the own individual memory (Cabeza *et al.* 1997, Krishnan *et al.* 1999), a process that occurs also in FCP. When the recognition process occurs, long-term memory is accessed and perception is involved; however, when a recall process occurs, neural patterns must be reactivated without any perceptual input. In general, more brain areas are activated during recall than during recognition processes because more activity is needed to generate a response in recall processes. Because fewer brain areas are activated by recognition than by recall, recognition is indeed easier (Cabeza *et al.* 1997), thus, explaining why attribute elicitation seems to be more straightforward in CATA than in FCP (Johnson 2010). As stated by Nevid (2012), an individual is more likely to remember the name of the author of a book when seeing it in a multiple choice list than when the individual has to write it from memory on a blank paper.

The percentages of selected attributes in the four different modalities, both in CATA and in FCP, were very similar (30% and 32% for appearance, 20% and 18% in odor, 24% and 23% in flavor and 26% and 27% in texture, respectively). A balanced distribution of descriptors among sensory modalities is expected when dealing with trained subjects (Losó *et al.* 2012). By contrast, nontrained assessors utilize attributes that tend to favor those modalities that are easier and more familiar for them (Hersleth *et al.* 2013).

Even though these two methods were performed with similarly trained assessors, a noticeable variability among individuals was observed with regard to the number of selected attributes within the same sensory modality. This finding is probably a consequence of personal factors (e.g., minimum and maximum of 1 and 9 attributes selected, respectively, for flavor in the FCP method). As stated by Fichet *et al.* (2011) well-trained assessors are susceptible to variation over time and a lack of agreement among themselves despite their skills and expertise. The results having the highest variability (based on the coefficient of variation) within members of the same panel, both in CATA and FCP, were found in the flavor modality (CV = 20.67% and CV = 57.35%, respectively).

Odor judgments in descriptive analysis tend to be more difficult than visual, textural or taste judgments (Lawless and Heymann 2010). Successful odor identification depends on commonly encountered substances, a connection between the odor and its name, and assistance in odor name recall. The absence of any one of these three components impedes performance drastically (Cain 1979). However, in this study, agreement over the number of elicited odor attributes was higher than in corresponding flavor, and the existence of the recalling process in the CATA method did not seem to increase the relative number of selected descriptors. The existence of clear odor differences between fish samples assessed could possibly have favored the total number of attributes elicited. Varying degrees of personal skills in the recall process might explain the highest discrepancy observed in the number of selected attributes when using FCP compared with CATA (expressed as coefficient of variation).

A total of 94 different sensory descriptors were selected for both methods and the same eight fish species (Table 4), from which 52% were selected simultaneously in both CATA and FCP. These attributes may be more relevant in describing the products assessed, as these attributes are generated through both recognition and recall processes. The observed concordance between both methods can also be explained by the fact that all assessors were trained together and by the same panel leader. Consequently a similar vocabulary and descriptive sensory knowledge should be expected (Stone *et al.* 2012). The remaining 48% of elicited attributes corresponded to those only being selected by the CATA method (25.5%) or by the FCP method (22.3%). The difference between the number of attributes that were selected with both methods (49 out of 94) and the number of descriptors selected only in the CATA method (24 out of 94) or in the FCP method (21 out of 94) was quite different. This difference could be due to the personal variability among individuals or, more likely, to the effect of the methodology applied.

With regard to the four sensory modalities for descriptors shared by both methods, the most noticeable difference was observed in the odor category, which presents less agreement between panels and methods (only eight odor descriptors were selected simultaneously in both methods, compared to the 15 agreed on for appearance). As already mentioned, odor description tends to be more complex than the other sensory modalities. Accordingly, more odor attributes were only selected in the CATA method when compared to those only selected in FCP method (11 vs. 5), probably because in the CATA method, panelists were provided with assistance (i.e., a checklist) when recalling the possible descriptors to choose. Evident differences between the two methods were also observed in the appearance category. However, it is important to remark that the majority of those descriptors only selected in the FCP method (7 out of 9) corresponded to a visual texture (dry, firm, gelatinous, greasy, juicy, rubbery and shrinkage).

