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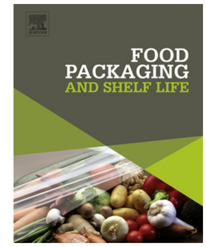

Effect of package perforation on the spoilage process of poultry stored under different modified atmospheres

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ABSTRACT

The effect of a perforated package on the development of typical spoilage parameter and shelf life of poultry packed under high oxygen- (70% O_2; 30% CO_2) and high nitrogen- (70% N_2; 30% CO_2) containing atmospheres were studied. Perforations of 0.2 mm were made in the top foil and samples were stored at 4 °C for 20 days.

During storage the development of the total viable count and the growth of typical spoilage organisms (*Brochothrix thermosphacta*, *Pseudomonas* spp., *Enterobacteriaceae* and *Lactobacilli* spp.) were analyzed and modeled by using the Gompertz function. Sensory analysis of the samples was carried out to analyze color, odor, texture, drip loss and general appearance. Also the development of the gas atmosphere and the pH value was measured. The results showed that under both atmospheres the growths of all spoilage organisms and all sensory attributes were influenced by a perforation. Sensory shelf life was reduced under both atmospheres by 26% due to a perforation.

1. Introduction

Modified atmosphere packaging (MAP) was introduced in the market in 1979 at the retailer Marks and Spencer (Church, 1994). This preservation technique is used for fresh meat to prolong the shelf life of this highly perishable product (Singh, Wani, Saengerlaub, & Langowski, 2011). In Europe different kinds of atmospheres are used for poultry: Several producers are using oxygen free atmosphere (70% N_2 and 30% CO_2) to pack fresh poultry. The residual oxygen content in such packages varies normally between 0.5% and 2% (Mills, 2005). Other producers (e.g. the German poultry industry) are using a high concentration of oxygen (>60%). The main reason for using high-oxygen packaging is to preserve the red color of meat, which is caused by the muscle pigments myoglobin and hemoglobin (Phillips, 1996; Totosaus, Pérez-Chabela, & Guerreo, 2007). Poultry breast muscles are referred to white meat, with a low quantity of myoglobin (McKee, 2007). Therefore the effect of a high oxygen concentration is controversially discussed (Löwenadler, 1994).

The gas atmosphere inside the package, after temperature, is one of the most important factors influencing the microbial growth respectively the composition of the spoilage flora and thus on the spoilage kinetic of the product. Changes in the gas atmosphere during storage caused e.g. by damaged packages decrease the positive effect of MAP and lead to an accelerated spoilage process. Tauschitz, Washüttl, Wepner, and Tacker (2003) analyzed the gas concentration inside the packages of different products (e.g. baked goods, cheese, snacks, meat) at the retailer. Only 48% of the modified packed products exhibit the optimal gas composition. At 4% of the tested packages the gas composition was similar to air (21% O_2). However, in this study of Tauschitz et al. (2003) only 14 of the 386 tested packages contained meat products. Reasons for perforation are improper

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sealing or mechanical damage during handling and transport. Particularly the trend to light-weight packaging components can contribute to packaging failure and product damage during the supply chain (Randell et al., 1995; Vergehese, Lewis, Lockrey, & Wiliams, 2013). Up to now, the control of the gas atmosphere inside the package is measured randomly. So far, one package out of 300–400 packages is tested during production. If a defect package is detected all of the 300–400 packages are scrapped or repackaged (Mills, 2005). Voidarou et al. (2011) investigated the quality of damaged MA packaged food products detected at the retailer stage. The samples were sorted out by the store manager due to the impression that the packaging was defective. The results of this study indicate that even a slight damage caused an increase in bacterial count.

Generally, the effect of damaged packages on the spoilage process depends on the product characteristic, the packaging material used, the initial atmosphere and the rate of change of the atmosphere. With increasing perforation size the oxygen concentration increases and the carbon dioxide concentration decreases. This leads to a faster spoilage process of the food. Recently, only a few studies are available which describe the influence of perforations on product quality. Randell et al. (1995) for example determined that the perforation affects the growths of yeast and molds and coliforms of modified atmosphere packed marinated chicken pieces. Eilamo, Ahvenainen, Hurme, Heiniö, and Mattila-Sandhoim (2005) determined that at 5 °C the development of the aerobic plate count in minced meat steaks increases with increasing perforation size. The maximum bacterial count increases 1–2 log levels in the packages with a perforation inside (33 d).

