Effects of gas atmosphere, storage temperature and time on the quality and shelf-life of sliced poultry sausage

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Introduction

Consumers show a growing interest in the so called "convenience food", contributing to a constant improvement in its chill storage conditions. That applies both to fresh meat and processed meat products and is aimed at ensuring high quality during extended periods of product storage and marketing.

Modified atmosphere packaging is one of the ways to keep the quality of refrigerated products on the desired level. The modification of atmosphere composition in various wholesale and retail packagings in the chill storage room can be reached by reduction of oxygen content followed by an increase of carbon dioxide and/or nitrogen concentration (GILL, 1989; FARBER, 1991; BLAKISTONE, 1998a). The data on the optimal composition of the modified atmosphere used in the storage of meat and processed meat products vary considerably (BLICKSTAD and MOLIN, 1983; BENTLEY et al., 1989; FARBER, 1991; BLAKISTONE, 1998b). The composition of the modified atmosphere proposed by those authors is dependent, first of all, on the kind of the stored product and, therefore, has to be designed individually taking into consideration its specific properties.

Numerous studies have been conducted to investigate the effects of modified gaseous atmosphere on the quality and shelf life of fresh, whole or cut-up carcasses of poultry, mainly broilers, kept under refrigerated storage (SANDER and SOO, 1978; BALEY et al., 1979; WESLEY and STADELMAN, 1985; SAWAYA et al., 1995; ANG and HUANG, 1994; BUYS et al., 1994; KRALA, 1996; KRALA et al., 1997). On the other hand, only few studies have been published on the effect of modified atmosphere packaging of processed poultry meat products on their quality and shelf life (YOUNG et al., 1988; INGHAM and TAUTORUS, 1991; PIKBUS et al., 1991; PIKUL et al., 1997).

An extension of shelf life of those products at chill temperatures is essential due to their relatively short storage period prior to consumption. It results from the undesirable quality changes caused by a number of factors such as: growth of aerobic microflora, activity of tissue and bacterial enzymes, evaporation of product surface as well as oxidation of meat lipids and pigments (KRALA, 1996; BLAKISTONE, 1998a).

The studies on modified atmosphere packaging carried out so far concentrated mainly on fresh meat and, less frequently, on processed meat products, whereas many of them did not cover all aspects of that issue. The purpose of this study was, therefore, to investigate to what extent the modification of atmosphere can extend the shelf-life of sliced poultry meat sausage stored under various temperatures.

Material and Methods

Unsmoked, cooked, medium-comminuted poultry meat sausage in poliamid casing of 60 mm diameter, produced in a commercial poultry processing plant was used as experimental material. Chilled breast muscles of broilers and mechanically deboned broiler meat obtained from carcasses without breast and leg muscles were taken as raw material at the proportion of 1:1. The raw sausage was heated in a steam-cooking chamber for around 10 minutes after reaching 70 to 72 °C temperature in the central part of the sausage, and was followed by chilling under running cold water.

Twenty four hours after production, the chilled sausages without casings were sliced and placed in two rows of 16 slices each on trays made from expanded polystyrene (EPS). All trays with slices of poultry meat were divided in three groups and packed in different way (Diagram 1). Sausage slices on EPS trays packaged into polyethylene film to prevent evaporation were used as controls. The second and third group of the product on trays were put into gas-proof OPALEN X65 barrier film bags manufactured by Walki Pac Co. (Finland). The physical properties of the packaging film were as follows: permeability of oxygen < 1 cm³/m², carbon dioxide < 4 cm³/m²·24 h·0.1 MPa · 23 °C at 50% relative humidity, permeability of nitrogen < 0.1 g/m² while of water vapour 14 g/m²·24 h·38 °C at 50% relative humidity. Air was first evacuated from gas-tight plastic bags containing trays with sliced sausage and nitrogen or a mixture of nitrogen and carbon dioxide was flushed into bags at the proportion of 7:3. Gaseous nitrogen and the mixture of nitrogen and carbon dioxide were delivered by AGA Gaz Comp. Evacuation of air from and sealing of bags was performed in the P.Z.P 21-G vacuum packaging unit of SPOMASZ Ostrów Wlkp. manufacture. Two storage temperatures, i.e. 1 °C ± 1 °C and 7 °C ± 1 °C were used for all examined packaging atmos-

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Slices of poultry sausage

Method of packaging

EPS trays polyethylene film

EPS trays barrier films bags

Storage temperature

Air (Control)

1 ± 1°C

100% N₂

7 ± 1°C

70% N₂/30% CO₂

Final storage time (days)

A 7

B 28

C 35

Diagram 1. Scheme of experimental design Unsuschungsplan

phrases: air (control); 100% N₂; 70% N₂/30% CO₂ (Diagram 1).

