EFFECT OF THE PACKAGING METHOD ON THE SENSORY AND MICROBIOLOGICAL PROPERTIES OF BROILER CHICKEN BREAST MUSCLES STORED IN CONTROLLED ATMOSPHERE

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Abstract. The aim of the present study was to determine the sensory and microbiological (total microbial count) properties of broiler chicken breast meat stored in controlled atmosphere (95% nitrogen, 5% oxygen) at 2°C for 5 to 25 days. The samples were Nordfilm–Nordform-packed or left unpacked. The results of the study showed that the sensory quality of meat (especially aroma, juiciness and tenderness) deteriorated when the time of cold storage was prolonged to 20 days. The rate of these undesirable changes was faster in unpacked samples than in packed ones. A microbiological analysis of breast muscles, based on total microbial count per g, indicated that microbial contamination was at a safe level in packed samples stored under controlled atmosphere conditions for 20 days, and in unpacked samples stored for 15 days.

Keywords: chicken breast muscles, controlled atmosphere packaging, sensory and microbiological quality.

VIŠČIUKŲ BROILERIŲ KRŪTINĖLIŲ RAUMENŲ, LAIKOMŲ KONTROLIUOJAMOJE ATMOSFEROJE, PAKAVIMO METODO ĮTAKA SENSORINĖMS IR MIKROBIOLOGINĖMS SAVYBĖMS

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Santrauka. Mokslinio tyrimo tikslas buvo nustatyti viščiukų broilerių krūtinėlių mėsos, laikomos kontroliuojamoje atmosferoje (95 proc. azoto, 5 proc. deguonies) 2°C temperatūroje nuo 5 iki 25 dienų, sensorines bei mikrobiologines savybes (bendrą bakterijų skaičių). Vieni mėginiai buvo supakuoti naudojant „Nordfilm-Nordform“, kiti – palikti nepakuoti. Tyrimo rezultatai parodė, jog sensorinė mėsos kokybė (ypač aromatas, sultingumas ir švelnumas) pablogėjo, kai laikymo laikas buvo užtęstas iki 20 dienų. Nepageidautini pokyčiai greičiau vyko nepakuotuose mėginiuose nei pakuotuose. Mikrobiologinė viščiukų broilerių krūtinėlės raumenų bendro bakterijų skaičiaus analizė parodė, jog mikrobinis užterštumas neviršijo leistinos normos pakuotuose mėginiuose, laikomuose kontroliuojamose atmosferos sąlygomis 20 dienų ir nepakuotuose mėginiuose, laikomuose 15 dienų.

Raktažodžiai: viščiukų krūtinėlių raumenys, pakavimas kontroliuojamoje atmosferoje, sensorinė ir mikrobiologinė kokybė.

Introduction. Fresh poultry meat is available in the form of packed elements or fillets. In a model system, packaging provides a physical barrier between the protected product and the external environment. The protective functions performed by packaging can be interpreted as the capability to selectively reduce the effects of mechanical and climatic factors, combined with the lack of own, harmful impacts (Czerniawski and Michniewicz, 1998; Jankowski, 2003). The simplest method for atmosphere modification is to remove air from the packaging and store meat under vacuum conditions. According to Buchmüller (1970), the shelf-life of vacuum-packed poultry depends on the properties of the packaging. Czerniawski and Michniewicz (1998) found that the vacuum inside the packaging may change considerably during meat storage due to the diffusion of gas through the film and oxygen penetration from the outside into the packaging. In consequence of these changes gas and vapor permeability of packaging material increases, and the vacuum effect decreases as the time of cold storage is prolonged. Vacuum storage of poultry meat is also restricted by the possible juice drip inside the packaging, followed by microbial contamination and sensory quality deterioration.

Meat can be stored under controlled atmosphere conditions in cold rooms. The main advantage of this method is the possibility to control the composition of a gaseous mixture applied during the cold storage of various kinds of meat. The gases used in this method are carbon dioxide, nitrogen, and their mixtures with oxygen (Kondratowicz and Kawałko, 2003).

