Meat Science 90 (2012) 314–322

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Identification of chemical markers for the sensory shelf-life of saveloy

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ARTICLE INFO

Article history:
Received 23 February 2011
Received in revised form 21 July 2011
Accepted 23 July 2011

Keywords:
Aroma composition
Chemical markers
Saveloy
Spoilage

ABSTRACT

The aroma composition, the microbial composition and the sensory profile were measured in sliced saveloy samples packed in modified atmosphere (MA). The main objective was to identify aroma compounds with potential as chemical markers to identify the sensory changes of saveloy. The 60 aroma compounds isolated from the saveloy samples by dynamic headspace extraction and measured by Gas Chromatography Mass Spectrometry (GC-MS) were used to model the sensory attributes sour&old odour and meaty odour using partial least squares regression (PLS). 2- and 3-methylbutanal, 2- and 3-methylbutanol, acetoin and diacetyl were found to have the highest impact on both sour&old odour and meaty odour of the samples. The results show that these four aroma compounds have high potential as chemical markers for the sensory shelf-life of sliced and MA-packed saveloy.

1. Introduction

The link between sensory shelf-life and microbial activity in cooked and sliced meat products packed in modified atmosphere (MA) is well established (Borch, KantMuermans, & Blixt, 1996; Mataragas, Skandamis, Nychas, & Drosinos, 2007; Samelis, Kakouri, & Rementzis, 2000; Vermeiren, Devlieghere, De Graef, & Debevere, 2005). The cooking process eliminates practically all microorganisms and recontamination during slicing and packing is therefore largely responsible for the eventual spoilage of the product (Laursen, Byrne, Kirkegaard, & Leisner, 2009; Samelis, Kakouri, Georgiadou, & Metaxopoulos, 1998; Samelis et al., 2000). The rate of spoilage depends on the composition of the bacterial flora along with processing factors such as the oxygen permeability of the packing material and temperature fluctuations during transport and storage (Nychas, Skandamis, Tassou, & Koutsoumanis, 2008). Cooked and sliced meat products typically have a shelf-life of three to six weeks before they are spoiled by microbial formation of off-odours, gas and slime (Borch et al., 1996; Mataragas, Drosinos, Vaidanis, & Metaxopoulos, 2006). The typical spoilage flora of cooked and sliced meat products consists of a mixture of lactic acid bacteria (LAB) possibly in combination with *Brochothrix Thermosphacta* and *Pseudomonas* spp. (Borch et al., 1996; Stanley, Shaw, & Egan, 1981).

The growth of spoilage organisms and their production of off-odours have been studied in different cooked meat products (Leroy, Vasilopoulos, Van Hemelryck, Falony, & De Vuyst, 2009; Samelis et al., 1998; Vermeiren et al., 2005). Under anaerobic conditions LAB such as *Lactobacillus sakei*, *Leuconostoc carnosum* and *Carnobacterium divergens* dominate the spoilage flora and typically cause production of sour and acid off-odours and off-flavours when growth has reached a population of 10^7–10^8 CFU/g (Borch et al., 1996; Dainty & Mackey, 1992; Holzapfel, 1998; Leroy et al., 2009; Vermeiren et al., 2005). In the presence of oxygen the diversity of volatile compounds from microbial metabolism increases and their odour becomes increasingly offensive (Borch et al., 1996; Stanley et al., 1981; Vermeiren et al., 2005). Oxygen furthermore favours growth of *pseudomonas* spp. and *Brochothrix thermosphacta* which will interfere with the LAB under these conditions. This could lead to formation of diacetyl and acetoin, which are well known off-odours in meat products, produced by the aerobic metabolism of glucose by *B. thermosphacta* and some LAB (Bartowsky & Henschke, 2004; Borch & Molin, 1989; Dainty & Mackey, 1992; Stanley et al., 1981; Vermeiren et al., 2005).

