Sensory quality in relation to Maillard reaction products and other volatiles in fried beef patties

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Background

The Maillard reaction is an important reaction in many food industry processes, including the heat processing of meat. During the early stages of the reaction, amino acids combine with sugars, forming e.g. flavour compounds. Any given combination of process parameters, e.g. temperature, time and composition, may produce a unique aroma profile in the product (e.g. Reineccius, 1990). Knowledge of the relation of sensory characteristics and volatile Maillard reaction products (MRPs) in cooked meat products is scarce (Reineccius, 1990). In order to optimise flavour formation in meat products, knowledge of the relation of sensory quality, the formation of volatiles and the interaction between these is needed. The purpose of this study was to correlate sensory and chemical data in fried beef patties.

Objective

To relate sensory quality to Maillard reaction products and other volatiles in fried beef patties.

Methods

Beef patties were fried at 120, 150, 180, 220, 250, 290 and 320°C to a centre temperature of 80°C using a thermostatically controlled frying device. Sensory profiling was performed using an expert panel consisting of 19 panellists. The intensity of the following parameters was judged on an unstructured scale from 1 to 9 (1=no or very little; 9=very much) using a random design: aroma intensity, boiled aroma, fried aroma, burned aroma, fat aroma, aroma of petrol/exhaust, aroma of charcoal, meat flavour intensity, boiled flavour, fried flavour, burned flavour, acidity, bitter flavour, grilled flavour, off-flavour and overall acceptance.

For the headspace sampling of volatile compounds, 50 g of homogenised beef crust was equilibrated for 16 hours at 25°C. Volatiles were absorbed on a Tenax trap (Tenax TA, 60-80 mesh) with helium. GC/MS analysis was performed on a GC8000 gas chromatograph (Fisons, Fisons Nordic AB) connected to a Trio-1000 mass spectrometer (VG Masslab, Fisons Nordic AB). The chromatographic conditions were: an HP-1701 capillary column, 0.25 mm x 30 m, film thickness 1µm; oven temperature 35°C for 2 min, 35 to 200°C with a slope of 3°C/min, 200 to 250°C with a slope of 30°C/min, and finally 250°C for 5 min. Electron impact mass spectra were recorded with an ionisation energy of 70eV. The volatile compounds were tentatively identified from a library search (NIST/NBS).

The statistical evaluation was performed using multivariate data analysis (PLS1, PLS2) and The Unscrambler (version 6.11, Camo ASA, Trondheim, Norway). ANOVA and Tukeys´ test were performed using SYSTAT (Wilkinson, Leland, version 5.03).

Results and discussion

Sensory quality of fried beef patties: Frying temperature significantly ($p<0.05$) affected the intensity of most of the sensory attributes (i.e. aroma intensity, boiled aroma, fried aroma, burned aroma, aroma of petrol/exhaust, aroma of charcoal, boiled flavour, fried flavour, burned flavour, bitter flavour and overall acceptance) in fried beef patties, according to ANOVA, when temperature was a category variable. The influence of frying temperature on some sensory qualities of fried beef patties is shown in Figure 1.

The PLS1 analysis (Partial Least Squares), using overall acceptance as the y-variable and all other sensory parameters as x-variables, showed the variation in the overall acceptance of the fried beef patties to be explained by one PC to 87 % and by two PCs to 100 % by the other sensory parameters. As seen in the loading plot (Figure 2a), where PC 1 is plotted against PC 2, meat flavour intensity and overall acceptance correlated positively. Acidity, aroma intensity, roasted aroma, burned aroma, burned flavour, aroma of charcoal, aroma of petrol/exhaust and bitter flavour were strongly correlated to each other and negatively correlated to meat flavour intensity and overall acceptance. Fried aroma and fried flavour belonged mainly to PC 2 and were negatively correlated to boiled aroma and boiled flavour. Beef patties fried at 120°C were characterised mainly by a boiled aroma and flavour (Figure 2b). Beef patties fried at 150 and 180°C were characterized by a high meat flavour intensity and high overall acceptance. Beef patties fried at 220°C were best described as having a fried aroma and flavour, whereas the samples fried at higher temperatures were characterised by roasted aroma, burned aroma and flavour, aroma of charcoal, aroma of petrol or exhaust, burned aroma and flavour, and bitter flavour.