The agreement between assessors for the descriptors in common was higher for the CATA method. In all cases – except for the earthy odor – the number of panelists that agreed on the presence of a certain descriptor was lower in the FCP method (see frequency values in brackets in Table 4). Similar values were only observed for sour odor and

TABLE 4. SELECTED ATTRIBUTES IN CHECK-ALL-THAT-APPLY (CATA) AND FREE CHOICE PROFILING (FCP) TECHNIQUES FOR THE SAME EIGHT SPECIES*

Appearance	Odor	Flavor	Texture
CATA and FCP			
Black streaks (9,4)	Ammoniac (8,7)	Bitter (6,1)	Chewiness (8,3)
Coagulated proteins (6,1)	Butter (5,2)	Butter (5,3)	Cohesiveness (7,2)
Color brown (5,1)	Dairy (2,1)	Cooked vegetable (5,2)	Crumbliness (9,6)
Color uniformity (6,1)	Earthy (5,7)	Dairy (5,1)	Elastic (7,3)
Color ivory (8,1)	Sardine (4,3)	Earthy moist (6,2)	Firmness (8,8)
Color salmon (9,4)	Seafood (5,3)	Nutty (4,1)	Flakes (9,2)
Color white (9,3)	Sour (2,2)	Rancid (2,1)	Gelatinous (6,3)
Exudate presence (9,4)	Vanilla (5,1)	Salty (9,5)	Juicy (8,1)
Fat droplets (9,4)		Seafood (7,3)	Mouth residue (8,1)
Laminar structure (8,2)		Sea water (6,2)	Oily (9,2)
Shine (9,1)		Sweet (8,5)	Pasty (5,4)
Suspended particles (8,3)		Wet rag (5,1)	Rubbery (9,3)
Transparent exudate (9,1)			Stringy (8,4)
Turbid exudate (9,3)			Teeth adherence (9,4)
White spots (5,2)			
CATA			
Color grey (5,0)	Acetic (4,0)	Acid (7,0)	Floury (2,0)
White exudate (7,0)	Biscuit (3,0)	Ammonia (7,0)	Roughness (1,0)
Yellow exudate (8,0)	Cardboard (3,0)	Beef (3,0)	Film palate (3,0)
	Fish oil (9,0)	Fish oil (9,0)	
	Mold (6,0)	Mold (6,0)	
	Nutty (2,0)	Old (2,0)	
	Sea water (4,0)	Potato (5,0)	
	Stagnant water (3,0)		
	Thinner (2,0)		
	Toasted cereal (4,0)		
	Wet rag (5,0)		
FCP			
Color intensity (0,4)	Cookie (0,1)	Greasy (0,2)	Dry (0,1)
Dry (0,1)	Greasy (0,2)	Herbal (0,1)	Soft (0,2)
Firm (0,1)	Odor intensity (0,1)	Intensity (0,5)	
Gelatinous (0,4)	Rotten fish (0,1)	Spicy hot (0,1)	
Greasy (0,2)	Sweet (0,2)	Toasted cereal (0,1)	
Juicy (0,2)			
Mucus presence (0,1)			
Rubbery (0,1)			
Shrinkage (0,1)			

* Digits in brackets correspond to the number of panelists that elicited each descriptor in CATA and FCP analyses, respectively.

firmness in texture. In the same vein, it is worth highlighting that 12 out of 21 descriptors only selected in the FCP method were elicited by just one assessor.

Discriminant Ability

Due to the large amount of descriptors selected in both methods, the comparison between them was done separately for each sensory modality. Generally speaking, both the CATA and FCP techniques allow for the observation of differences among fish species.

Figure 1 shows results for the appearance attributes. Salmon and brown trout were located together in both FCP and CATA graphs, clearly differentiated from the remaining fish species, and were described as being pink in color and having fat droplets in their transparent exudates.