The aim of the present study was to determine the sensory and microbiological (total microbial count) properties of broiler chicken breast muscles stored in controlled atmosphere (95% nitrogen, 5% oxygen) at 2°C for 5 to 25 days. The samples were Nordfilm–Nordform-packed or left unpacked.

Materials and Methods. The experimental materials comprised Ross 308 broilers, reared to 7 weeks of age on a private farm, with live weights of about 2700 g. The sex ratio was 1:1. Slaughter and carcass processing were carried out by an industrial method, on an automatic processing line (Storck, the Netherlands). After slaughter the carcasses were chilled for 90 min. by a ventilation-spraying method to 3 - 6°C.

An analysis was performed on breast muscle (*musculus pectoralis*) samples of normal quality. The criterion of quality assessment was the value of pH_1 determined in breast muscles with a Radiometer pH-meter, 15 to 20 min. after slaughter. Normal-quality muscles were those whose pH_1 ranged from 5.9 to 6.2 (PSE and DFD samples were eliminated) (Gardzielewska et al., 2003; Kijowski et al., 1982; Kijowski et al., 2001; Niewiarowicz and Pikul 1979).

In the experiment chicken breast muscles were stored in controlled atmosphere. 100 breast muscle samples, each weighing about 300 g, were divided into two equal groups. The samples were PA/PE (Nordfilm–Nordform) packed or left unpacked. The packaging was performed at 4°C under standard conditions of a Poultry Plant, in accordance with ISO 9002 and HACCP, using a Multivac packaging machine, model A 300/52. A multilayer Nordfilm–Nordform foil 208 (thickness - 80 μm, weight - 78 g/m^2), with oxygen permeability (0% RH) –53, nitrogen permeability (0% RH) -21, carbon dioxide (0% RH) - 134) (Czerniawski and Michniewicz, 1998) was used. The samples, prepared for cold storage, were transported in isothermal containers (approx. 2°C) to the laboratory, where basic analyses were conducted.

Meat storage under controlled atmosphere conditions. The breast muscle samples (50 packed and 50 unpacked) were stored in a gas-tight cold room KA–600. A mixture of liquefied nitrogen and oxygen was supplied automatically from a TS–500 L'ari Liquide container. The storage conditions were as follows: temp. 2°C, concentration of gaseous nitrogen - 95%, concentration of oxygen - 5%, humidity - 40%. The composition of the gaseous mixture was controlled with an oximeter, accurate to 0.2%. Temperature was measured automatically with a Therm thermometer, and humidity was controlled with a psychrometer.

The samples were stored for 5 to 25 days, or until the meat was no longer suitable for consumption. The samples stored for 25 days under controlled atmosphere conditions were eliminated according to the following criteria: pH_u above 6.0, total microbial count per g of meat above 5 x 10^8, gray-green spots on the surface of meat and a perceptible putrefactive odor (Krala, 1999).

Meat quality assessment. In order to prepare the samples for laboratory analyses, the outer membranes and fat were removed from the surface of the muscles. The analyses were performed on muscles before storage (24 hours after slaughter) and after 5, 10, 15 and 20 days of cold storage. Meat quality was assessed taking into account weight losses during storage, pH_u, the sensory properties of muscles, and the total microbial count per g of meat. The sensory properties of meat were determined by the method described by Baryłko–Piekielna (1975). The samples, each weighing about 200 g, were cut out across fibers and cooked in a 0.62% NaCl solution at 75°C (weight ratio of the solution to the sample was 2:1). All samples were put into vessels with covers and numerical codes. The tasting was performed at 20°C. A five-point scale was used for sensory quality assessment. The following attributes were taken into account: aroma, juiciness, tenderness and palatability. The assessment was made by five panelists selected for their above-average sensory sensitivity, during three independent sessions. The total count of aerobic bacteria was determined by the flooding method described by Burbianka and Pliszka (1971), on plate count agar. The cultures were incubated at 23°C for 72 hours.

