QUALITY AND SHELF LIFE OF CHILLED, PRETREATED MAP POULTRY MEAT PRODUCTS

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Received for publication July 15, 2008

Abstract

The aim of the study was to assess the quality and shelf life of pretreated poultry meat with vegetables packaged in a modified atmosphere (30% CO₂, 70% N₂) and stored in refrigerated conditions. Microbiological analyses determined total counts of aerobic bacteria, Escherichia coli, Enterobacteriaceae, and Staphylococcus aureus. Sensory examination of the product was also conducted. The application of modified atmosphere packaging of pretreated poultry meat products stored at 1±1°C makes it possible to extend their shelf life over 2 times. We may state that modified atmosphere packaging and storage of pretreated poultry meat products, with the simultaneous maintenance of a continuous cooling chain, is a highly effective method of extending their shelf life.

Key words: poultry meat, modified atmosphere packaging, food preservation.

Changes in the lifestyle and diets of consumers, observed in recent years, have resulted in increased demand for convenience food, making it possible to prepare fast meals, at the same time preserving their high quality and health safety. A continuously popular method to preserve characteristic functional properties and sensory attributes of half-finished and final meat products, including those made from poultry meat is their cold storage. The dynamic development of trade and distribution networks requires constant improvement of cold storage methods (26). One of the ways to extend the shelf life of products stored at low temperatures, in both wholesale and retail is to apply a modified atmosphere, at present used in the packaging of meat, fish, dairy products, fruit, and vegetables (6, 8, 12, 17, 22, 27).

Important indicators to be carefully analysed when selecting the mixture of gases used in meat packaging include colour and microbiological changes. In the case of poultry meat, the modified atmosphere packaging is widely applied as a commercial practice. This method of packaging and storage is also used to extend shelf life of breaded, fried, roasted, and marinated poultry meat products. Less commonly, the method is used in the storage of products from meat of large slaughter animals (18, 20, 22, 25, 28). It needs to be stressed that the effectiveness of packaging in the case of meat and processed meats depends first of all on storage temperature. Studies concerning the modified packaging atmosphere of raw meat and processed meats suggest that it is necessary to maintain storage temperatures as low as possible (10, 13, 14, 19, 25). The lower the temperature, the longer the lag phase of bacteria causing spoilage of meat and its products. The effectiveness of action of CO₂, a component of gas mixtures, is dependent on its solubility, increasing with a decrease in temperature (11, 16, 34).

The period of shelf life of meat products packaged in the modified atmosphere depends on many other factors, apart from temperature, such as the quality of raw material, processing and preservation conditions and methods, packaging methods, and the composition of applied gas mixtures (8, 16). It is indicated that the optimum composition of used gas mixture frequently varies even in the case of products referred to by the same names, which may result from differing characteristics of products and preservation and storage conditions (9).

Due to the reduced content of oxygen or even its complete elimination in products packaged in an atmosphere with an altered gas composition, the development of anaerobic or facultative anaerobic pathogenic bacteria, such as Clostridium botulinum, Listeria monocytogenes and Campylobacter sp. is facilitated (5). The application of this technology requires basic principles of hygiene and temperature
requirements to be followed throughout the entire cooling chain (1, 5).

In recent years, an increased demand for marinated poultry meat products has been observed also for poultry meat. It was estimated that in Finland approx. 80% of poultry meat available in retail is sold marinated and packaged in modified atmosphere (3, 23). It seems necessary to collect information on the effect of modified atmosphere packaging on the quality of this group of products. The aim of the study was to perform microbiological analyses and sensory examination of pretreated poultry meat products packaged in air and in modified atmosphere, and stored at 1°C and 4°C.

**Material and Methods**

The experimental material consisted of poultry meat with addition of vegetables, *i.e.* green pepper and onion, previously blanched, of approx. 125 g, produced following the binding standard specification (29). Prior to the preparation of pretreated poultry meat products, the meat was marinated for 12 h. The marinate was prepared from water and spices (salt, peppers, sodium ascorbate). The poultry meat (fillets) was diced manually into cubes of approx. 5 cm/5 cm, while vegetables were diced into cubes of approx. 3 cm/3 cm. The chemical composition of meat was on average 74.5% of water and 22.3% of protein.

The analysed product was divided into two groups. The first one consisted of the control packaged and stored in air atmosphere. The processed meats were placed on trays made from expanded polystyrene EPS (with 4 pcs. each) and wrapped in polyethylene film in order to immobilise and prevent excessive drying. The other group was placed on trays and packaged in a modified atmosphere (Multivac), consisting of 30% of CO₂ and 70% of N₂. The trays with pretreated poultry meat products were automatically filled with gases and stored at 1°C and 4°C. The processed meats were immediately sealed and stored in modified atmosphere and stored at 1 ±1°C. They included total counts of aerobic bacteria, *Escherichia coli*, *Staphylococcus aureus*, and bacteria from family *Enterobacteriaceae*.