The odour is among the first quality attributes registered when opening a package of sliced meat products and therefore volatile organic compounds (VOC's) have potential as early markers for consumer acceptability. In the present study the relation between the formation of VOC's and shelf-life of saveloy was investigated. The VOC's were measured by dynamic headspace extraction coupled with Gas Chromatography Mass Spectrometry (GC-MS) whereas product shelf-life was measured by sensory profiling. The measurements were done in the fourth week of storage where the storage conditions were set to simulate the conditions at the consumers.

2. Materials and methods

2.1. Production and slicing of saveloy

The saveloy was produced in the pilot plant at Danish Meat Research Institute (DMRI) using a recipe containing approximately: 40% shank

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doi:10.1016/j.meatsci.2011.07.017

and belly meat, 20% pork trimmings, 5% pork fat, 26.3% water, 4% potato starch, 2% soy-isolate 1% nitrite salt, 0.6% spices, 0.3% phosphate, 0.7% vacuum salt and 0.1% sodium ascorbate. The sausage mince was stuffed in sterile plastic casings and steam pasteurised at 80 °C for 50 min, reaching a core temperature of 75 °C. After 10 min cooling by water sprinkling, the products were kept at 2 °C overnight. The saveloy was cut into 2 mm slices and packed in 100 g APET/PE-peel trays with an oxygen transfer rate (OTR) of 15 mL/m^2 (24 h, 1 atm, 23 °C), and sealed with a PETP12/PE-peel film with an OTR of 5 mL/m^2. The MA packaging gas consisted of 70% N_2 and 30% CO_2. The product-headspace relation in the package was approximately 1:1.2.

2.2. Experimental setup

The saveloy was sliced as described above at DMRI and at two industrial slicing facilities. The three slicing locations were denoted A, B and C. After slicing and packing in MA, the samples were stored at either 5 °C or 8 °C for 3 weeks. During the fourth and final week of the experiment the storage conditions were set to describe consumer simulated storage (CSS). This included package opening and introduction of a temperature programme which has previously been shown to represent storage by Danish consumers (5 °C for 12.7 h, 12 °C for 9.8 h and 20 °C for 1.5 h, Blom-Hansen, unpublished results). As a control of the CSS a series of saveloy samples from each slicing location was furthermore kept in closed packages at the initial storage temperature during the fourth week of the experiment. The saveloy samples were subjected to analyses after: 3 weeks, 3 weeks + 3 days, 3 weeks + 5 days, 3 weeks + 7 days and 4 weeks. Note that 3 weeks + 7 days and 4 weeks were actually the same day of the experiment but the samples were stored under different conditions. The analyses included measurements of the aroma composition with GC-MS, a sensory profiling and measurements of the microbial composition. Three replicate measurements for each combination of factors were performed for each of the analyses. Furthermore, separate packages of saveloy were used for each replicate in an analysis. In the figures in this paper the samples are denoted according to the initial temperature (5 or 8), the slicing location (A, B or C) and the days of storage after package opening (0, 3, 5 or 7). For the unopened samples analysed after 4 weeks k is used as time indicator. An overview of the experimental setup is provided in Fig. 1.