For odor attributes (Fig. 2), species location was clearly different for both methods. Salmon and brown trout were placed together in FCP and separately in CATA. These differences might be explained by the statistical technique used in each approach. The correspondence analysis used in the CATA test highlights the main differences between samples (Greenacre and Blasius 1994) and not their similarities, whereas FCP (principal component analysis) takes into consideration all elicited attributes, both similarities and differences, and their intensity. Salmon was mainly described by

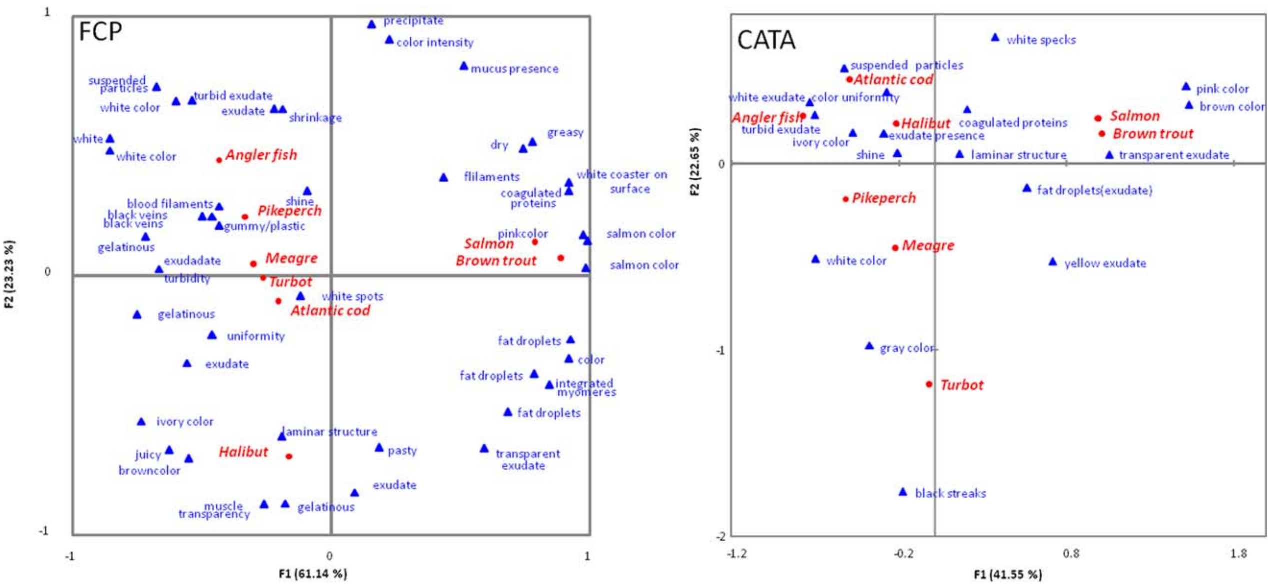

FIG. 1. APPEARANCE SELECTED ATTRIBUTES FOR EIGHT FISH SPECIES FROM GENERALIZED PROCRUSTES ANALYSIS (GPA) PERFORMED ON FREE CHOICE PROFILING (FCP) AND CORRESPONDENCE ANALYSIS PERFORMED ON CHECK-ALL-THAT-APPLY (CATA)

its fatty/oily character, properties shared with the Brown trout as well, which might explain why they were located together in the FCP map (both species had more similarities than differences) and separated in the CATA map (the earthy/mold descriptor was the main distinctive character between both species). Halibut and Atlantic cod present "ammoniac" as a common descriptor in CATA; however, in FCP, Atlantic cod was less influenced by this attribute and was placed consequently apart from halibut. Again, these differences can be explained by methodological issues because fish samples can have similar frequencies of elicitation for some descriptors (i.e., a similar position on the CATA map) and at the same time different intensity (i.e., different positions on the FCP map). Qualitative methods (CATA) seem to provide less information and discriminant abilities than quantitative data (FCP). CATA produces counts (frequencies)