The results were analyzed statistically, determining basic statistical measures ($\bar{x}$, s). The significance of differences between groups was verified by the Duncan test, using Statistica software, ver.6.0.

Results and Discussion. Table 1 presents the results of a sensory evaluation and the total microbial count in broiler chicken breast muscles, recorded before cold storage. The mean level of pH_u was 5.51 and indicated normal quality of breast muscles (Niewiarowicz and Pikul, 1979). The sensory properties of breast muscles were assessed applying a five-point scale. The scores for particular quality attributes ranged from 4.90 to 5.00 and were typical of best-quality poultry meat. A microbiological analysis showed that at the beginning of cold storage the total count of aerobes per g of meat, determined by the flooding method, was on average 3.40 E + 04; ± 2.52 E + 04 cfu, which means that the initial level of microbial contamination in chilled breast muscles remained within relevant norms (Polish Standard PN-A-86527, 1996).

Weight losses and the sensory quality of breast muscles, as dependent upon the packaging method and time of cold storage, are given in Table 2. Both in vacuum-packed (Nordfilm–Nordform) and unpacked samples weight losses increased with time, and reached a similar level after 20 days of storage, i.e. 5.23% and 5.26% respectively. It seems that considerable weight losses observed in packed samples could result from the difference in pressure between the outside and inside of the packaging, leading to increased forced juice drip. The use of foil providing a physical barrier between the product and the environment limited weight loss caused

by evaporation. In unpacked samples weight losses were most probably caused by water evaporation and spontaneous juice drip during storage (Kondratowicz and Kawałko, 2003).

Table 1. **Sensory quality and total microbial count in breast muscles of broiler chickens before cold storage, (n=10)**

Specification	Muscular tissue	$\bar{x}$	s
pH_u	*musculus pectoralis*	5,51	0,12
Aroma - intensity (points)	*musculus pectoralis*	5,00	0,00
Aroma - desirability (points)	*musculus pectoralis*	5,00	0,00
Juiciness (points)	*musculus pectoralis*	5,00	0,00
Tenderness (points)	*musculus pectoralis*	4,90	0,32
Taste - intensity (points)	*musculus pectoralis*	5,00	0,00
Taste - desirability (points)	*musculus pectoralis*	5,00	0,00
Total bacterial count (jtk/g)	*musculus pectoralis*	3,40E+04	2,52E+04

The final acidity of meat, determined after 5 days of storage (Table 2), was similar in both experimental subgroups, and indicated a normal course of post-slaughter glycogenolysis. As the time of cold storage was prolonged, the pH_u of breast muscles displayed a growing tendency. A faster rate of pH_u increase was recorded in unpacked samples, compared with vacuum-packed samples. After 20 days of storage the values of pH_u were 5.72 and 5.64 respectively.

Table 2. **Weight losses and sensory quality of breast muscles of broiler chickens depending on the packaging method and cold storage time, (n=10)**

