PE8.21 Effect of Slicing and Storage on the Aroma Composition of Saveloy 205.00

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***Abstract*—The effect of commercial slicing, consumer simulated storage and temperature of initial storage on the composition of volatile organic compounds (VOC) in the headspace of saveloy was investigated using dynamic headspace extractions and GC-MS measurements. Both commercial slicing and temperature loads, for simulation of consumer storage, increased the level of 2- and 3-methylbuthanal. This indicates that these factors increase the microbial activity and decrease product shelf life. Initial storage of saveloy at 8ºC compared to 5ºC also increased the amount of 2- and 3-methylbuthanal and furthermore raised the level of dimethyldisulfide. This also indicates a decrease in eating quality. The results of this experiment suggest that the composition of VOC's from the headspace of saveloy can be used as an indicator of product shelf life.**

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***Index Terms*—Aroma composition, saveloy, storage conditions, shelf life, VOC.**

I. INTRODUCTION

Changes in the composition of VOC's in the headspace of meat products are related to changes in eating quality and therefore also to product sustainability [1, 2]. The aroma impression that reaches the consumer is a result of chemical and microbial induced reactions that occur in the time span from production to consumption. These reactions are influenced by a number of factors which are important for product shelf life.
In this paper it is investigated how some of these factors (time, temperature, temperature loads and package opening) influence the composition of VOC's present in the headspace of saveloy. Furthermore sausages sliced and packed under experimental conditions are compared with sausages which were sliced and packed in a commercial scale. The results of this paper will be first step towards identifying VOC's which can be used as chemical markers for product shelf life.

II. MATERIALS AND METHODS

A. Production and slicing

The saveloys were produced at the Danish Meat Research Institute (DMRI) and contained: 25% fat, 10% protein, 1% Collagen, 56% water plus spices and additives. The mixture was stuffed in sterile plastic casings and steam pasteurized at 80ºC for 50min, reaching a core temperature of 75ºC. After 10min cooling by water sprinkling, the products were kept at 2ºC overnight.
After one week the saveloys were cut in 2mm thick slices and sealed in packages of 100g in modified atmosphere (MA, 70% N_2, 30% CO_2). The sausages were sliced under experimental condition in DMRI's pilot plant and in a commercial production facility. The packages were placed in a chill cabinet, at temperatures and conditions as described below.

B. Treatments

Samples sliced under experimental (Exp) conditions were subject to 3 different treatments after 3 weeks of storage at 5ºC. Exp1: Stored 1 week at 5ºC, Exp2: The packages were opened allowing atmospheric air to enter, then reclosed with a lit and stored 1 week at 5ºC, Exp3: The packages were opened, then reclosed and stored 1 week with temperature loads in a repeated daily pattern shown to represent storage in a consumer situation (5ºC for 12.7h, 12ºC for 9.8h and 20ºC for 1.5h) [3]. Samples sliced in a commercial (Com) facility were subject to 2 treatments. Com1: Stored for 3 weeks at 5ºC, the opened and reclosed and stored 1 week with temperature loads, Com2: Stored for 3 weeks at 8ºC, then opened and reclosed and stored 1 week with temperature loads. The aroma analysis was performed 4 times during the experiment for all the different treatments: 3weeks, 3weeks+3days, 3weeks+5days and 3weeks+7days. For each combination of treatment and measure point a new package of saveloy was used. 3 repetitions of each measurement were made.

C. *Aroma extraction*

The aroma composition of the saveloys was measured by dynamic headspace using traps containing 73mg Tenax TA (60-80 MESH) and 100mg carbograph 1 TD (Llantrisant, UK). 25g of sample was chopped, placed in a closed system and conditioned in a water bath at 30ºC for 10min. The samples were then purged with a N_2-flow at 60mL/min for 15min. The N_2 flow passed the trap which retained the volatiles released from the sample. All traps were back purged with N_2 (20mL/min) for 5 min in order to remove water from the trap.

For each day of measurement a mixture of aroma standards corresponding to the compounds chosen for quantification were loaded on traps. The traps were loaded with different concentrations (20-500ppm) of the standards, and were used to generate a standard curve for quantification purposes.