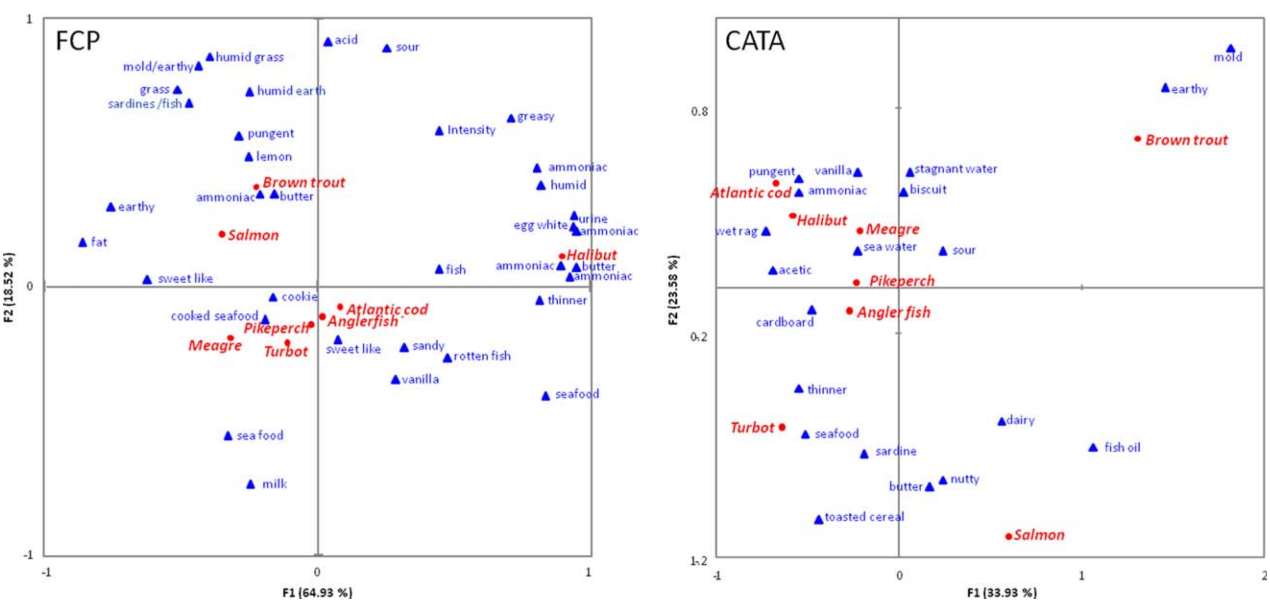

FIG. 2. ODOR SELECTED ATTRIBUTES FOR EIGHT FISH SPECIES FROM GENERALIZED PROCRUSTES ANALYSIS (GPA) PERFORMED ON FREE CHOICE PROFILING (FCP) AND CORRESPONDENCE ANALYSIS PERFORMED ON CHECK-ALL-THAT-APPLY (CATA)

