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Relationships between odorant characteristics and the most odorant volatile compounds of salmon smoked by four industrial smoking techniques

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Summary

Salmon fillets were smoked by four different smoke generation processes: smouldering, thermostated plates, friction and liquid smoke. The effects of three times of smoke exposure (1, 2 or 3 hours) and two smokehouse temperatures (22°C and 32°C) on smoked salmon flavour were evaluated. Smoked salmon fillets were submitted to sensory analysis and the concentration of odorant volatile compounds were investigated from aromatic extracts of smoked salmon by gas chromatography coupled to mass spectrometry and olfactometry (GC-MS/O). Analyses of variance (ANOVA) were performed on the sensory and analytical data in order to study the effects of smoking parameters. Secondly, Partial Least Squares regression analysis have allowed to relate the sensory attributes of the different smoked salmons to their composition in odorant volatile compounds. Liquid smoke atomisation smoking process led to products described by “cold smoke” and “vegetal” caused by lipid oxidation products, pyridine derivatives, alkyl aryl ethers and several phenolic compounds such as syringol or p-cresol. The other smoked salmons were characterised by “salmon-like” attributes for a short time of process until “wood fire smoke” attributes. This odorant evolution is due to the increase of the deposition of phenolic and furannic compounds with increases of smoking parameters (time of smoke exposure and smokehouse temperature).

Keywords : smoked salmon ; sensory analysis ; olfactometry ; Partial Least Squares ; Flash table.

1. Introduction

In the traditional technique of smoking to preserve fish, smoke compounds are of considerable importance for the preservation and organoleptic properties of smoke products. The control and improvement of smoked fish flavour is one of the challenges of processor who want to adapt their products to consumers demand. Previous works clearly indicated that the process affect the smoke compounds content of herring fillets [1]. However, some studies have already highlighted the difficulties to establish correlation between flavour characteristic of herring fillets and their phenolic compounds content [2]. Recent works allow us to elucidate, by using GC-MS/O, the main odorant compounds in smoked salmon flesh [3]. However, establishment of correlation between odour characteristics of the odorant compounds individually perceived by judges during GC-O and overall flavour attributes of product determined by sensory analysis is not so easy [4]. Therefore, it seems necessary to develop methodology allowing to determine the real contribution of the concentrations of odorant volatile compounds in the overall odour composition of a product.
In this study we assess the possibility by means of PLS regression to explain the data of sensory analysis performed on smoked salmon and data of GC-MS/O of volatile extract obtained by SDE. In this work the relationships between sensory attributes, odorant volatile compounds contents of smoked salmon and several smoking parameters as smoking generation technique, time of smoke exposure and smokehouse temperature

have been studied but only the works on the relationships between sensory attributes evolutions and concentrations of odorant volatile compounds are presented here.

2. Material and methods

Raw material and reagents, smoking procedures, isolation of volatiles and GC-MS analysis were previously described [5,6].

Gas chromatography-Olfactometry methods
The panel was composed of eight judges (6 females and 2 males) all previously trained in odour recognition and sensory evaluation techniques and had experience in gas chromatography / olfactometry on seafood products. Thus, two olfactometric methods were used: frequency of detection (FD) and time intensity (TI). Only the volatile compounds detected by at least six judges in at least one of the four types of smoked salmons according to FD method were selected and quantified. Thirty six odorant volatile compounds were then selected.

Sensory analysis

A descriptive test with conventional profiling was carried out to evaluate the sensory characteristics of smoked salmon. Samples were scored by twenty panellists trained on sensory descriptors for smoked salmon. The attributes related to the odour (o) and flavour (f) of smoked salmon slices: global intensity (glo), wood fire smoke (wf), cold smoke (cs), butter (but), vegetal (veg), raw salmon-like (salm) and herring-like (her). Sessions were performed in individual partitioned booths equipped with a computerised system (Fizz system, Biosystèmes, Dijon). Panellists rated the sensory attributes on a continuous scale, from low intensity (0) to high intensity (10). An experimental design was built in order to balance the process parameters (kind of smoke generation, smoking and time temperature) associated to the products presented within a session. Four products, assigned 3-digit numbers, randomised for the order of presentation were simultaneously presented at each session. Six sessions were necessary to test all the products. Assessors received, packed in aluminium foil, a smoked salmon slice of 2 cm large taken from the front part of the fillet previously thawed one night at +2°C.

