Sensorial characterization and consumer preference analysis of smoked mackerel *(Scomber japonicus)* fillets

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Abstract

The aim of this work was to develop a list of descriptors to evaluate smoked mackerel fillets combining brine salting with cold smoking at 22 or 28ºC by the conventional sensory profile method and to analyze their consumer acceptance. The samples were investigated by eight descriptive panelists for aroma and flavor attributes before further evaluated by sixty-five consumers for acceptance levels. The trained panel was efficient since judges managed to point out the differences between products, indicating a consensual and discriminative panel performance. Samples treated at 28ºC were scored higher in aroma descriptors than at 22ºC, while these last ones showed high values in flavor descriptors. Consistent with the descriptive panel, the evaluation by the consumers showed the smoked mackerel samples were comparable to the commercial liquid smoke salmon being no significant difference (p>0.05) found in acceptability scores. The sample smoked at 22ºC was the favorite according to the preference consumer test. The results obtained in the present study were highly positive and encouraging that both developed products were accepted by the consumer and had higher preference or equivalent to the one commercial product.

Introduction

Smoking is a traditional processing technology of meat and fish products, belonging to the oldest systems in food processing, storage and consumption and being nowadays considered as current technology. The principal preservation mechanisms of smoking include lower water activity levels (drying) and the antimicrobial and antioxidant effects of the smoke components (Suñén, 1998; Kjällstrand and Petersson, 2001; Muratore *et al.*, 2007). Since the advances in packaging technology and storage, smoking is used primarily for its sensory advantages (taste and colour), in minimally processed products with lower salt content to satisfy consumer taste.

Furthermore, smoking has become a feasible alternative to develop high value-added fishery products. Atlantic salmon is one of the fish species most commonly used in smoking (Rørå *et al.*, 1998; Løje, 2007). There is an extensive body of scientific literature dealing with the physicochemical, microbiological, biochemical and sensory quality of cold-smoked Atlantic salmon (Cardinal *et al.*, 2001; Espe *et al.*, 2001; Birkeland *et al.*, 2004; Gallart-Jornet *et al.*, 2007 ; Løje, 2007; Martinez *et al.*, 2007;

Martinez *et al.*, 2012). Also the Atlantic salmon is traditionally eaten as a smoked fish product there are other fish species that can be subjected to the smoking process. In order to explore the potential of underutilized fish species as added value products, studies have been conducted with satisfactory results on alternative species such as rainbow trout, sea bass (Fuentes *et al.*, 2010), mackerel (Goulas and Kontominas, 2005), whiting and sardine (Gómez-Guillén *et al.*, 2009), herring (Cardinal *et al.*, 2006) and swordfish (Muratore and Licciardello, 2005). These studies have in common a physicochemical and microbiological characterization of the developed fish products with the application of simple sensory tests. Improving the sensorial characteristics of the products with more complex sensorial test should be an industry goal since it contributes to assure product acceptance in the market (Watts *et al.*, 1992; Coggins, 2012). The sensorial complexity that the smoking process confers to the product makes the sensorial topic less studied. There are few papers that analyzed the sensorial characteristic of smoked fish products with the appropriate descriptors not only with a trained panel but also with a consumer test (Cardinal, *et al.*, 2004; Fuentes *et al.*, 2010).

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This work is focused on a common fish specie in different countries around the world and popular in Argentina which is the mackerel *(Scomber japonicus)*, presented principally in the Latin-American market as a canned product (Casales *et al*., 1991; Checmarev *et al*., 2013). The mackerel flesh is considered as one of high nutritional level, due to their protein content and polyunsaturated fatty acids, being also rich in vitamins and minerals (Perrota *et al*., 2001).

Also, the smoking technology results an alternative process to increase mackerel market, as well as diversify the fish consumption. Knowing the sensorial characteristics of this product as the consumer acceptance will promote a new tool for the fishery commercial sector. Therefore, the objective of this study was to develop an aroma and flavor profile for mackerel fillets smoked a 22 and 28ºC and to analyzed consumer acceptability of this products.

Materials and Methods

Samples

Different kinds of samples were used according with sensorial test stages:

Samples used for selection of descriptors and sensory training

The samples to achieve these goals were purchased in the local market. The samples were the following: Atlantic salmon *(Salmo salar)* cold-smoked, canned and smoked with liquid smoke, smoked rainbow trout *(Oncorhynchus mykiss),* smoked herring *(Clupea harengus)* fillets, smoked anchovy *(Engraulis anchoita)* fillets.