D. *Desorption and GC-MS analysis*

The traps was thermally desorbed at 240ºC for 10min with a helium flow of 20ml/min using an ATD 400 automatic thermal desorption system (Perkin Elmer, Bucks, UK). The volatiles were cryofocused on the ATD-cold-trap at -30ºC, and subsequently desorbed from the cold-trap at 250ºC for 5min with a helium flow of 10mL/min and an outlet split ratio of 1:10. The temperature of the transfer line to the gas chromatograph was 200ºC.

Further analysis of the volatiles was preformed with GC-MS. The GC was equipped with a HP-INNOWax column (30 m x 0.25mm with 0.25µm film thickness, Agilent 19091N-133) and operated with following parameters: carrier gas, helium; column pressure, 7.6 psi; oven programme, 35 ºC for 5min, from 35ºC to 110ºC at 10ºC/min, from 110ºC to 260ºC at 20ºC/min and 260ºC for 10min. The MS was equipped with a quadrupole mass analyser (Agilent Technologies, Palo Alto, USA). The mass selective detector was operated in the electron impact mode with energy of 70eV and an emission current of 35µA. The MS scanned from 33m/z to 350m/z at a rate of 3scans/s, and simultaneously chosen m/z ratios and selected ions were collected in SIM-mode.

E. *Data analysis*

18 aroma compounds were selected for quantification based on results from previous experiments [4]. These compounds were: 2- and 3-methylbutanal, hexanal, heptanal, 2-pentylfuran, dimethyldisulfide, dimethyltrisulfide, α-pinene, camphene, β-phellandrene, 3-carene, α-phellandrene, β-myrcine, α-terpinen, limonene, β-phellandrene1, γ-terpinen and myrsticin. These compounds were quantified (in ng/25g of sample) using Chemstation version D.02.00.275 (Agilent Technologies, Palo Alto) for calculation of standard curves. 3-carene, limonene and α-pinene were the only terpenes included in the standard mixture. The remaining terpenes were quantified using standard curves from α-pinene or limonene. 2- and 3-methylbutanal co-eluted from the GC and it was chosen to quantify these compounds together.

The effect of slicing environment, temperature loads, time- and temperature- of storage was analysed using mixed models in SAS version 9.13 (SAS statistical systems, SAS institute, Cary, USA). The analysis was done by comparing the relevant treatments. Time was considered a continuous variable and repetition was considered as random effect.

III. RESULTS AND DISCUSSION

The effect of the 5 different treatments on VOC's extracted from saveloy sausages are shown Table 1. Only the most relevant of the quantified compounds are included in the table and quantification results are not included in the paper.

A. *Effect of commercial slicing vs. slicing at DMRI*

Slicing at commercial conditions compared with experimental conditions (Exp3 vs. Com1, table 1) had significant effect for the level of 2- and 3-methylbutanal and hexanal

The quantified amount of 2- and 3-methylbutanal was significantly higher for commercially sliced sausages than for sausages sliced at DMRI. 2- and 3-methylbutanal are produced by some bacteria and can be used as an indicator of microbial growth [5, 6]. Under experimental conditions it was possible to minimize microbial contamination which could explain the observed differences in 2- and 3-methylbutanal concentration. The slicing environment therefore appears to play an important role for product sustainability.

The amount of hexanal, which is known to be a lipid oxidation product [2, 7], was lowest in commercially sliced saveloy (table 1). Moreover a decrease in hexanal level was observed throughout the fourth week of storage for both Exp3 and Com1. The hexanal level therefore seems to have peaked during the first 3 weeks after slicing, which could imply that it has been further oxidised to yield other volatiles.

B. *Effect of consumer simulated storage*

The temperature loads under consumer simulated storage had significant effect on the quantified amount of 2- and 3-methylbutanal (Exp2 vs. Exp3, table 1). The average storage temperature is increased considerably by the temperature loads during the fourth

week of storage. This could cause an increase in microbial activity and explain the elevated level of 2 and 3-methylbutanal compared to the level in saveloys kept at 5ºC during the fourth week.