Specification	Statistical measure	Packaging method								Statistical significance of differences
		Packed samples				Unpacked samples				
		Time of storage (days)								
		A (5)	B (10)	C (15)	D (20)	E (5)	F (10)	G (15)	H (20)	
Weight losses during storage, (%)	$\bar{x}$	0,25	1,66	4,10	5,23	0,68	2,14	2,73	5,26	H,D>A,B,E,F,G ** C>A,B,E**; G>A**
	s	±0,49	±0,99	±1,26	±3,36	±1,11	±1,47	±2,32	±3,97	
pH_u, (after storage)	$\bar{x}$	5,53	5,61	5,59	5,64	5,57	5,57	5,60	5,72	H>A,B,C,D,E,F,G** E,F,G,D,C,B>A**
	s	±0,11	±0,09	±0,14	±0,09	±0,08	±0,14	±0,14	±0,14	
Aroma - intensity, (points)	$\bar{x}$	5,00	5,00	5,00	4,90	5,00	5,00	5,00	4,20	A,B,C,E,F,G>H**
	s	±0,00	±0,00	±0,00	±0,32	±0,00	±0,00	±0,00	±0,42	
Aroma - desirability, (points)	$\bar{x}$	5,00	5,00	5,00	4,90	5,00	5,00	4,20	3,50	A,B,C,E,F,D>G,H** G>H**
	s	±0,00	±0,00	±0,00	±0,21	±0,00	±0,00	±0,79	±0,82	
Juiciness, (points)	$\bar{x}$	4,80	4,56	4,60	4,20	4,60	4,60	4,30	3,20	A,C,E,F,B,G,D>H ** A>D,G**
	s	±0,42	±0,44	±0,21	±0,42	±0,52	±0,70	±0,26	±0,42	
Tenderness, (points)	$\bar{x}$	4,95	4,80	4,70	4,65	4,90	4,40	4,40	4,35	A,E>F,G,H ** B>H**
	s	±0,16	±0,42	±0,42	±0,41	±0,32	±0,52	±0,70	±0,34	
Taste - intensity, (points)	$\bar{x}$	5,00	5,00	4,80	4,70	5,00	4,80	4,05	3,50	A,B,E,C,F,D>G,H ** G>H*
	s	±0,00	±0,00	±0,42	±0,26	±0,00	±0,42	±0,37	±0,53	
Taste - desirability, (points)	$\bar{x}$	5,00	5,00	4,80	4,65	5,00	4,80	3,65	3,05	A,B,E,G,F,D>G,H** G>H**
	s	±0,00	±0,00	±0,42	±0,24	±0,00	±0,42	±0,47	±0,16	

* significant differences at $p \leq 0,05$
** significant differences at $p \leq 0,01$

An analysis of the sensory properties of breast muscles stored under controlled atmosphere conditions showed statistically significant ($p \leq 0.05$ and $p \leq 0.01$) differences in meat quality, related to the packaging method and storage period. It was found that the sensory quality of meat deteriorated when the time of cold storage

was prolonged. These changes were less pronounced in Nordfilm–Nordform packed samples, in comparison with unpacked samples. Over the entire storage period (20 days) changes in the sensory quality of vacuum-packed breast muscles were relatively slight. A taste-panel evaluation of unpacked samples, performed after 20 days of storage, revealed distinct changes in the aroma, especially its desirability, and a rapid decrease in juiciness and palatability. Therefore, it may be assumed that according to sensory quality criteria packed and unpacked chicken breast meat should be stored in controlled atmosphere for no longer than 20 and 15 days respectively, to preserve its good quality.

The main reason for undesirable qualitative changes in stored poultry meat is bacterial microflora. The presence and growth of harmful microorganisms are factors that negatively affect both the nutritive value and sensory properties of meat (Krala, 1999). The total count of aerobic bacteria per g of muscular tissue is also a good indicator of microbiological safety. Table 3 presents the results of a microbiological analysis of broiler chicken breast muscles stored in controlled atmosphere, depending on the packaging method and time of cold storage. It was found that during 20 days of storage, the rate of microorganism growth was slower in Nordfilm–Nordform-packed samples, compared with unpacked samples. During this period the total microbial count in packed meat did not exceed the threshold limit value of 5 x 10^6 cfu per g of meat, set in the Polish Standard PN-A-86527 (1996). In unpacked samples the level of bacterial contamination exceeded the above value on the 20th day of storage, which suggested that the process of microbiological spoilage had already begun. The results of microbiological examinations show that the maximum storage life under controlled atmosphere conditions is 20 day for vacuum-packed breast muscles and 15 day for unpacked breast muscles.