Samples used to determine the judges performance and consumer acceptance

Samples of cold smoked mackerel fillets were processed to determine the judge performance and consumer acceptance. After brine stage, samples were smoked at 22 and 28ºC in a local fish factory with traditional methodology. Brine salting technique was done with a solution prepared with a mixture of salt and sucrose: 250 g/ l and 30 g/l, respectively, in which the fillets were placed (ratio 1: 4). After one hour, the fillets were removed, rinsed and stored overnight (12 h) in a cold room at 2°C until smoking. A traditional cold-smoking process was carried out at two different temperatures in accordance with industrial practices based on different fish products (Knockaert, 1990).

The smoking process began with a drying step in the smoking oven (Kerres smokehouse, H-1950/1 model) for 2.5 h, followed by a smoking step also during 2.5 h. The relative hygrometry of 65% ± 3% and air speed of 2 ms^{-1} above the products were used during all process. These procedures were done at 22 and 28ºC. For the consumer acceptance analysis, three samples of smoked fish were prepared to taste: fillets of smoked mackerel at 22 and 28ºC aforementioned and fillets of liquid smoked salmon *(Salmo salar)* purchased in the local market.

Descriptive analysis of aroma and flavor

The aroma and flavor profile was developed by a trained panel consisting of eight judges (two males and six females) with large experience in fish products sensory evaluation. The panel did six training sessions of one hour each, using the samples described before in order to adequate its experience in fish products to the fish smoked mackerel fillet. The aim of these training sessions was to obtain common sensory terminology that describes the aroma and flavor of smoked fish products. For this, the panelists were induced to individually generate a list of terms that describe these characteristics.

After group discussion, a consensus was reached and eleven descriptors with their respective definitions were selected. Panelists were familiarized with the evaluation techniques and how to rate intensity of the sensory attributes using 100-mm unstructured line scales.

This was followed by the formal test of the smoked mackerel samples. Two test sessions were done in individual boxes, in order to analyze samples of mackerel smoked at 22 and 28ºC by duplicate. Panelists received samples placed in individual expanded polystyrene containers coded with three digit random numbers, per session. Samples of 40 g of each product were necessary at each session day to evaluate all the descriptors and they were presented at 12-15°C. Judges received the containers one by one. They were instructed to open the pots and score the aroma and then take a bite of the samples and score the flavor. To reduce carry-over effect, panelists were instructed to cleanse their palates with mineral water or table water cracker between samples and also wait 2-3 min between each one (Lawless and Heymann, 2010) . Judges were request to evaluate the intensity of each attribute by assigning a score between 0 (absence of the sensation) and ten (extremely intense).

Consumer testing

Samples of mackerel fillets brined and smoked at 22 and 28ºC were also used for the consumer test. A total of sixty-five untrained consumers were asked to participate among the students and staff at Universidad de la Fraternidad de Agrupaciones Santo

Tomás de Aquino (FASTA). The possible panelists eat fish products often and they were notified about the product that they had to taste. Then, consumers did the sensorial evaluation knowing about the products that they had to evaluate. All participants were between 18 and 50 years old. The recruited sample of consumers consisted of 53% female and 47% male with an age between 18 and 50 years old. Inclusion criteria allowed reducing sources of variation, obtaining results which provided truly information about the acceptance of the developed products (Costell *et al.*, 1992).

To determine how well a new product is liked by consumers, the mackerel samples were tested with a commercial product (Pedrero and Pangborn, 1989). Fillets of liquid smoked salmon were used, as the third sample, in this analysis as the commercial product due to its availability in market. Each consumer received simultaneously for evaluation the smoked salmon with two samples of smoked mackerel at 22ºC and 28ºC. Sample of approximately 10 g were placed on white bread and inside a transparent small container. Each untrained panelist received the samples with a glass of water for palate cleansing purposes between sample tasting. Each sample was coded with three digit random numbers. Consumers were also presented with a simple questionnaire and instructions on proper filling.