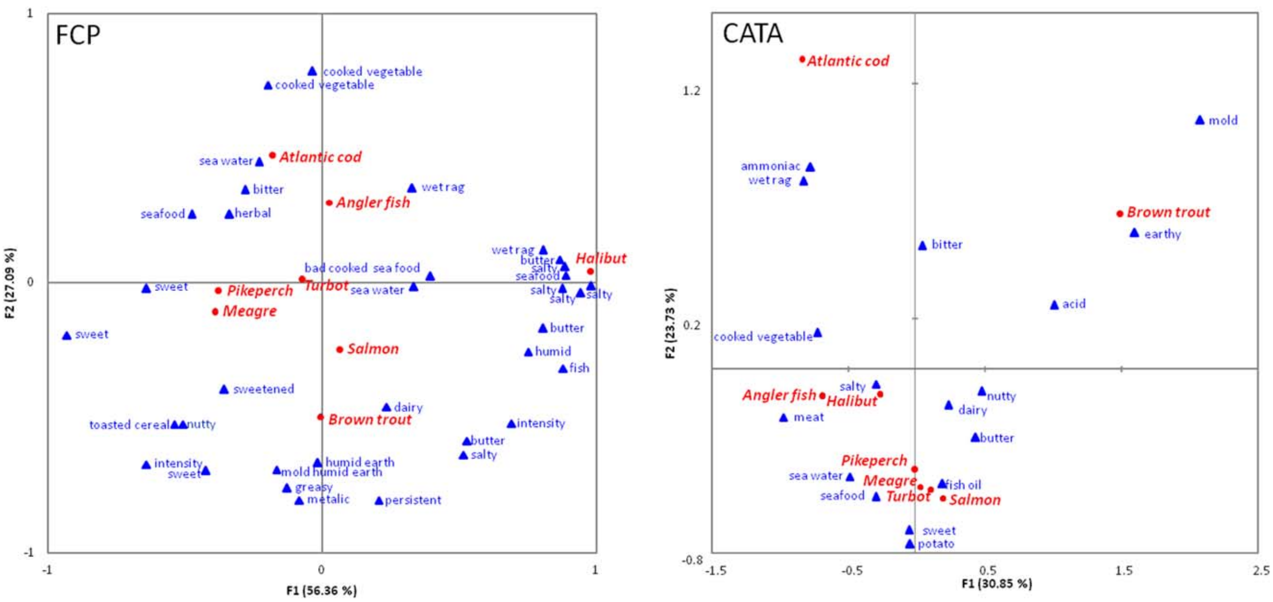

FIG. 3. FLAVOR SELECTED ATTRIBUTES FOR EIGHT FISH SPECIES FROM GENERALIZED PROCRUSTES ANALYSIS (GPA) PERFORMED ON FREE CHOICE PROFILING (FCP) AND CORRESPONDENCE ANALYSIS PERFORMED ON CHECK-ALL-THAT-APPLY (CATA)

instead of scoring or intensities (Dooley *et al.* 2010) and as stated by Valentin *et al.* (2012), nonparametric data has a tendency to have less power than parametric data (FCP). In any case, "ammoniac" was described as the main halibut descriptor for odor in both methods. Finally, turbot was described as having a "seafood odor" in both cases.

Flavor attributes are shown in Fig. 3. Atlantic cod and Brown trout were among the most different species both in CATA and in FCP. Again, halibut was well differentiated with FCP procedures and not with the CATA method in agreement with the statistical peculiarities of each method, as previously mentioned. Brown trout was characterized by "earthy mold" and "humid earth" flavors, as was observed in odor attributes. However, descriptors used for Atlantic cod were different in the two methods ("ammoniac" and "wet rag" odors were reported in the CATA method and

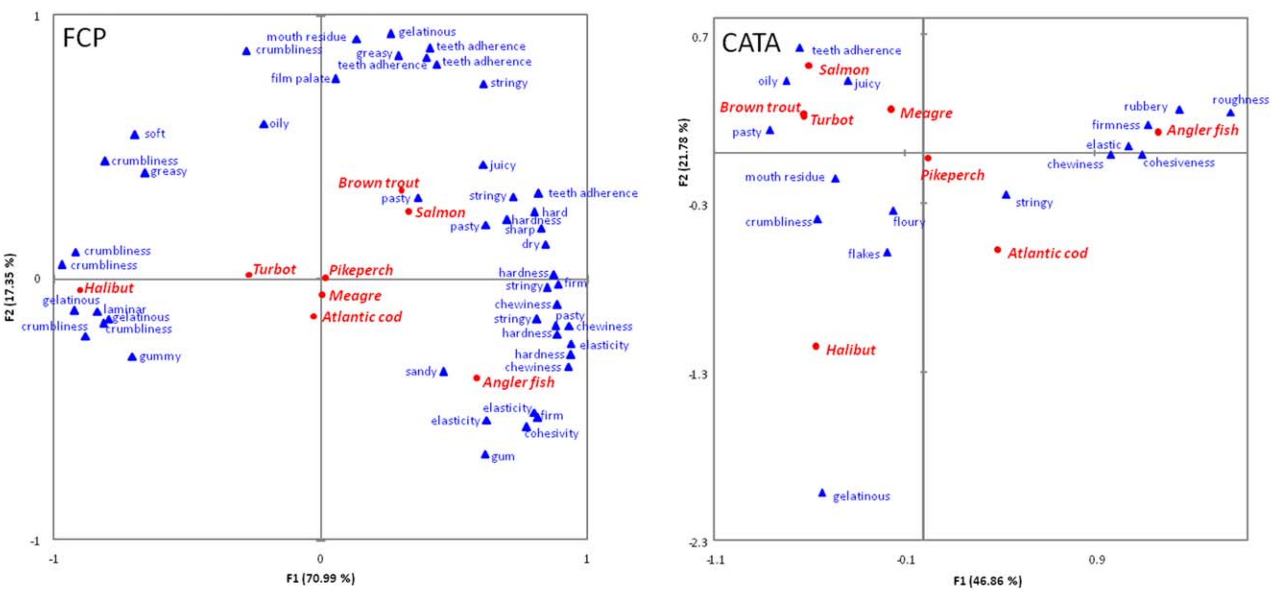

FIG. 4. TEXTURE SELECTED ATTRIBUTES FOR EIGHT FISH SPECIES FROM GENERALIZED PROCRUSTES ANALYSIS (GPA) PERFORMED ON FREE CHOICE PROFILING (FCP) AND CORRESPONDENCE ANALYSIS PERFORMED ON CHECK-ALL-THAT-APPLY (CATA)