Presence of volatiles in fried beef patties: Headspace was sampled at 25°C to avoid the formation of volatiles due to reheating the sample. 206 volatile compounds were detected in the headspace of fried meat samples using GC/MS. Of these, 133 compounds were identified. Among the identified compounds were common hydrocarbons and lipid oxidation products, together with pyrazines and furans. The number and relative amount of bases, especially pyrazines, increased with frying temperature.

Relationship of volatiles and sensory quality of fried beef patties: The relation of volatile MRPs and other volatiles in fried meat samples and their sensory attributes was evaluated using PLS2. In the model, all sensory parameters constituted y-variables and volatile compounds were x-variables. The degree of explanation of the y-variables was high for most of the parameters. High explanation of the model was seen for burned aroma (R^2=81 % for 1 PC, 94 % for 2 PC), aroma of petrol/exhaust (R^2=91 % for 1 PC), aroma of charcoal (R^2=82 % for 1 PC), burned flavour (R^2=90 % for 1 PC), bitter flavour (R^2=86 % for 1 PC), and grilled flavour (R^2=81 % for 1 PC). As shown in the loading plot (Figure 3a) most volatiles clustered in the centre of the plot. However, 2,6-dimetylpyrazine, 2-ethyl-5-methylpyrazine and 2-methylpyridine were located in the direction of burned flavour, burned aroma and bitter flavour, whereas 3-ethyl-2,5-dimethylpyrazine coincided with fried flavour, aroma intensity, grilled taste and aroma of charcoal. Meat flavour intensity, boiled aroma and boiled flavour correlated strongly with heptanal, pentanal and 3-hydroxy-2-butanone. A grouping of samples according to frying temperature is seen in the score plot (Figure 3b).

To our knowledge, this is the first study relating sensory attributes to MRPs and other volatiles in fried beef using multivariate data analysis. The results are in accordance with previous studies using aroma extract dilution analysis (e.g. Specht & Baltes, 1994).

Conclusions

Beef patties fried at lower temperatures were characterized by a boiled flavour and a meat flavour, whereas samples fried at higher temperatures were characterized by a fried flavour, an aroma of charcoal and a high aroma intensity, according to sensory profiling. At the highest frying temperatures, a bitter flavour and a burned flavour were predominant. 2,6-dimetylpyrazine, 2-ethyl-5-methylpyrazine and 2-methylpyridine were related to a burned aroma and flavour and a bitter flavour, whereas 3-ethyl-2,5-dimethylpyrazine was related to a fried flavour, an aroma intensity, a grilled taste and an aroma of charcoal, according to PLS2. Meat flavour intensity, boiled aroma and boiled flavour correlated strongly with heptanal, pentanal and 3-hydroxy-2-butanone.

Acknowledgement

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Reference

Reineccius, G.A. (1990) in *The Maillard Reaction in Food Processing, Human Nutrition and Physiology* (Finot, P.A. *et al.* eds.), pp.157-170, Birkhäuser Verlag.

Specht, K. & Baltes, W. (1994) J. Agric. Food Chem., 42, 2246-2253.

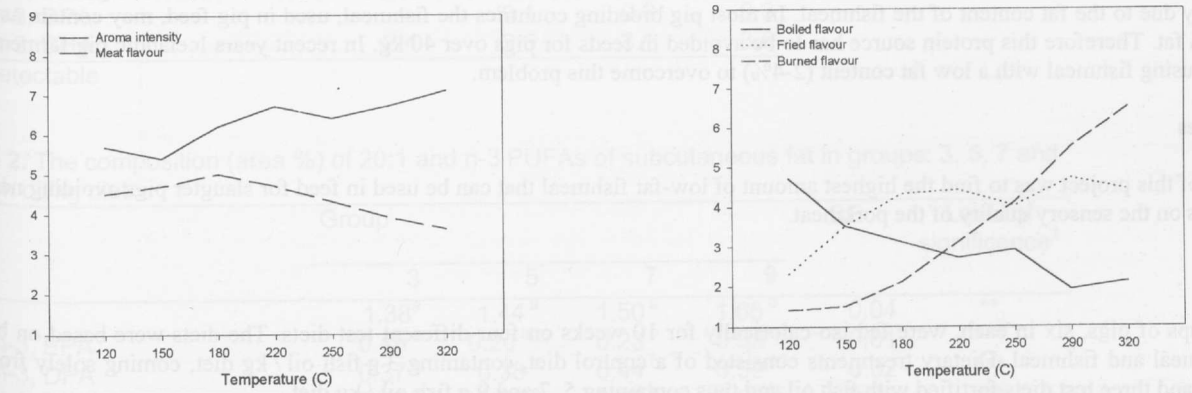

Figure 1. Sensory evaluation of aroma intensity and meat flavour (a) and boiled flavour, fried flavour and burned flavour (b) of beef patties fried to a centre temperature of 80°C using different frying temperatures (LS-means of scores from sensory profiling).