Statistical treatment

The relationships between the smoking parameters (smoking technique, time of smoke exposure and smokehouse temperature) and firstly, the sensory attributes and secondly, concentrations of odorant volatile compounds were performed by Multiple factor Analysis of variance (ANOVA). ANOVA analyses were performed using Statgraphics Plus 5.1 software (Sigma Plus, Paris, France). Analysis of the relationships between the concentrations of odorant volatile compounds and the scores rated by the judges for each sensory attributes was performed by means of PLS2. PLS analysis was performed using Unscrambler Windows version 9.1 (Camo A/S, Trondheim, Norway).

3. Results and Discussion

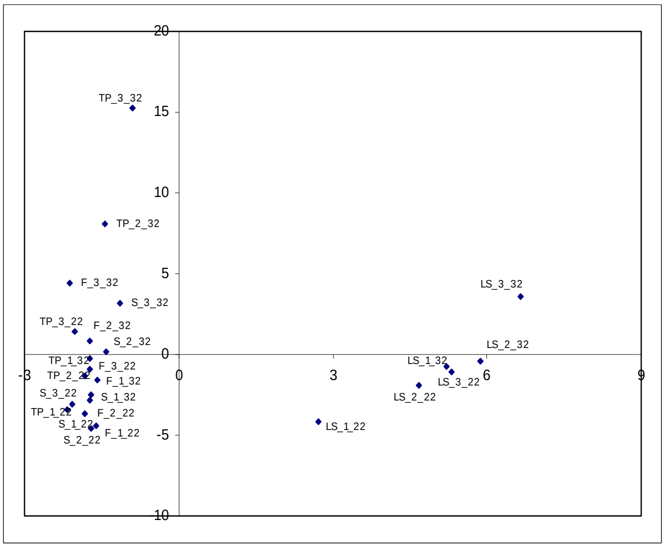

Figure 1. Score plots of the PLS analysis (S : Smouldering, TP : Thermostated Plates, F : Friction and LS : Liquid Smoke ; 1, 2, 3 are the times of smoke exposure applied ; 22 and 32 are the smokehouse temperatures applied.)

