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Analysis of sensory quality changes during storage of a modified atmosphere packaged meat product (pizza topping) by an electronic nose system

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Abstract

The objective of this study was to determine whether an electronic nose could be used for measuring and modelling sensory quality changes in a pizza topping product during storage. A method involving a minimum of sample preparation in combination with a short sampling cycle mimicking an on-line situation was developed. A multivariate data analysis strategy involving principal component analysis (PCA) and partial least squares regressions (PLSR) was applied to determine the relationships between the electronic nose data, sensory analysis data and storage time. The results showed that the electronic nose was capable of detecting quality changes related to odour in the early stage and again from half-way to the last stage of the storage time, whereas the trained sensory panel could detect quality changes during the whole storage time. Applicability of the electronic nose for modelling the sensory perceived quality of the pizza topping product showed to be very promising indicating strong relationships between the electronic nose data and the perceived changes in odours during storage.

Keywords: Electronic nose; Ion mobility spectrometry; Sensory analysis; Quality; Meat; Multivariate data analysis

1. Introduction

Efficient quality control is becoming increasingly important in the food industry. Also the demands for (cost) efficient control methods particularly at- or on-line quality sensors controlling, e.g. automated processes and the raw material stream are growing. Thus objective automated non-destructive techniques measuring sensory quality (raw materials and end product quality) and shelf-life (microbial, sensory, chemical etc) which are amongst the most important quality parameters of foods are needed (Haugen & Kvaal, 1998; Holm, 2003). One promising technology is chemical sensor arrays combined with multivariate data processing methods, which have demonstrated to have a potential for rapid analysis of meat quality. In a recent study Hansen, Petersen, and Byrne (2005) found that an electronic nose system could detect the raw materials that led to unacceptable products (meat loaf), as determined by two types of sensory analyses. The electronic nose system could however not detect all the sensory unacceptable meat loaf samples due to changes in volatile composition after cooking. Blixt and Borch (1999) determined the degree of spoilage of vacuum-packaged beef using an electronic nose system with a sensor array consisting of 10 MOSFET (metal oxide semiconductor field effect transistor) sensors and 4 Tagushi sensors (MOS) and found, that the degree of spoilage had high correlation with a sensory panel ($r^2 = 0.94$). In a storage study on modified atmosphere packaged poultry meat it was found, that an electronic nose system comprising of 10 MOSFET sensors and 12 MOS sensors clearly could distinguish between broiler

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chicken packages with deteriorated quality from fresh packages either earlier than or at the same time as the sensory perceptible deterioration occurred (Rajamäki et al., 2006). In a recent study of warmed-over flavour (WOF) in pork O'Sullivan, Byrne, Jensen, Andersen, & Vestergaard (2003) showed that the MGD-1 could clearly separate samples on the basis of muscle type, treatment and degree of WOF development during storage. Repeating the experiment 11 months later in another laboratory, gave clear evidence of the reproducibility and repeatability of the MGD-1. An overview over different electronic nose systems and applications to different foods was made by Schaller, Bosset, and Escher (1998). Haugen and Kvaal (1998) have given an overview over meat applications.

The objective of this study was to determine whether an electronic nose could be used for measuring and modelling sensory quality changes in a pizza topping product during storage. In order to achieve this aim, sensory descriptive profiling using a trained panel was carried out. As an additional reference method for the product quality during storage the microbiological quality was determined. One of the main conditions for future implementation of industrial electronic nose at-line/on-line applications is rapidity of the measurement (sampling cycle). Rapid laboratory methods make it possible to give a realistic estimate of at-line/on-line applicability, thus this study also aimed at developing a method including a minimum of sample preparation.

2. Materials and methods

2.1. Preparation and storage of modified atmosphere packed pizza topping

The study was carried out using pizza topping produced and packed on the production plant in accordance with normal product standards. Pizza topping samples were prepared from cooked sausages cut in pieces ($4 \times 4 \times 40$ mm) and packed in 300 g consumer packages (Flow-pack laminate; PET12, PE-EVOH-PE 50 MY) in modified atmosphere (25% CO_2, 75% N_2). Sausages were prepared from a finely comminuted pork sausage mix (53% fat free pork meat), stuffed into artificial casings (120 mm × 800 mm, weight 8–9 kg) and steam cooked. The sausages were stored 2 days at 3–4 °C prior to cutting and packaging as described above. Samples were made in two batches prepared from the same raw material (sausage batch). Samples were stored in the dark at 7 °C corresponding to 1 °C over the highest permitted storage temperature in Finland. The two batch samples were analysed after 1, 5, 7, 9, 12, 14, 16 and 19 days of storage according to Table 1.

Shelf-life of the pizza topping product has been determined to 17 days after packaging by the company producing the pizza topping in accordance with a national guideline (Anonymous, 2003) prescribing determination of both sensory and microbiological shelf-life of meat products ($+7 \pm 1$ °C).

2.2. Determination of microbiological quality

As a control parameter of shelf-life the microbiological quality of the pizza topping samples were determined in accordance with a general accepted test scheme (Anonymous, 2001) for meat products in Finland. The guidelines also prescribe limits for microbiological activity on the last day of expiry (lde). The limits for the lde referred to in the present study correspond to the limits of the category "acceptable quality" reflecting a borderline limit of microbiological quality (Gilbert et al., 2000). The microbial groups examined were (limits for lde): aerobic bacteria, 30 °C ($<10^7$ cfu/g) (Anonymous, 1991b), coliform bacteria (<10 cfu/g) (Anonymous, 1991a), *Enterobacteraceae* ($<10^4$ cfu/g)(Anonymous, 1992) and lactic acid bacteria ($<10^7$ cfu/g) (Anonymous, 1991c). Microbiological quality was determined from two packages with three repetitions. Microbiological analyses were carried out by an accredited laboratory (Savolab Ltd. Finland). The methods for aerobic bacteria, coliform bacteria and *Enterobacteraceae* were accredited. The average results were used for studying the microbiological quality at shelf-life.

2.3. The electronic nose MGD-1

The commercially available electronic nose MGD-1 (Environics Ltd., Finland) based on the principle of ion mobility spectroscopy (IMS) was used. Ionization of molecules takes place in the IMCell with an Am-241 5.9 MBq (160 μCi) radiation source. Electrical fields, which can be set individually between three electrode pairs, interfere with the ion flow. Since the polarity of the electric field is changed in short time intervals, ions of both polarities can be detected simultaneously. The channel output of the electrodes is thus doubled to six (IMC-1 to IMC-6). IMC-1 to IMC-3 measure signals from positive

Table 1
Analytical scheme for the pizza topping experiment

Analysis (batch 1 &2)	Storage time (days)							
Microbiology	1	5	7	9	12	14	16	19
Electronic nose								
Sensory descriptive analysis								

Analysis performed during storage ($+7$ °C).