For the overall liking analysis rated of the products a seven-point hedonic scale was used, (1= dislike extremely, 4 = neither like nor dislike, 7= like extremely) (Stone and Sidel, 1993). The just-about-right (JAR) scale was also used, according to Rothman and Parker (2009) in order to obtain the level of specific sensory descriptors in a product in relation to the ideal product for consumers. A five-point structured scale was used, in which, (5) - represented the intensity of the sensorial descriptor as much stronger than the ideal; (3) – ideal and (1) - represented the intensity of the sensorial descriptor as less strong than the ideal. Finally, the consumers were requested to rank the samples according to their preference.

Data analysis

Panel performance

To evaluate the performance of the trained panel, the following model was used where "Descriptor Score" represents the mean for each parameter which has been used to describe the products:

The parameters "Panelist" and "Sample x Panelist" interaction were considered as random effects while "Sample" and "Session" as fixed effects

(Martin *et al.*, 2000; Pagès and Husson, 2001). After the training sessions, the judges carried out the aroma and flavor profile of the two samples of mackerel smoked fillets according to the methodology previously explained. Obtained data were analyzed by Analysis of Variance (ANOVA) with three factor and interaction effects. The significance of these effects was tested with Fisher test (α=0.05). The results were used to compare the performance of the assessors in relation with reproducibility (FSession) and level of use of the whole scales (FPanelists), discriminate power of attributes (FSample) and panel consonance (FProductxPanelist).

The data processing was done using the R statistical software (Version 2.10.1, R Development Core Team, 2010), using the «panelperf» function of the package SensoMineR.

Consumer tests analysis

Based on the results of the test with overall liking and just-about-right scale frequency histograms were constructed. Individual differences between rank sums of Simple Ranking tests were determined by the nonparametric analogue to Fisher's least significant difference. Data analysis was conducted using R statistical software (Version 2.10.1,R Development Core Team, 2010) and Microsoft excel 2003 (Microsoft Corp., USA).

Results and Discussion

Aroma and flavor descriptive analysis

Table 1 showed the list of sensorial descriptors that best express the flavor and aroma characteristics of smoked fish products, according to the trained panelists. The panel first arose to an initial list of twenty descriptors that was reduced to a final eleven descriptors after removing the terms with similar meaning and taking into account those who allow discriminating the samples according to the objective of this study.

After the training sessions, the judges carried out the aroma and flavor profile of the two samples of mackerel smoked fillets according to the methodology previously explained. Obtained data at both samples and for each descriptor were subjected to model presented before and analyzed with ANOVA. Table 2 summarizes, for each descriptor, the results of the analysis of variance in which panelists, samples, session and the interaction were considered as factors.

This table showed the analysis results and enables to determine the whole panel performance on all the descriptors. In order to do it, tests on several effects (main effects and interaction) were performed.

Table 1. Sensory attributes and definitions for the evaluation of smoked mackerel

Sensory attributes		Description
	Global intesity	Intensity of aroma before eating the product
	Smoke level	Characteristic odour of smoked meat products
Aroma	Wood fire	Defined as the odour of a wood fire
	Raw fish	Characteristic aroma of the corresponding fish
	Strange	Presence/intensity of foreign aromatics for this specific product
	Global intesity	Product flavor intensity in mouth
	Smoke level	Characteristic taste of smoked meat product
	Salt level	Intensity of salt taste.
Flavor	Sweet level	Intensity of sweet taste.
	Raw fish	Characteristic taste of the corresponding fish
	Strange	Presence/intensity of foreign taste for this specific product

Table 2. Global panel performance: P-values of the ANOVA model for all the descriptors for principal effects and interaction

Descriptor	Sample	Panelist	Session	Sample x Panelist
Aroma, global intensity	2,81E-18	0,835	0,126	9,04E-10
Smoke level	7,06E-19	0,620	0,910	0,0561
Wood fire	3,98E-18	0,977	0,605	0,120
Strange	0,377	0,213	0,295	0,357
Raw Mackerel	0,908	0,131	0,670	0,001
Flavor, global intensity	3,18E-19	0,349	0,712	0,002
Smoke level	3,67E-29	0,319	0,558	3,69E-07
Salt level	0,0178	0,233	0,395	0,171
Sweet level	0,0262	0,984	0,304	0,050
Strange	0,046	0,451	0,258	0,053
Raw Mackerel	0,415	0,018	0,388	5,59E-07

According to the p-values obtained for the Sample effect, most of the descriptors were effective to discriminate between samples since their p-values were under 0.05, so products have different sensory perceptions. Sorted the descriptors by their p-values from the smallest to the biggest, the descriptors for Aroma: global intense, smoke level, wood fire and for Flavor: global intense and smoke level, were the most discriminating parameter ($p < 0.05$) and Aroma and Flavor: strange and like raw mackerel were the least ones. Cardinal *et al*. (2004) used the similar discriminate parameters, among others, to characterize samples of commercial European smoked salmon from different brands and country of origin.