Ahvenainen, Eilamo, and Hurme (1997) studied the effect on perforation size on the sensory deterioration process of Pizza. The sensory spoilage of the product increased with increasing size of the leakage.

Most of the named studies are focusing on the effect of microholes of various sizes on a few typical spoilage parameter. But studies about the influence of leakages on the product specific spoilage organisms and sensory attributes under different gas atmospheres are rare.

Therefore the objective of the present study was to determine the influence of perforation on different sensory and microbiological spoilage parameter and the shelf life of MA packed poultry meat which is packed under high and low oxygen concentrations.

Poultry breast filets were packed under the two common used gas atmospheres 70% O_2; 30% CO_2 and 70% N_2; 30% CO_2 and one part was packed under air (reference). In half of the MA packages a perforation was made in the top foil (Ø = 0.2 mm). All samples were then stored at 4 °C for 20 days and typical spoilage parameters, the pH value and the change of the atmosphere with and without poultry inside were investigated after different time intervals.

2. Material and method

2.1. *Poultry samples*

Unisex 42-day-old broiler chickens (Ross 308/708) were slaughtered and air-chilled. Skinless chicken breast filets were used as test samples. The filets were obtained as double breast filets from a German slaughtering and processing plant. Filets were wrapped in polypropylene (PP) foil, packed in a card box and transported within 24 h after slaughtering to a German wholesaler and forwarded to a local retailer. Afterwards filets were transported to the laboratory under temperature-controlled conditions.

2.2. *Packaging, storage conditions and experimental design*

Before packaging the double breasts were divided into two single breast filets using a sterile scalpel. The bottom filet was removed, so that every filet weighed about 230 g to achieve a headspace to product ratio of nearly 3:1. Later one of the single breasts was stored in an intact package and one was stored in a perforated package. For each test day two samples per gas atmosphere were prepared and the storage test was repeated twice. Thus at one investigation point for each scenario were four samples tested.

The chicken filets were packed at the laboratory in polypropylene trays (171 mm × 127 mm × 50 mm; 680 ml, nominal foil thickness, my: 900, no absorber inlay, R. Fearch Plast A/s, Holstebro, Denmark) using a traysealer packaging machine (Traysealer T200 Multivac Sepp Haggenmüller GmbH & Co. KG Wolfertschwenden, Germany). As liddingfilm a low gas and water vapour permeable foil consisting of biaxial oriented polyester, polyethylene, EVOH and polypropylene. (Top Tray 50 LAF, SÜDPACK Verpackungen GmbH & Co. KG, Ochsenhausen, Germany) with an oxygen transmission rate of $\leq$1.5 cm^3/m^2 d bar 23 °C 35% r. F and a water vapor permeability of $<$3.5 g/m^2 d 23 °C 85% r. F was used.

The gas mixtures 70% N_2 and 30% CO_2, and 70% O_2 and 30% CO_2 were adjusted by a four-component gas blender machine (WITT-GASETECHNIK GmbH & Co KG, Witten, Germany). After packaging one perforation was made in each package by an acupuncture needle (Ø 0.2 mm) through the top foil of half of the samples. Reference samples were packed under normal atmosphere using the same trays and a low density polyethylene film as top foil (aerobic packaging). Further on, control blank samples without poultry were stored during the entire storage period to investigate the influence of the product on the headspace gas atmosphere. Table 1 shows the storage conditions of the different test scenarios.

Table 1 – Storage conditions of the different test scenarios.

Scenario	Gas concentration	Scenario description
A 1	70% N_2, 30% CO_2	Intact packages with product
A 2	70% N_2, 30% CO_2	Perforated packages with product
A 3	70% N_2, 30% CO_2	Intact packaging without product
A 4	70% N_2, 30% CO_2	Perforated packaging without product
B 1	70% O_2, 30% CO_2	Intact packages
B 2	70% O_2, 30% CO_2	Perforated packages
B 3	70% O_2, 30% CO_2	Intact packaging without product
B 4	70% O_2, 30% CO_2	Perforated packaging without product
C 1	Air	Aerobic packaging