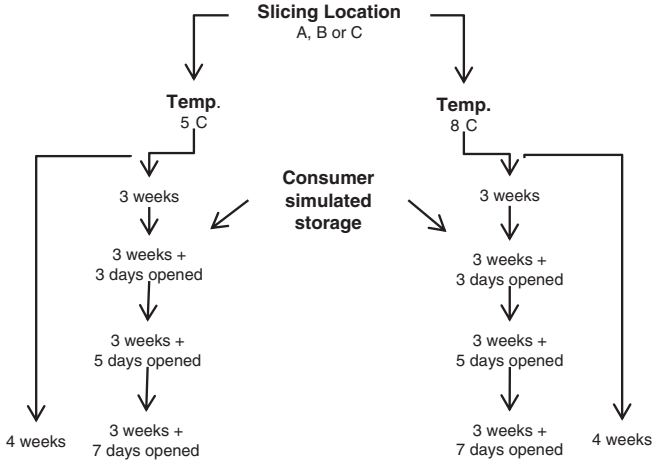

Fig. 1. Overview of the experimental design. The samples were sliced at three different locations (A, B and C) and opened after 3 weeks storage at either 5 °C or 8 °C. After package opening the samples were stored with temperature loads during the fourth week of the experiment. Measurements were performed after 3 weeks, 3 weeks + 3 days, 3 weeks + 5 days, 3 weeks + 7 days. A series of samples were not opened, kept at the initial storage temperature and measured after 4 weeks.

2.3. Aroma extraction

The aroma composition of the saveloy samples was measured by dynamic headspace extraction using traps containing 73 mg Tenax TA (60–80 MESH, Markes International Ltd., Llantrisant, UK) and 100 mg carbograph 1 TD (Markes International Ltd., Llantrisant, UK). 25 g of sample was coarsely chopped, placed in a 500 mL closed glass container and conditioned in a water bath at 30 °C for 10 min. The samples were then purged with a N_2-flow of 60 mL/min for 15 min. The N_2 flow was let through the trap which retained the volatiles released from the sample. All traps were back purged with a N_2 flow of 60 mL/min for 5 min in order to remove water from the trap.

2.4. Desorption and GC-MS analysis

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

Further analysis of the volatiles was performed with GC-MS. The 6890 N GC system (Agilent Technologies, Santa Clara, CA, USA was equipped with an HP-INNOWax column (30 m × 0.25 mm with 0.25 μm film thickness, Agilent 19091 N-133) and operated with the following parameters: carrier gas, helium; column pressure, 7.6 psi; oven programme, 35 °C for 5 min, from 35 °C to 110 °C at 10 °C/min, from 110 °C to 260 °C at 20 °C/min and 260 °C for 10 min. The system was equipped with a 5973 network mass selective detector (Agilent Technologies, Santa Clara, CA, USA) which was operated in the electron impact mode with energy of 70 eV and an emission current of 35 μA. The MS scanned from 33 m/z to 350 m/z at a rate of 3 scans/s.

The retention times were standardised using the Kovats retention index (KI) calculated from GC-MS runs of a C5-C15 alkane standard (Air Liquide, Paris, France). Furthermore GC-MS runs of Tenax traps spiked with dilutions of the following compounds were used for identification purposes: 2-methylbutanol and hexanal (Merck KGaA, Darmstadt, Germany). 3-methylbutanal and acetoin (ChemService inc., West Chester, Pennsylvania, USA), 1-octen-3-ol and 1-hexanol (Sigma-Aldrich, St. Louis, Missouri, USA), octanal (Bie & Berntsen, Herlev, Denmark), toluene (Honeywell Ridel deHaen, Seelze, Germany).

2.5. Sensory analysis

The sensory analysis was done using a six person sensory panel with previous experience in assessing meat products. The sensory panel had furthermore passed a training programme based on ISO 8585–1 and ASTM STP758. During training sessions four odour descriptors and eleven taste and texture descriptors were chosen for the assessment. However, after 3 weeks and 5 days of storage some of the saveloy samples were rejected for taste/flavour and texture evaluation by the sensory panel due to spoilage. Together with the staff of the sensory laboratory it was agreed to assess the saveloy samples using only the odour descriptors for the rest of the experiment. As a consequence of this only the odour descriptors are available throughout the experiment. The odour descriptors were: Meaty odour, Sour & Old odour, Spicy odour and Acidic odour. The attributes were assessed on a 15 cm unstructured line scale. The samples were placed in closed glass containers at room temperature before being served. Three replicates of each combination of factors were presented to the panellist in random order and assessed by each panellist twice. Furthermore the sensory panel was calibrated before each session using a reference saveloy sample which had been stored at −1 °C since production.