Sliced sausages were examined prior to packaging and after different time of storage depending on the type of packaging and storage temperature. Standard analytical methods were used to determine the content of water, protein, fat, sodium chloride, and nitrates in the product according to A.O.A.C. (1980). Water was determined by air drying method, protein using the Kjeltec Systems 1026 Distilling Unit (Tecator, Sweden), fat by Soxhlet method, sodium chloride by Mohr method, and nitrates with Griess reagent. Malonaldehyde content as an indicator of lipid oxidation was determined by distillation method with water vapour (TARLADGIS et al., 1960 modified by PIKUL et al., 1989), and expressed as TBA (thiobarbituric acid) measured at the surface of slices for pale areas (pieces of deboned poultry meat) as well as dark (mechanically deboned muscles) as regards to overall acceptability. Panelists were trained according to Polish standards. Organoleptic evaluation of poultry sausage was done in a specially designed room, equipped with separate boots, ventilation, special lights, and computers. Sensory analysis by using nine-score scale and selected quality traits (BAKER et al., 1986) was also carried out. In the case of: colour, binding ability, juiciness, and hardness, the score five denoted that the given trait was at its optimum level. Lower and higher scores indicated poorer quality of the examined trait. In the case of other sensory traits such as: taste, odour, and overall acceptability, the score one means the lowest, score nine the highest quality level, while scores below five meant that sausage slices were not accepted by panelists. On the basis of overall acceptability, the shelf-life was determined. The presented results of analyses were based on three series for three repetitions in each series.

Processing of data and statistical analysis were performed using statistical software SPSS/PC+ (NORUSIS, 1992). Duncan's method was used to test differences between means.

Results and Discussion

The basic chemical composition of poultry meat sausage was as follows: 70.23% water, 16.55% protein, 9.87% fat, 2.14% sodium chloride, and 87.5 mg/kg sodium nitrite. Regardless of the packaging condition of the sliced sausage no difference was found in pH at the end of storage period in comparison to that noted prior to packaging (6.37).

The results of sensory analysis of the overall acceptability of sliced poultry meat sausage revealed a decrease in quality traits with the duration of storage time. However, it was dependent on the composition of gaseous atmosphere in the packaging and storage temperature. The unfavourable changes in the overall acceptability resulting, first of all, from deterioration of taste and odour were noted at the highest rate in the sliced sausage packed in air atmosphere. The shelf-life of the same sliced sausage in a package containing 100% nitrogen atmosphere and stored at 1 ± 1°C temperature could be extended to a five times longer period (Figure 1). With the atmosphere composed of 70% nitrogen and 30% carbon dioxide in the package the shelf-life was extended by 7 days in comparison to 100% nitrogen atmosphere.

In the examined storage period no significant changes in colour parameters were observed evaluated by the reflectance method. Colour evaluation of pale areas (compressed breast muscles) and dark areas (mechanically deboned poultry meat) of sausage slices demonstrated no significant difference in L*, a*, and b* colour parameter values in comparison to those noted prior to packaging, regardless of the composition of gas atmosphere in the package (Table 1). That finding was confirmed by visual assessment of colour. The earlier study by Blakistone (1998b) also revealed that the use of modified atmosphere packaging in the storage of poultry meat products induced smaller colour changes than those found in red meat products.

Diversified composition of neutral gas atmosphere and storage temperatures (1 ± 1°C, 7 ± 1°C) affected significantly the total count of psychrophilic aerobic bacteria at the end of storage period (Figure 2). The growth of these microorganisms up to the level of 10⁸ cfu/g was noted after 28 days of sliced sausage storage under nitrogen atmosphere and after 35 days of storage under the mixture...
Figure 1. Results of overall acceptability of sliced poultry sausage packed under different atmospheres and stored at two temperatures

Gesamtakzeptanz aufgeschnitzter Geflügelwurst, die bei unterschiedlichen Atmosphären verpackt und unter zwei Kühltemperaturen gelagert wurde

Methods of packaging: ■ air atmosphere, ▲ 100% N₂, ● 70% N₂/30% CO₂

Storage temperature: — — ± 1 °C, — — ■ 7 ± 1 °C

a–b: different letters used for mean values concerning the influence of the type of packaging and temperature of storage for the same sausage denote statistically significant differences at the level of p = 0.05

Table 1. Colour parameters of sliced poultry sausage packed under different atmospheres and temperatures