TABLE 5. DISCRIMINANT ABILITY OF CHECK-ALL-THAT-APPLY (CATA) AND FREE CHOICE PROFILING (FCP) METHOD

Sensory modality	FCP‡	Discriminant analysis†	CATA‡	Discriminant analysis†	RV coefficient*
Appearance	8.042	100%	6.926	98.61%	0.765**
Odor	6.589	85.94%	6.478	95.83%	0.588 ns
Flavor	5.762	90.63%	7.410	100%	0.707***
Texture	7.790	100%	9.171	100%	0.602 ns
Average	7.046	94.14%	7.496	98.61%	

* Ns, no significant ($P > 0.05$); ** $P \leq 0.01$; *** $P \leq 0.001$.

† Percentage of correctly classified fish samples in their corresponding species (confusion matrix).

‡ *F* values of ANOVA.

"seafood" and "cooked vegetable" odors were reported in the FCP method). Lastly, halibut was mainly described as "salty."

Figure 4 shows the sensory profile for textural attributes. Halibut, brown trout, salmon and angler fish were all well differentiated in both methods. Halibut was described as "gelatinous" and "crumbly."

Even though these figures (Figs. 1–4) provide a good descriptive overview of the main attributes associated to each sample and allow speculating about the respective discriminant ability of each method, they do not provide strong enough arguments to draw conclusions. Table 5 shows the discriminant power of the two methods for each sensory modality based on two different statistical approaches (ANOVA and Discriminant analysis) as well as the closeness between CATA and FCP data calculated by means of the RV coefficient. According to the *F* value, FCP had higher discriminant ability for appearance and odor, while CATA had higher values for flavor and texture. However, the *F* value does not allow knowing whether all the species were clearly differentiated among each other or simply one of them differed to a great extent from the rest. This information can be obtained from the discriminant analysis. The percentage of samples correctly classified in their respective species (confusion matrix) by means of the discriminant function was similar for Texture descriptors (100%). However, CATA showed higher discriminant ability than FCP for Odor and Flavor modalities. In average, CATA had higher discriminant scores than FCP for both the *F* value and the percentage of fish samples correctly classified. These conclusions can also be inferred from Fig. 5, where at first impression CATA seems to discriminate better between fish species than FCP. However, some species such as meagre, pikeperch or turbot were poorly differentiated by CATA compared to FCP data. Based on all these results it seems difficult to conclude which method performs better regarding the discriminant power.