The total bacterial count was determined on agar medium using the flooding method (Standard Plate Count Agar AHA, Oxoid). Incubation was run at 30°C ±1°C for 72 h. Tryptone glucuronide medium with bile salts was used in the determination of *E. coli* counts. Plates were incubated at 44 ±1°C for 18–24 h and counts of β-glucuronidase-positive *E. coli* were determined. Counts of *Enterobacteriaceae* rods were determined on solid selective VRBG medium (Oxoid). The samples were incubated at 37 ±1°C for 24 h. Counts of *S. aureus* were determined on solid Baird-Parker medium. The samples were incubated at 35°C for 24 and 48 h (30, 31). The pH values were determined in pretreated meat product samples packaged in the air and in modified atmosphere and stored at 1 ±1°C.

Statistical calculations were performed using Statistica 7.1. The Weibull model was applied to describe changes in overall acceptability of the tested products, while logarithmic growth curves were used to determine dynamics of changes in bacterial counts.

**Results**

An increase in the counts of aerobic microorganisms as well as *Enterobacteriaceae* with an extension of their storage time was recorded in the tested pretreated poultry meat products stored in a modified atmosphere and in air atmosphere.

The initial count of aerobic bacteria both in samples packaged in the modified atmosphere and in air atmosphere was 3.3–3.6 log cfu/g. After five-day storage, the total bacterial count in samples packaged in air atmosphere was 7.4 log cfu/g, whereas in modified atmosphere packaged samples it was by 2.3 log cycle lower. The total count of aerobic bacteria in samples packaged in modified atmosphere after ten-day storage was lower (6.2 log cfu/g) than it was after five-day storage in samples packaged in air atmosphere (7.4 log cfu/g). In the last period of the study (14 d), the total bacterial count in modified atmosphere samples was comparable with the bacterial counts in samples packaged in air atmosphere after seven-day storage. The slope of the growth curve for the total bacterial count

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Barrier properties of the film used</th>
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<tr>
<td>Oxygen¹</td>
<td>Nitrogen¹</td>
</tr>
<tr>
<td>35</td>
<td>6</td>
</tr>
</tbody>
</table>

1) cm³/(m² x 24 h x atm), 23°C, 50% rF
2) g/(m² x 24 h), 38°C, 90% rF.
indicated a more dynamic bacterial growth in air atmosphere packaged samples (Fig. 1).

During the analysed product storage time, the count of bacteria from family Enterobacteriaceae was lower than the total bacterial count (Fig. 2). In the case of Enterobacteriaceae, their initial count in samples packaged in modified atmosphere and in air atmosphere was 2.3 and 2.7 log cfu/g, respectively. After seven-day storage in air atmosphere, the bacterial count was by 0.7 log cycle higher in comparison to the bacterial count in modified atmosphere packaged samples, amounting to 5.0 log cfu/g. A comparable count of bacteria from family Enterobacteriaceae in modified atmosphere packaged samples was recorded after ten-day storage. The count of Enterobacteriaceae was higher in samples packaged in air atmosphere in course of the tested storage time. The slope of the growth curve for bacteria from family Enterobacteriaceae indicated a more dynamic growth of the bacteria in samples packaged in air atmosphere (Fig. 2).

E. coli count determined in samples packaged in air atmosphere and in modified atmosphere did not change markedly and during the analysed storage time at 1±1°C remained at 1.1–1.9 log cfu/g. In pretreated meat samples packaged in air atmosphere and stored for seven days, it was 1.3 log cfu/g and was comparable with E. coli count in modified atmosphere packaged samples after ten-day storage. No increase in the count of S. aureus was observed in samples packaged under in atmosphere and in modified atmosphere during the analysed storage time. The count was 1.0 log cfu/g.

During cold storage of the pretreated poultry meat product scores for the overall acceptability, aroma, and colour were observed to decrease gradually, although the decrease was dependent on the applied packaging method and storage temperature. In both samples packaged in air atmosphere and those packaged in the atmosphere of protective gases, the recorded scores of organoleptic examination were higher for samples stored at 1±1°C than for those stored at 4±1°C (Fig. 3).

Organoleptic examination scores indicate that for both analysed temperatures pretreated poultry meat products samples packaged in air atmosphere exhibited poorer quality than those packaged in a modified atmosphere. The pretreated products packaged in the atmosphere of protective gases and stored at 1 ±1°C were found acceptable by the assessing panel up to day 12 of storage, while those stored at 4 ±1°C to day five. On the 14th day of storage, adverse changes were observed in both the aroma and texture, and this was manifested in scores of organoleptic assessment.