Table 3. **Total microbial count in breast muscles depending on the packaging method and cold storage time, (n=10)**

Total bacterial count [jtk/g]	Statistical measures	Packaging method								Statistical significance of differences
		Packed samples				Unpacked samples				
		Time of storage (days)								
		A (5)	B (10)	C (15)	D (20)	E (5)	F (10)	G (15)	H (20)	
Pouring method	$\bar{x}$	1,03E+04	3,63E+04	1,83E+05	3,33E+05	1,87E+05	5,57E+05	3,47E+06	8,22E+07	H,G > A,B,C,D,E,F**
	se	4,38E+03	3,27E+04	1,69E+05	2,49E+05	2,91E+04	2,62E+05	6,93E+05	6,94E+07	F>A,B,C,E**
	min	4,80E+03	1,20E+04	4,70E+04	7,00E+04	1,50E+05	2,00E+05	2,50E+06	1,30E+06	D,E,C>A,B**
	max	1,60E+04	8,20E+04	4,10E+04	7,20E+05	2,40E+05	8,30E+05	4,60E+06	1,80E+08	H>G**

** - significant differences at a level of $p \leq 0,01$

Conclusions. The results of a study on the sensory and microbiological properties of broiler chicken breast meat stored in a controlled atmosphere (95% nitrogen, 5% oxygen), affected by the packaging method and storage period, enabled to formulate the following conclusions:

1. Changes in the sensory properties of broiler chicken breast muscles were related to the packaging method and storage time. The sensory quality of meat (especially aroma, juiciness and tenderness) deteriorated when the time of cold storage was prolonged to 20 days. The rate of these undesirable changes was faster in unpacked samples than in packed ones.

2. A microbiological analysis of breast muscles, based on total microbial count per g, showed that microbial contamination was at a safe level in packed samples stored under controlled atmosphere for 20 days, and in unpacked samples stored for 15 days.

References

1. Baryłko–Pikielna N. Zarys analizy sensorycznej żywności. Warszawa. 1975. 210 s.

2. Buchmüller J. Gaseanwendungstechnik in der Lebensmitteltechnologie. Tendenzen und neue Entwicklungen Fleischwirtschaft. 1990. Vol. 70(7). P. 753–758.

3. Burbianka M., Pliszka A. Mikrobiologia żywności. Warszawa.1971. 174 s.

4. Czerniawski B., Michniewicz J. Opakowania żywności. Food Technology, Czeladź. 1998. 358 s.

5. Gardzielewska J., Jakubowska M., Buryta B., Karamucki T., Natalczyk–Szymkowska W. Zmiany pH_1 a jakość mięsa kurcząt brojlerów. Medycyna Wet. 2003. Vol. 59(3). P. 426 – 428.

6. Jankowski S. Ocena jakości materiałów opakowaniowych oraz opakowań z tworzyw sztucznych. Opakowania. 2003. Vol. 6. P. 6–8.

7. Kijowski J., Niewiarowicz A., Kujawska–Biernat A. Biochemical and technological characteristics of hot chicken meat. J. Food Technol. 1982. Vol. 17 (5). P. 553–560.

8. Kijowski J., Cegielska–Radziejewska A., Krala L. Shelf – life extension of meat and its further processed products stored under modified atmosphere packaging (MAP). Pol. J. Food Nutr.Sci. 2001. Vol. 10 (51). P. 4, 3–12.

9. Kondratowicz J., Kawałko P. Zmiany właściwości

fizykochemicznych i mikrobiologicznych mięsa kurcząt brojlerów w zależności od metody i czasu przechowywania chłodniczego. Żywność. Nauka. Technologia. Jakość. 2003. Vol. 4 (37).P. 184–193.

10. Krala L. Oddziaływanie atmosfery kontrolowanej i modyfikowanej na właściwości chłodzonego mięsa kurcząt. Wyd. Nauk. Politechniki Łódzkiej. Rozp. Nauk. 1999. Vol. 255. 5–141.

11. Niewiarowicz A., Pikul J. pH – Wert der Hautoberfläche von der Schlachtung als Indikator für PSE und DFD – Fleisch bei Broilern. Fleischwirtschaft. 1979. Vol. 59 (3). S. 405–407.

12. Polska Norma PN–A–86527. Produkty drobiarskie. Półprodukty z surowego mięsa drobiowego. Wymagania i metody badań. 1996. 359 s.