<table>
<thead>
<tr>
<th>Method of packaging</th>
<th>Colour parameters</th>
<th>The final storage time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>~ L * ~ a * ~ b *</td>
<td>pale areas</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>sd</td>
</tr>
<tr>
<td>storage temperature 1 ± 1 °C</td>
<td>7</td>
<td>72,65</td>
</tr>
<tr>
<td>pale areas</td>
<td>28</td>
<td>73,38</td>
</tr>
<tr>
<td>air</td>
<td>35</td>
<td>73,24</td>
</tr>
<tr>
<td>100% N₂</td>
<td>7</td>
<td>64,75</td>
</tr>
<tr>
<td>70% N₂/30% CO₂</td>
<td>28</td>
<td>64,76</td>
</tr>
<tr>
<td>dark areas</td>
<td>35</td>
<td>65,05</td>
</tr>
<tr>
<td>air</td>
<td>7</td>
<td>72,45</td>
</tr>
<tr>
<td>100% N₂</td>
<td>14</td>
<td>73,19</td>
</tr>
<tr>
<td>70% N₂/30% CO₂</td>
<td>21</td>
<td>73,31</td>
</tr>
<tr>
<td>storage temperature 7 ± 1 °C</td>
<td>5</td>
<td>64,36</td>
</tr>
<tr>
<td>pale areas</td>
<td>14</td>
<td>65,56</td>
</tr>
<tr>
<td>air</td>
<td>21</td>
<td>64,88</td>
</tr>
</tbody>
</table>

* Data are presented as means ± standard deviation

Colours parameters of sliced poultry sausages before packaging

for pale areas: ~ L * 69,28 ± 2,091, ~ a * 9,84 ± 0,693, ~ b * 10,80 ± 0,582

for dark areas: ~ L * 65,68 ± 1,151, ~ a * 12,18 ± 0,362, ~ b * 12,05 ± 0,257
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Figure 2. Effect of packaging conditions and two storage temperatures on aerobic psychrophiles bacteria in sliced poultry sausage

Figure 3. Effect of packaging conditions and two storage temperatures on lactic acid bacteria count in sliced poultry sausage

Figure 4. Effect of packaging conditions and two storage temperatures on meat lipids oxidation in sliced poultry sausage

of nitrogen and carbon dioxide at the ambient temperature of 1 ± 1 °C. Such changes in the total count of psychrophilic aerobic bacteria have been reported by other authors (HOTCHKISS, 1989; FARBER, 1991; CHURCH and PARSONS, 1995). They found that the use of at least 30% of carbon dioxide in the modified atmosphere significantly reduced growth of bacteria. As expected, storage at the temperature below 2 °C to the greatest extent reduced the growth of psychrophilic aerobic bacteria, their number after 35 days of storage was lower than that after storing the same samples for 21 days at a temperature of 6–8 °C. Substantially faster increase of total count of bacteria was observed in the sliced sausage kept in all examinated atmospheres and stored at the temperature of 6–8 °C.

Dynamics of changes in bacteria count was lower in sliced sausage kept in the atmosphere containing 70% nitrogen and 30% carbon dioxide in comparison to 100% nitrogen. As early as after 4 days, sausage samples stored in packagings containing air atmosphere revealed a bacteria count at the level of $10^5$ cfu/g. After 7 days of sliced sausage storage at the temperature of 6–8 °C, the bacteria count in the samples packaged with nitrogen was comparable with that after 21 days of the same sliced sausage kept at the temperature of 0–2 °C. SAWAYA et al., (1995) also pointed out that bacteria growth rate in meat and its processed products packaged in a mixture of nitrogen and carbon dioxide was dependent upon chill storage temperature.

Similar effect of packaging condition and storage temperature was observed on the changes in lactic acid bacteria count (Figure 3). In the samples packaged in the mixture of nitrogen and carbon dioxide, the growth rate of lactic acid bacteria was lower than that in the samples packaged in air atmosphere or nitrogen only. No stimulating effect of higher carbon dioxide concentration on lactic acid bacteria growth was observed.

Regardless of the modified atmosphere used, no coliform bacteria, and the anaerobic sporeforming bacilli were found in 0.1 g of samples of the sliced sausage during storage at the two examined temperatures. In the studied period of sliced sausage storage at the temperature of 1 ± 1 °C, no yeasts and moulds were isolated from the samples of sliced sausage irrespectively of the packaging conditions. On the other hand, growth of yeasts and moulds was observed in sausage samples packaged under air atmosphere and stored under the temperature of 6–8 °C after the period in which their quality was not accepted by the sensory panel. During storage of sliced sausage at the temperature of 6–8 °C, the growth of yeasts and moulds after 14 days storage reached $1.8 \times 10^7$ cfu/g in samples packaged under nitrogen only. However, after that storage period, sausage slices obtained overall acceptability scores below 5 in the 9-score quality scale and were not accepted by panelists.