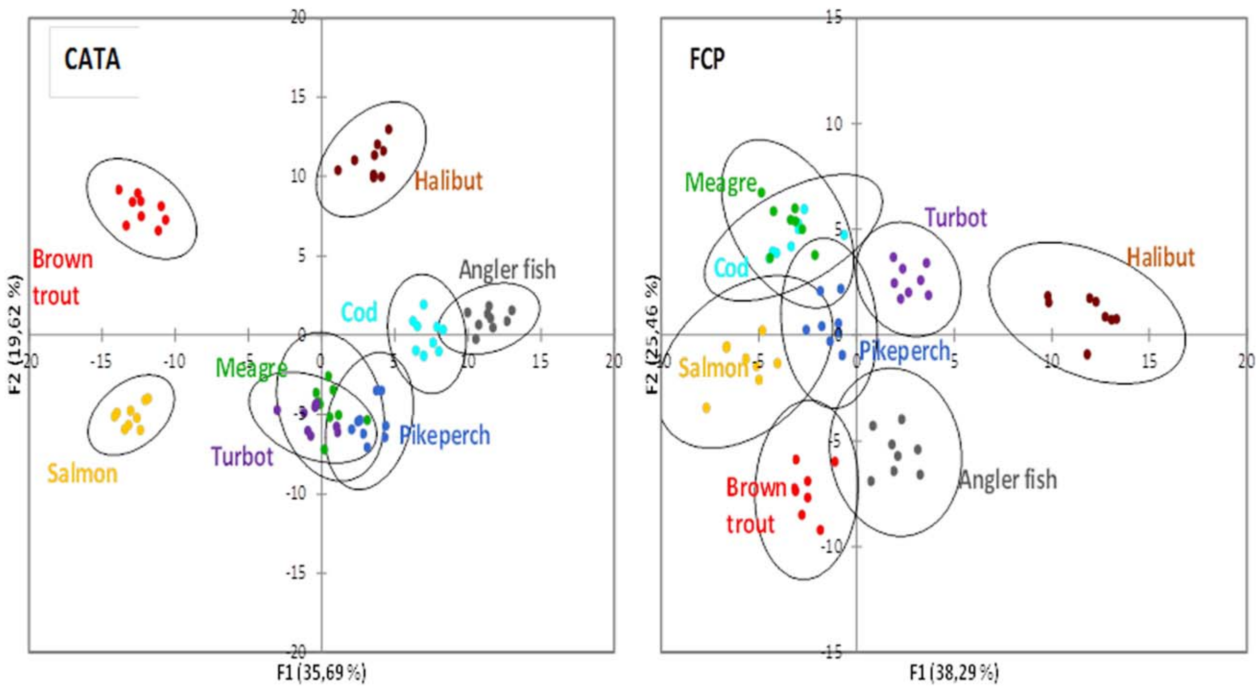

FIG. 5. LOCATION OF THE SAMPLES IN THE FIRST TWO DIMENSIONS OF THE DISCRIMINANT ANALYSIS PERFORMED FOR THE FREE CHOICE PROFILING AND CHECK-ALL-THAT-APPLY DATA. CONFIDENCE ELLIPSES WERE COMPUTED AT 5% OF ERROR

In any case, it is worth to mention that although CATA simply measures the frequencies of elicited attributes and FCP measures not only their presence or absence but also the magnitude of the differences in their intensity, both techniques exhibited, at least, similar discriminant ability. Statistical test based on quantitative data (GPA) make use of more information than those focusing on frequencies or binary data (correspondence analysis) because real numbers provide more precise information than categories alone. Consequently, parametric data tend to be more discriminating or powerful than nonparametric data (O'Mahony 1986) contrary to what was observed in this study. In the same vein, Kim *et al.* (2013) did not find higher discrimination between products when comparing GPA (parametric data) vs. Correspondence analysis (frequencies profile) with consumers.

The use of trained assessors for descriptive attribute elicitation, as described in this article, might increase the quality of a descriptive profile by avoiding useless terms and, especially in the case of CATA, ensuring that the most relevant descriptors are included. This fact is especially important when explaining consumers' preferences by means of sensory data because small changes in the descriptive profile could lead to important changes when drawing conclusions about preference patterns (Gou *et al.* 1998). In addition, both techniques can provide valuable information when selecting the most appropriate descriptors to retain for a final descriptive profile. Descriptors can be checked for their discriminant ability without having to train the assessors specifically for them and without having to develop standards (references) before knowing whether they would be discriminant or not.

Generally speaking and based on the results obtained in the present paper, CATA performed better than FCP in terms of the descriptive ability and slightly better regarding the discriminant capacity. According to the RV coefficients, both methods provided similar product location in the multidimensional space. This coefficient was significantly different from zero for all the sensory modalities except for odor and texture (Table 5). However, noticeable differences were observed in product description (Figs. 1–4). These differences could be explained by the type of data obtained in the different methods previously discussed in this article (absence/presence in CATA vs. scoring in FCP) or by the nature of the mental process involved in both methods.

One the main limitation of the present study is the lack of a descriptive profile performed with a consensual method to compare with both CATA and FCP. This consensual profile would allow the assessment of the real improvement derived from these two techniques. In addition, the use of different number of fish species in both methods might have had a contextual influence on the results shown. In any case, this contextual effect cannot be estimated in this study and could have been partially blocked by the high training and descriptive experience of the assessors involved.

ACKNOWLEDGMENTS

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration (KBBE-2013-07 single stage, GA 603121, DIVERSIFY).

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