The panelist effect was not significant for most of the descriptors (p-value above 0.05), being only significant for the flavor like raw material (p=0.018) descriptor. In order to detect differences between the mean values expressed by each judge for this descriptor, a Tukey test ($p < 0.05$) was performed. According to the results, 60% of the panelists scored between 1 and 3 while the remaining percentage scored between 3 and 5. These results indicate that although the panelists had training sessions, they did not use the scale in the same way for this descriptor. It could be result of a generally better understanding and work experience with others kind of fish products. The remaining descriptors presented p-values above 0.05. This indicates that the panel was consensual at using the scales of intensity (Martin *et al*., 2000; Husson and Pagès, 2003).

Since the session effect was not significant (p> 0.05) in all the descriptors, this implies that from one session to another each product was assessed in the same way and that the panel resulted reproducible inter-session (Latreille *et al*., 2006; Nogueira-Terrones *et al*., 2006.). The consonance of the panel could be analyzed by the p-values of the interaction Sample x Panelist. If the interaction is significant, it would mean that there was no total consensus among the panel to evaluate each product. In the present research, the highest p-value for interaction Sample x Panelist were for the Aroma smoke and strange and salt flavor level, with their respective p-values 0.0561, 0.357 and 0.171, indicating consensus of the panel in grades for these assessment parameters. While the significant differences ($p < 0.05$) in the classification of smoked mackerel samples were found for attributes as Aroma global intensity, like raw mackerel, Flavor global intensity, smoke level and like raw mackerel flavor. This same significant effect ($p < 0.05$) was observed by Pagès *et al*. (2007), in 9 of 16 sensory attributes for the evaluation of biscuits by two trained panels from different nationalities and by Carbonell *et al*. (2002) in 4 of 11 descriptors for the evaluation of samples of cooked gilthead sea bream *(Sparus aurata)*.

In order to study the panel reproducibility, the coefficients of the interaction Sample x Panelist was considered for both products with each panelist. For the descriptor Aroma global intensity with the lowest p-value (9.04E-10), the coefficients of the interaction Sample x Panelist was calculated in the following way: for each product, the mean grade given by all the judges, all the sessions taken together, was considered as the expected grade for a product. The difference between this expected grade and the one given by a concrete judge, both sessions also taken together, was represented by the interaction Sample x Panelist coefficient. According to these estimations, the judges scored the samples close to the mean value, being the panelists 2 and 4 the closest to the mean to score (± 0.125) both samples in this descriptor. This
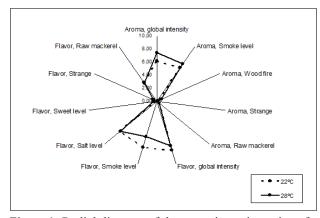
Figure 1. Radial diagram of the mean intensity ratings for the sensory attributes of the formulated smoked mackerel fillets samples

* Each spoke of the diagram represents an individual sensory attribute. The intensity scales each go from lower values at the center point to higher values at the outer end of the spoke. The intensity of an attribute in a specific product is represented by the point on the spoke at which the connecting line for that product crosses

means that although there was no exact consensus on the score, the panel scored around the average value without exceeding the difference of one unit from the mean (Kermit and Lengard, 2005; Le and Husson, 2008).

With respect to all the analysis previously done, the trained panel was efficient at obtaining differences between both samples. Indeed, the Sample effect was significant for most of the sensory parameters, thus ensuring that the judges could find differences between the samples analyzed. The panel agreed on the discrimination of samples by six major descriptors, overall intensity of aroma, smoky, toasty, overall flavor intensity and smoky. Session was not significant ($p<0.05$) in all the descriptors, then the panel scored each sample in the same way in both sessions.

