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Sensory evaluation of chicken breast packed in two different modified atmospheres

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ABSTRACT

Sensory acceptance is the key criterion for consumers judging the freshness of chicken meat. Especially prior to any preparation the sensory impression is the deciding factor for further processing or any form of consumption. The focus of this study was the sensory evaluation and microbiological characterization by MALDI-TOF of raw chicken meat packaged in two different atmospheres ("CO_2(30)": 30/70% CO_2/O_2 and "CO_2(15)": 15/85% CO_2/O_2) over a period of 14 days for CO_2(30) and 8 days for CO_2(15). The results showed that the composition of the modified atmospheres affects the sensory perception. The chicken meat packaged in CO_2(30) was characterized by a sensorial longer shelf life, than the one stored in CO_2(15). This could be attributed to the limited inhibition of *Pseudomonas* sp. in CO_2(15). In addition, only a few attributes lead to the waste of meat, while other attributes were found to influence sensory perception only when a critical value of 10^7 CFU (colony forming units) cm^{-2} had already been surpassed. The two attributes *general visual impression* and *general orthonasal impression* were suggested as the most suitable indicators of spoilage. By utilisation of sequential logistic regression the meat quality was subdivided in different levels of decay including "fresh", "no longer fresh" and "spoiled", in correlation with the sensory evaluation.

1. Introduction

Fresh meat is often provided in a packaging with increased O_2/CO_2 contents by utilizing modified atmosphere packaging (MAP). During the packaging process air is substituted by a mixture of gases including O_2, CO_2 and N_2. MAP not only enhances the convenience, but also extends the shelf life of the meat by suppressing the growth of *Pseudomonas* sp. These organisms are the main microorganisms responsible for the spoilage in aerobic conditions (Farber, 1991). Under MAP the microbiota mainly consists of gram positive microorganisms like *Brochothrix* (*B.*) *thermosphacta* and lactic acid bacteria (Doulgeraki, Ercolini, Villani, & Nychas, 2012; Farber, 1991; Höll, Behr, & Vogel, 2016), which metabolize meat ingredients of low molecular weight like sugars and amino acids (Batt & Tortorello, 2014). These metabolic activities can lead to changes in sensory properties including odor, color, texture and drip loss. Of these characteristics odor is the most important indicator regarding the spoilage of MAP chicken (Rossaint, Klausmann, & Kreyenschmidt, 2015).

Typically raw fresh chicken meat does not have a perceptible flavor (Bouthilet, 1951; Jayasena, Ahn, Nam, & Jo, 2013). According to Dainty, Edwards, & Hibbard (1985), meat is sensorially considered as "fresh" up to a microbial count of 10^7 colony forming units per (CFU) g^{-1}. However, the total viable count provides little insight in the spoilage potential of the microbiota, which varies with initial contamination and type of MAP atmospheres (Höll et al., 2016). Therefore, lower numbers of total viable counts may also cause sensorial spoilage depending on the composition of the microbiota. The odor is considered to be characteristic of spoilage as of a cell count of 10^8 CFU g^{-1} onward (Dainty et al., 1985). Off-odors in MAP are described as *sweet* and *cheesy,* which was explained by the development of 3-hydroxy-2-butanone, organic acids including acetic, isobutyric and isovaleric acid and volatile fatty acids from glucose and amino acids (Dainty & Hibbard, 1980; Nychas, Dillon, & Board, 1988). In O_2-enriched atmospheres a *rancid* flavor caused by lipid and protein oxidation (Jongberg, Wen, Tørngren, & Lund, 2014) is also produced. Chicken meat is characterized by higher levels of unsaturated fatty acids than red meat and is therefore very susceptible to lipid oxidation (Jayasena et al., 2013).

The odor of meat depends on many influencing factors. These include the production, processing, breed, age, feeding, pH value, the presence of free amino acids, storage conditions (Jayasena et al., 2013;

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Pettersen, Nissen, Eie, & Nilsson, 2004) and the types of microorganisms growing on the meat surface.

During the course of the study two different atmospheres were examined: "CO_2(30)": 30/70% CO_2/O_2 and "CO_2(15)": 15/85% CO_2/O_2. Meredith et al. claimed, that the bacteriostatic effect of CO_2 within MAP is primarily influenced by CO_2 absorption into the food, resulting in an equilibrium concentration, which is lower to that one in the initially used gas (Meredith et al., 2014). Therefore, an initial minimum headspace concentration of 20 to 30% CO_2 is required to achieve a bacterial inhibition, namely *Pseudomonas*, in poultry meat (Farber, 1991; Meredith et al., 2014; Stiles, 1991). On the basis of this information, the first concentration labelled with CO_2(30) was selected. Furthermore it is said to be the gas composition generally utilised for poultry meat (Rossaint et al., 2015). The second initial concentration CO_2(15) was utilised as this concentration is obviously below the required gas composition causing bacteriostatic effects. By choosing this MA below the critical value of 20% CO_2, it was expected, that pseudomonads, which are speculated to be responsible for sensorially perceptible spoilage are not fully suppressed in their growth. Consequently, we would have a means to assign sensorially perceptable spoilage to this specific group of organisms. Therefore, the objectives of this work were to evaluate the influence of different MA-compositions on the growth dynamics of the meat spoilage microbiota and their identification by matrix assisted laser desorption/ionization – time of flight mass spectrometry (MALDI-TOF MS), as well as to investigate sensory changes occurring during the storage of chicken breast packaged in two types of MA and possibly assign sensorially perceptible spoilage to *Pseudomonas* spp. The following hypotheses should be tested:

1. The panel can detect the end of shelf life by sensory analysis
2. The sensory analysis can be quantitatively correlated to microorganisms known to produce a certain sensory effect.
3. At least three different sensory levels – "fresh", "no longer fresh", "spoiled" – can be differentiated
4. Differences in the sensory evaluation due to the different carbon dioxide concentrations can be observed.