Packaging of sliced poultry meat sausage under modified atmosphere of various composition had also a significant effect on meat lipids oxidation during storage at both studied temperatures (Figure 4). Those processes were found to occur at the lowest rate in sliced sausage packaged with a mixture of nitrogen and carbon dioxide and stored at the temperature of 1 ± 1 °C. After 14 days of storage the TBA numbers in those samples were comparable with the TBA numbers found in sausage samples packaged with air atmosphere and stored for 1 day only. After 7 days of storage, for the sliced sausage packed under 70% nitrogen and 30% carbon dioxide at the tempera-
Figure 3. Effect of packaging conditions and two storage temperatures on lactic acid bacteria in sliced poultry sausage
Einfluss der Verpackungsbedingungen und Lagertemperaturen auf den Gehalt an Milchsäurebakterien in aufgeschnittener Geflügelwurst
foot note see Figure 1
siehe Abbildung 1

Figure 4. Effect of packaging conditions and two storage temperatures on TBA number in sliced poultry sausage
Einfluss der Verpackungsbedingungen und Lagertemperaturen auf die Menge an TBA in aufgeschnittener Geflügelwurst
foot note see Figure 1
siehe Abbildung 1
ture of 6–8 °C, statistically significant higher TBA numbers were noted in comparison to the same samples stored at the temperature of 0–2 °C, thus indicating that under such composition of atmosphere lipid oxidation rate increases with the increase of storage temperature.

Conclusion

The microbiological, chemical, and sensory quality of sliced poultry meat sausage was dependent on the composition of gas atmosphere used in the packaging and storage temperature. At both temperatures, the longest period of sliced sausage shelf-life was noted when the mixture of nitrogen and carbon dioxide was applied. The elevation of storage temperature from 1 °C to 7 °C was found to reduce twice the shelf-life of sliced sausage packed under 70% nitrogen and 30% carbon dioxide. When in the packaging 50% of nitrogen was replaced with carbon dioxide the storage life of product at the temperature of 1 ± 1 °C was extended by 1 week in comparison to the atmosphere containing 100% nitrogen. The experimental findings in this study confirmed that reduction of chemical and microbiological changes at both temperatures can be reached in the sliced sausage by using a modified atmosphere containing 30% carbon dioxide in the packaging.

Summary

The aim of the study was to determine the effect of modified atmosphere packaging (100% nitrogen or 70% nitrogen and 30% carbon dioxide), compared to air atmosphere packaging, on the quality and shelf-life of medium comminuted poultry meat sausage stored at temperatures of 1 ± 1 °C and 7 ± 1 °C. Basic chemical composition, malonaldehyde content, pH value, and colour by reflectance method were determined. Microbiological examination comprised: total count of psychrophilic aerobic bacteria, lactic acid bacteria count, yeasts and moulds total count, coliform bacteria, and anaerobic spore forming bacilli. Microbiological, chemical, and sensory quality of sliced poultry meat sausage was dependent on the composition of atmosphere used in the packaging and storage temperature. At both examined temperatures, the sliced sausage packaged with modified atmosphere containing nitrogen and carbon dioxide resulted in a lower count of psychrophilic aerobic bacteria, lower dynamics of changes in TBA number, and substantially lower rate of unfavourable changes of taste and odour, in comparison to sausage samples packaged with nitrogen only or with air atmosphere. The elevation of storage temperature from 1 ± 1 °C to 7 ± 1 °C resulted in a twice as large reduction of the shelf-life of sliced sausage packaged with the mixture of nitrogen and carbon dioxide. The replacement of 30% nitrogen with carbon dioxide in the packaging, in comparison with 100% nitrogen atmosphere, resulted in extension of product shelf-life at 1 ± 1 °C temperature by 1 week. The experimental findings confirmed the effectiveness of 30% carbon dioxide content in the packaging in the reduction of chemical and microbiological changes that occur in perishable meat products at both studied storage temperatures.

Keywords

Modified atmosphere, poultry meat sausage, storage temperature, shelf-life

Zusammenfassung

Auswirkungen der Lagerungstemperatur, -temperatur und -dauer auf die Qualität und Haltbarkeit von aufgeschlit­terener Geflügelwurst


Stichworte

Modifizierte Atmosphäre, Geflügelwurst, Lagertemperatur, Halt­barkeit

References


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