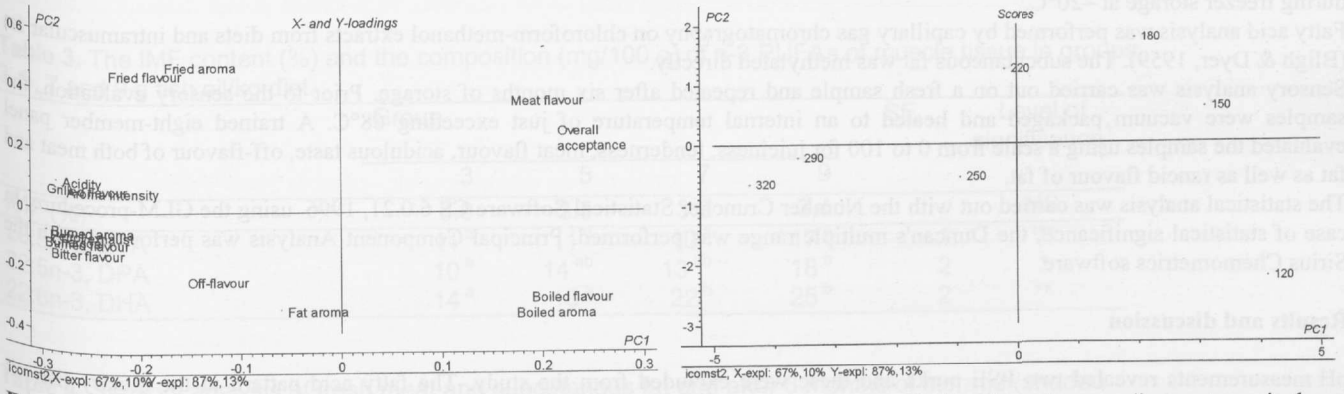

Figure 2. Loading (a) and score plot (b) for sensory parameters and samples according to PLS1, where the overall acceptance is the y-variable and all other sensory parameters are x-variables (R^2=87 % for 1 PC). Numbers in score plot indicate frying temperature.

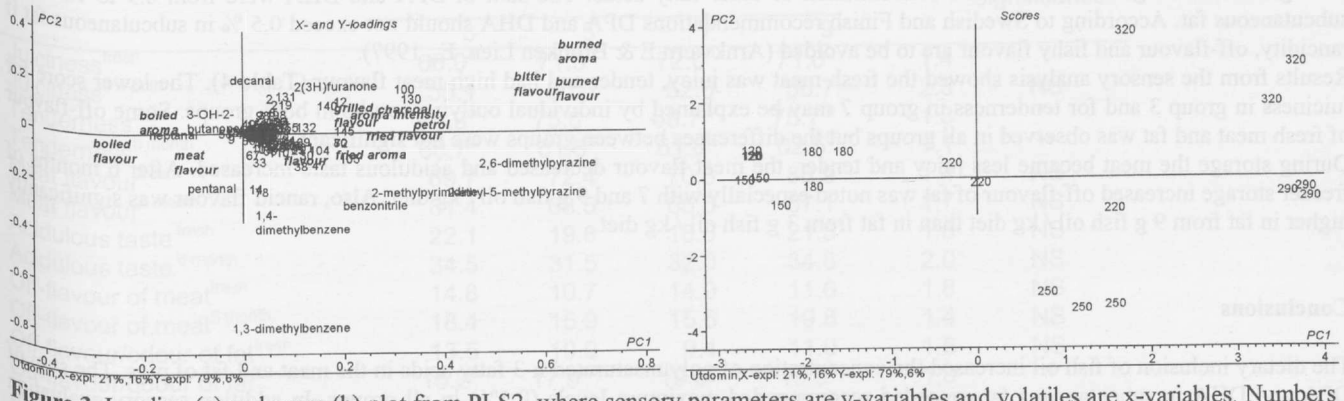

Figure 3. Loading (a) and score (b) plot from PLS2, where sensory parameters are y-variables and volatiles are x-variables. Numbers in loading plot indicate ID from GC/MS analysis; numbers in score plot indicate frying temperature.