2. Materials and methods

2.1. Sample preparation

Chicken breast packaged in a modified atmosphere with a declared shelf-life of 8 days was obtained at the delivery day from a local retailer (day 0). The product was slaughtered no earlier than two days before. The meat was immediately transported within 30 min to the laboratory, while being continuously cooled (stored on ice). Upon arrival the gas composition in the original MA packaging was analyzed by a Dansensor Checkmate 2 (MOCON GmbH, Bendorf, Germany) with respect to O_2 and CO_2 concentrations, the balance being N_2. Under sterile conditions the packages were opened and each chicken breast fillet was cut in two pieces. Each half was repacked in a defined modified atmospheres (CO_2(30): 30/70% CO_2/O_2, CO_2(15): 15/85% CO_2/O_2) in polypropylene trays (ES-Plastic, Hutthurm, Germany, O_2 transmission rate: < 234 cm^3(STP)/(m^2 d bar), average material thickness: 270 µm) and PET/PA/EVOH/PP lid film (Südpack, Ochsenhausen, Germany, O_2 transmission rate: 3 cm^3(STP)/(m^2 d bar)) by utilizing a tray sealer (Multivac T 250, Wolfertschwenden, Germany). The samples were stored in a cold storage room at 4 °C until undergoing analyses.

2.2. Sensory analysis and training course of assessors

Individual samples were evaluated by a trained sensory panel consisting of 10 assessors (8 f, 2m, average age 29) for CO_2(30) and 11 assessors (8 f, 3 m, average age 32) for CO_2(15). The training course comprised two steps. In a first step, the panellists were handed samples of different ages and were asked to describe the visual and orthonasal impression. During the second step, all mentioned attributes were reviewed as part of a group discussion. Every attribute named only once was discarded or assigned to another attribute with a similar meaning. In addition, corresponding references were set for the individual attributes to achieve an agreement with the association of certain olfactory impressions.

Table 1
Summary of the final attributes used for sensory analysis of chicken breast.

attribute	scale 0–100
visual impression	
visual impression	fresh - spoiled
gloss	weak - gloss
smeary	imperceptible - clearly perceptible
red	light red - dark red
grey	imperceptible - clearly perceptible
drip loss	no drip loss - obvious drip loss
odorous impression	
orthonasal impression	fresh - spoiled
spoiled	imperceptible - clearly perceptible
pungent	imperceptible - clearly perceptible
bloody	imperceptible - clearly perceptible
cheesy	imperceptible - clearly perceptible
plastic	imperceptible - clearly perceptible
oily	imperceptible - clearly perceptible
butter-like	imperceptible - clearly perceptible
sourish	imperceptible - clearly perceptible
fermented	imperceptible - clearly perceptible
honey-like	imperceptible - clearly perceptible
fruity	imperceptible - clearly perceptible
bad egg	imperceptible - clearly perceptible
fishy	imperceptible - clearly perceptible

Sensory analyses were performed in independent duplicates with samples stored in CO_2(30) for a time span of 1, 5, 6, 7, 9, 11 and 14 days. The samples stored in CO_2(15) the time intervals of 1, 4, 5, 7 and 8 days were selected, as it was assumed to spoil faster. The intensity of the defined attributes was evaluated for all samples on a visual analogue scale ranging from 0 to 100. The value of "0" was correlated with a visual and orthonasal fresh meat, defined off-odors were imperceptible. A rating of "100" was linked to a visual and orthonasal spoiled meat, off-odors were clearly perceptible (see Table 1).

2.3. Microbiological analysis

For the microbiological analysis samples were cut sterile and homogenized with Ringer's solution. Afterwards dilution series were prepared and aliquots were spread on brain heart infusion (BHI) agar. A detailed description of this sampling procedure can be found in a study by Höll et al. (2016).

In order to determine the microbiota MALDI-TOF MS was utilised for the so-called on target extraction of proteins. This was done as described by Höll et al. (2016).

The raw data was processed as described by Kern, Usbeck, Vogel, & Behr, (2013) and Usbeck, Kern, Vogel, & Behr, (2013).

2.4. Data analysis

The data was collected and edited using a spreadsheet calculator (Excel by Microsoft). The data analysis was realised utilizing the software package R. The analysis is comprised of three main steps: in a first step, groups of relevant sensory attributes were extracted, clustered with the complete linkage method and illustrated as a heatmap for both variants, CO_2(15) and CO_2(30). In a second step, the day was estimated at which each defined attribute became noticeable in relation to the declared "best before" date. Since the sensory analysis was scaled between "imperceptible" and "clearly perceptible" on an analogue scale between 0 and 100, the data was transformed to a binary outcome "not