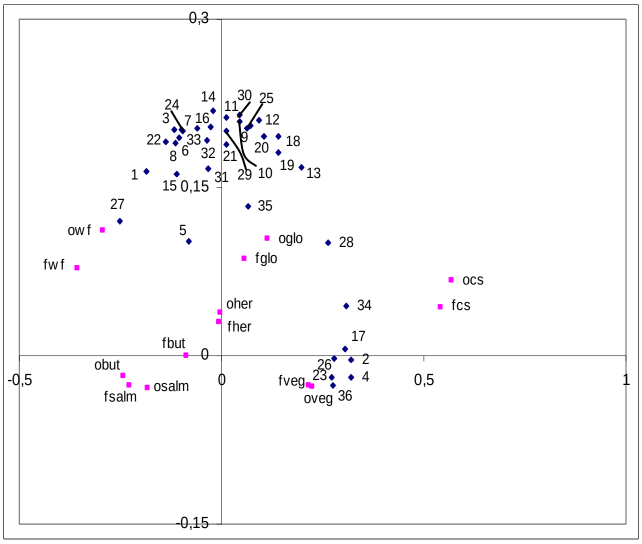

Figure 2. Loading plots of the PLS analysis

The scores of the PLS analysis are described in Figure 1 and Figure 2 shows the loading plots of the sensory and the odorant volatile compounds variables for the two dimensions of the PLS2 analysis. The first PLS-component explained 26 % of the odorant volatile compounds concentrations (X-block variables) and 79 % of the sensory attributes (Y-block variables). The second PLS-component explained 56 % of the X-block variables and 7 % of the Y-block variables.
The first PLS-component allows to discriminate the product treated by liquid smoke atomisation of the products smoked by traditional processes using wood pyrolysis. Moreover, in the case of liquid smoke, this component is also useful to illustrate the effect of the other smoking parameters. The second PLS-component allows to discriminate the products according to the intensity of the smoking process;
The loading plots (Figure 2) show that the "vegetal" odour and flavour attributes of smoked salmon could be explained by high contents of (E)-2-decenal (23) and (E,E)-2,4-decadienal (26) which are produced during lipid oxidation and also to, the pyridine derivatives (2,4) and 8-heptadecene. These characteristics correspond to products treated by liquid smoke at low settings of smoking parameters (Figure 1). The perception of "cold smoke" odour and flavour attributes could be explained by increase of syringol (28) and corresponds to products treated by liquid smoke during high time and temperature.
It can be noticed in Figure 2 that the intensity of global odour and flavour and perception of "wood fire smoke" sensory attributes can be related to high contents of the majority of the other odorant volatile compounds especially of 4-vinylguaiacol (27) and furannic compounds such as furfural (1), furfuryl alcohol (3), 2-acetylfuran (7) and 5-methylfurfural (8). High contents of phenolic compounds which are the main odorant volatile compounds of smoked salmon aroma are correlated with "global" and "wood fire smoke" sensory attributes. Whereas the perception of "butter", "salmon-like" and "herring-like" sensory attributes characteristic of salmon fillets smoked during short times and at low temperature seems to be strongly negatively correlated to high contents of odorant volatile compounds. These results can be explained by an increase of smoke compounds deposition with increase of time of smoke exposure and smokehouse temperature. These compounds responsible of woodfire smoke sensory perception should gradually mask the initial odor of smoke salmon in relation with evolution of smoking parameters. It can also be noted that products smoked by using thermostated plates process are strongly characterised by wood fire attributes and high contents of phenolic and furannic compounds and enolones derivatives. This result can be explained by the high wood pyrolysis temperature used for this process, (500°C vs 380°C for friction and 450°C for smouldering).
Our results show also the excellent correlation between the perception of flavor and perception of odour. The same compounds are probably responsible of orthonasal and retronasal perception of smoke.

4. Conclusion

This data treatment has allowed to explain the relationships between the sensory attributes and the concentrations of odorant volatile compounds in the different samples of smoked salmon. The results of this study confirm the importance of phenolic and furannic compounds in smoked salmon aroma, particularly for "wood fire smoke" odour and flavour in products smoked by thermostated plates, friction or smouldering. Deposited in increasing quantities, the aroma of smoked salmons evolves from "salmon-like", "herring-like" to "wood fire smoke". Pyridine derivatives and lipid oxidation products are responsible for the « vegetal » odour and syringol and cresols are implied in the "cold smoke" sensory attributes of the products treated by liquid smoke. However, the results concerning the products treated by liquid smoke correspond to only one type of smoke condensates. More investigation with other smoke flavourings must be carried out in order to validate our conclusions. This kind of statistical treatment should be more often used to invest the relationships that link the overall odour of a matrix assessed by sensory analysis and its composition in odorant volatile compounds assessed by olfactometry in order to understand the interactions of the odour-active compounds between themselves, with the matrix, and how they contribute to the overall odour. More investigation on hedonic analyses should be carried out in order to identify the favourite sensory attributes of the consumer. The study of consumer preferences for different kind of products, associated to the identification of the odor-active molecules could allow smoked salmon manufacturers to orientate the final overall odorant composition by acting on the parameters of smoking implied in the generation of required odorant volatile compounds. However, it is important to carry out in parallel a sanitary study because modifications of smoking parameters can cause variations in smoking contaminants contents and can affect the growth of microorganisms because a lot of volatile compounds of wood smoke have antimicrobial effects.

References

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