The terpenes, which derive from the spices in the saveloy [8], were also affected by temperature loads. The level of 3-carene, α-pinene, α-terpinen, and limonene all increased when applying temperature loads in the fourth week compared to storage at 5ºC. The temperature reached 20ºC for 1.5 hours each day. This could change the texture of the saveloy and favor the release of terpenes from the sample matrix explaining the raise in terpene level.

C. Effect of temperature during the first 3 weeks of storage

The amount of 2- and 3-methylbutanal was higher in the saveloy samples measured 3 weeks after slicing and packaging when stored at 8ºC compared to samples stored at 5ºC (Com1 vs. Com2, table 1). However, a decrease in 2- and 3-methylbutanal concentration was observed during the fourth week of storage for samples initially stored at 8ºC. This could indicate that 2- and 3-methylbutanal at 8ºC has been further degraded. Temperature of initial storage seems to be important for the rate of 2- and 3-methylbutanal formation and perhaps also for the following degradation.

Hexanal, concentration was lower for the packages stored at 8ºC compared to the ones stored at 5ºC, and moreover a reduction during the fourth week of storage was observed for both temperatures. Again this could indicate that hexanal is further oxidised and that the reaction rate increases with temperature of storage.

For saveloy stored at 8ºC there was a significant rise in dimethyldisulfide compared to sausages stored at 5ºC (Com1 vs. Com2 in table 1). This compounds is not detected in most of the other samples, and since Com2 is the most extreme treatment in the experiment this could imply that these compounds are formed late in the shelf life period. This corresponds well with the findings of Withfield, 1998 [9]. Dimethyldisulfide has been shown to be produced by *Staphylococcus carnosus* in dry sausages and increase with high inoculation levels [6]. Their odours have furthermore been described as onion-like, cabbage-like and putrid [10]. It therefore seems likely that these compounds contribute negatively to the aroma of saveloy.

IV. CONCLUSION

The aroma composition in the headspace of saveloy was influenced by all of the investigated factors.

Slicing commercially compared to slicing at DMRI increased the level of 2- and 3-methylbutanal. This indicates a raise in microbial activity which is expected to shorten the shelf life period. Storing the samples with temperature loads, simulating a consumer situation, also increased the level of 2 and 3-methylbutanal which indicates an acceleration of microbial spoilage. Applying temperature loads furthermore increased the level of terpenes released from the product. Increasing the initial storage temperature from 5ºC to 8ºC increased the rate of 2- and 3-methylbutanal and dimethyldisulfide formation and hereby decreasing the shelf life period.

GC-MS measurements coupled with sensory and microbial measurements would help understanding to which extend the observed changes in headspace composition affects the eating quality. However the result of this study indicates that the composition of volatiles in the headspace of saveloy can be used as an indicator of product shelf life.

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Table1. The effect of the investigated factors on the quantified amount of selected aroma compounds. Exp3 vs. Com1 shows the effect of slicing at DMRI vs. slicing commercially. Com1 vs. Com2 shows the effect of initial storing saveloy at 5ºC vs. storing at 8ºC. Exp2 vs. Exp3 shows the effect of storing saveloy at 5ºC vs. applying temperature loads during the fourth week of storage. Effects were considered significant for $p<0.05$.

Compound	**Exp3 vs. Com1**		**Com1 vs Com2**		**Exp2 vs. Exp3**	
	slicing	**time**	**temp**	**time**	**loads**	**time**
2/3-methylbutanal	<0.001	ns	0.013	0.015	<0.001	ns
dimethyldisulfide	ns	<0.001	0.012	0.022	ns	0.011
hexanal	0.007	<0.001	<0.001	0.002	ns	0.020
3-carene	ns	ns	Ns	ns	0.004	ns
α-pinene	ns	ns	Ns	ns	0.010	ns
α-terpinen	ns	ns	Ns	ns	0.018	0.032
limonene	ns	ns	Ns	ns	<0.001	ns