In the case of pretreated meat products packaged in air atmosphere, the difference in the scores of samples stored at 1 ±1°C and 4 ±1°C was smaller. A considerable deterioration of scores for overall acceptability both in case of samples stored at 1 ±1°C and 4 ±1°C was recorded after five-day storage. Disadvantageous changes in overall acceptability of the pretreated meat products packaged in air atmosphere and stored at 4 ±1°C were connected with the generation of large amounts of drip and transparency of onion. During cold storage of the pretreated meat products packaged in modified atmosphere, adverse changes among analysed sensory attributes were found first of all in the aroma as well as overall acceptability towards the end of storage. No statistically significant differences in pH were recorded in the course of the analysed period of pretreated meat products storage at 1±1°C, irrespective of the applied packaging method. In the final period of the storage, the pH was 5.9–6.0. The storage time of pretreated poultry meat products required to obtain overall acceptability scores of three, depending on the packaging method and storage temperature, was calculated from the Weibull model (Table 2).

<table>
<thead>
<tr>
<th>Packaging method</th>
<th>Storage temperature</th>
<th>Initial value</th>
<th>Curve parameters</th>
<th>R</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>b</td>
<td>c</td>
<td>d</td>
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<td>-0.682</td>
</tr>
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</table>

R - correlation coefficient between experimental data and data calculated from the model
D - storage temperature required to obtain overall acceptability score of 3 d

Table 2
Parameters of the Weibull curve y=a·b^(-c·x+d) for changes in overall acceptability of pretreated poultry meat products (y) depending on the packaging method and storage temperature
Fig. 1. The growth curve for aerobic bacteria growth in pretreated poultry meat products packaged in air atmosphere and in modified atmosphere and stored at 1±1°C.

Fig. 2. The growth curve of Enterobacteriaceae in pretreated poultry meat products packaged in air atmosphere and in modified atmosphere and stored at 1±1°C.
Discussion

The conducted investigations confirmed the suitability of the application of a modified atmosphere to extend shelf life of meat, meat half-finished products, and processed meats (4, 8, 11, 22, 28). It was shown that packaging of pretreated poultry meat products in modified atmosphere (30% CO₂ and 70% N₂) and storage at 1°C result in a considerable extension of shelf life of the product and facilitates the preservation of its good microbiological and organoleptic quality. The reduction of the growth dynamics of aerobic bacteria, including bacteria causing meat spoilage (4, 28), and bacteria from family Enterobacteriaceae observed in pretreated poultry meat products packaged in a modified atmosphere results from the effective action of the applied atmosphere. It confirms the studies indicating the inhibitory action of carbon dioxide on the development of aerobic bacteria, especially at low storage temperatures (2, 16). No increase in the counts of S. aureus in the pretreated poultry meat products packaged in modified atmosphere was observed. Analyses concerning the modified atmosphere packaging of meat and its products indicate a lack of effect or possible limitation of S. aureus growth thanks to the application of high CO₂ concentrations (5, 15, 24). Literature data indicate that the range of shelf life extension for products packaged using gas atmosphere is dependent on many factors, including storage temperature (2, 8, 10, 11, 19, 32). It was found that a two- to four-fold extension of shelf life in the case of modified atmosphere packaged products is possible only when specific packaging conditions are ensured (28).

The application of a modified atmosphere in the packaging of pretreated poultry meat products stored at 1°C makes it possible to extend over two times the duration of their shelf life. Earlier studies concerning the effect of the applied packaging method on the shelf life of sliced poultry meat products showed that the longest shelf life was recorded for samples stored at a temperature of max. 2°C. Increasing the temperature to 6-8°C reduced the shelf life by approx. 25% (7).

It needs to be stressed that the composition of a gas mixture should be selected individually and depending on the type of the packaged product (5, 9). It is reported that considerable oxygen content (up to 80%) is required in the applied gas mixture when packaging a fresh meat, especially of large slaughter animals, in order to preserve a desirable red meat colour (5). The conducted analyses confirmed that in the case of poultry meat, the changes in the colour play a lesser role due to the lower content of haem pigments (16). No negative effect of the applied gas mixture on meat colour was observed in the analysed meat products. Adverse changes in the colour in samples packaged in a modified atmosphere and stored at 1°C was found during the final period of storage (day 14). Comparable scores for the colour of pretreated poultry meat products samples packaged in air atmosphere and stored at 1°C were recorded for day 7.

In the case of the production of meat half-finished products, such as pretreated poultry meat products, crucial elements are microbial contamination of initial basic and additional raw materials as well as the maintenance of recommended hygienic conditions throughout the entire production process (1, 33). The
application of a modified atmosphere in the packaging of products from raw poultry meat, such as poultry meat with vegetables, poses a lesser microbiological hazard, due to the necessity to apply thermal processing before consumption. It may be stated that packaging and storage in a modified atmosphere in the case of pretreated poultry meat products with the simultaneous maintenance of a continuous cooling chain is a highly effective method to extend the shelf life of these products. It would also be crucial to determine the effect of a modified atmosphere on the growth of lactic acid bacteria in the analysed pretreated poultry meat products, due to the development of this group of microorganisms in marinated poultry meat products packaged in a modified atmosphere (3, 21).

References

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