The average values of each descriptor are presented as a radial diagram in Figure 1, as the aroma and flavor profile of smoked mackerel fillets treated at 22 and 28ºC. According to the average values for each descriptor (Figure 1), the samples smoked at 28°C showed higher scores in parameters related to overall aroma and smoke intensity. Results were in concordance with those found by Cardinal *et al.* (2001) for smoked salmon fillets at 20 and 30ºC and by Sérot *et al.* (2004) in their studies over samples of herring smoked at different temperatures. According to Cardinal *et al.* (2001) and Sérot *et al.* (2004) the oven temperature increase affects fish muscle lipid fluidity, increasing the diffusion of odorant compounds over the fish surface.

The samples smoked at 22°C, showed higher

scores ($p<0.05$) in flavor descriptors: overall intensity and smoke level. Similar results were obtained by Chan *et al.* (1975) in their studies analyzing different variables of smoking process (temperature, relative humidity and air velocity) on the smoke components diffusion in mackerel tissue. The samples moisture content acts as a carrier to spread smoke components inside the muscle (Möhler, 1980). Thus, the samples treated at lower temperature resulted in a lesser dried and therefore a higher absorption of the smoke components than the ones process at higher temperature.

Consumer testing

Mean consumer ratings of overall acceptability are presented in Figure 2. All samples showed a unimodal distribution with the score 6 (quite like) as the modal value. Smoked mackerel samples were well accepted among consumers, since their scores on the assessment of the overall acceptability were mostly 5, 6 and 7 (I like slightly, I quite like and I like a lot).The cumulative percentage of scores greater than 4 points were 68%, 65% and 57% for the mackerel samples treated at 22 and 28ºC and for the commercial product, respectively. The currently marketed product was the least acceptable, while the product developed under a treatment at 22ºC was the most acceptable for consumers. All the samples resulted acceptable for the consumers, since there was not significant difference (p=0.1587) between the mean scores.
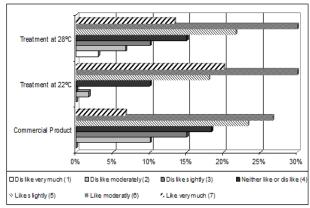

Figure 2. Overall acceptability of the three samples studied

Six descriptors were used to assess overall acceptability. Data from the JAR scales provide an idea of how the panelists accepted the samples according to their ideal or preferred product (Gacula *et al.*, 2007; Villegas *et al.*, 2010). If only the JAR rating is analyzed (Figure 3), it can be seen that the samples from smoked mackerel presented higher percentage of consumers with score descriptors as its ideal level. Comparing both samples of mackerel, the
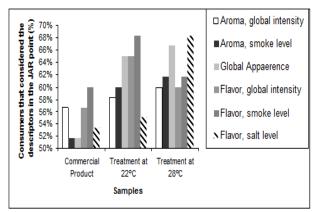
Figure 3. Smoked fish samples evaluated against percentage of consumers who consider descriptors as JAR

product at 28°C showed higher percentages in aroma intensity, smoke intensity, salty flavor and overall appearance than the product treated at 22°C. These results are in accordance with those related to the aroma and flavor profile obtained by the trained panel, since the average score given in the profile could fit with the JAR point considered by consumers.

The commercial product, salmon with liquid smoke, resulted with lower percentages of consumers who considered descriptors in the just right point than those obtained for samples of mackerel. About preference ranking, according to the obtained results the sample treated at 22°C was the most preferred by consumers, with a 48% of the population who considered this product as the favorite. From the multiple comparison test (F-value=7.95), the sample of smoked mackerel at 28°C and the sample of liquid smoked salmon resulted with an equal preference level in a second place with respect to the sample treated at 22°C.

Conclusion

The trained panel established a consensual vocabulary to describe the aroma and flavor of smoked mackerel fillets. The developed aroma and flavor descriptors were accurate to characterize and differentiate the sensorial profile of the studied samples. In terms of panel performance, the trained panel was consensual and discriminative according to the statistical analysis done. Samples treated at 28°C presented higher scores in descriptors related with aroma while with a treatment at 22°C the flavor descriptors were higher scored.

The mackerel samples developed in this work received a good acceptability from consumers. From this point of view, the results obtained in the present study were highly positive and encouraging, since the smoked product at 22°C was placed as first in the preference order followed by the smoked at 28°C

with the commercial product with equal preference results. About the JAR scales study, the commercial product resulted with lower percentages of consumers who considered descriptors in the just right point than the ones obtained for mackerel samples. Both developed products were well accepted by consumers and had higher preference or equivalent to the one commercial product.

Acknowledgements

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