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Changes in the texture of scalded sausages stored under modified atmosphere conditions

Änderung der Textur von unter modifizierter Atmosphäre aufbewahrten Brühwürsten

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Summary

The objective of the study was to determine changes in the texture of processed cooked sausages stored in a modified atmosphere (MAP) and to indicate the most beneficial storage method. The experimental materials comprised cooked sausages, i. e. coarsely-ground ham sausages and finely ground sausages. The sausages were produced in accordance with standard procedures and technologies. Sausages were stuffed into artificial protein casings which provide optimal steam, meat juice and smoke permeability. The sausages were packaged in a MAP with the following composition: vacuum (P); 20 % CO_2, 80 % N_2 (A1); 50 % CO_2, 50 % N_2 (A2); 80 % CO_2, 20 % N_2 (A3). The samples were stored at around 4 °C (±1 °C) for 15 days. The experiment was performed in eight series. Three samples were collected and analyzed each time. Measurements were performed at the completion of the production process and at three-day intervals (day 0, 3, 6, 9, 12, 15) throughout the storage period. The following texture parameters were analyzed during storage: hardness, elasticity, gumminess, chewiness. Meat products packaged in vacuum featured an increase in the following texture parameters: hardness, gumminess, chewiness. Neither increases nor decreases were noted in springiness values over the entire storage period, regardless of the packaging method. It was found that storing meat products in a MAP had a non-significant effect on changes in texture parameters.

Keywords: Cooked sausages, storage, modified atmosphere, texture parameters

Zusammenfassung

Ziel der durchgeführten Arbeiten war es, Änderungen von Parametern der Textur von Brühwürsten, die unter modifizierter Atmosphäre aufbewahrt werden, zu bestimmen sowie auf die günstigste Aufbewahrungsmethode hinzuweisen. Das Untersuchungsmaterial waren Brühwürste mit unterschiedlichem Zerkleinerungsgrad. Die Würste wurden nach Standardrezepten und -technologien hergestellt. Zum Füllen der Würste sind wasserdampf-, fleischsaft-, rauch- und luftdurchlässige Eiweiß-Kunststoffdärme verwendet worden. Nach Beendigung des Produktionsprozesses sind sie in mit modifizierter Atmosphäre gefüllten Verpackungen untergebracht worden. Es wurden 4 Varianten angewandt und zwar Vakuum (P) oder 20 % CO_2, 80 % N_2 (A1) oder 50 % CO_2, 50 % N_2 (A2) oder 80 % CO_2, 20 % N_2 (A3). Die Produkte wurden bei einer Temperatur von ca. 4 °C (±1 °C) 15 Tage lang aufbewahrt. Es wurden 8 Untersuchungsserien durchgeführt. Es wurden jeweils 3 Proben entnommen und analysiert. Die Bestimmungen wurden nach der Herstellung sowie nach 3, 6, 9, 12, 15 Tagen Lagerung vorgenommen. Während der Aufbewahrung wurden folgende Texturparameter untersucht: Härte, Elastizität, Gummiartigkeit, Kaubarkeit. Bei den in Vakuumverpackungen aufbewahrten Produkten wurde der Anstieg des Wertes folgender Texturparameter beobachtet: Härte, Gummiartigkeit, Kaubarkeit. Bei der Elastizität wurden keine deutlich steigenden oder fallenden Tendenzen während der gesamten Aufbewahrungszeit in unterschiedlichen Verpackungsarten festgestellt. Es wurde nachgewiesen, dass die Aufbewahrung von Fleischprodukten unter modifizierter Atmosphäre unerheblich die Änderung von Texturparametern beeinflusst.

Schlüsselwörter: Brühwürste, Aufbewahrung, modifizierte Atmosphäre, Texturparameter

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Introduction

The methods of storing meat are being continuously improved so as to extend the shelf-life and preserve the desirable quality attributes of meat products. Modified atmosphere packaging (MAP) is a modern preservation method used for prolonging the shelf-life of fresh and minimally processed foods.

Modified atmosphere packaging has evolved from the vacuum packaging technique which has been in use for many years. In this process, the internal atmosphere surrounding a product is modified with a selection of gases. This solution enhances the quality of the end product (Andres et al., 2002; Czerniawski and Sarzynski, 1996; Gajewska-Szczerbal, 2005; Jayas and Jeyamkondan, 2002; Rubio et al., 2008; Ruiz et al., 2002; Summo et al., 2010).

Texture is one of the key criteria used by consumers to evaluate the quality and freshness of meat products. Texture is defined as a set of mechanical, geometrical and surface properties of a food product, perceived and detected through the senses of humans and animals (Hylding and Nielsen, 2001; Szczesniak, 1977; Palka, 2000; PN-ISO 1999). Texture comprises independent parameters (hardness, cohesiveness, elasticity, viscosity, adhesiveness) and dependent parameters (brittleness, chewiness, gumminess). The texture of meat and meat products is affected by in vivo and postmortem factors. The former include the breed, age, sex and anatomical traits of animals, muscle type, strain put on muscles, pre-slaughter handling and other. The latter include carcass chilling, postmortem aging, the use of physical, chemical, biochemical and enzymatic methods to improve meat texture (electrical stimulation, hanging of half-carcasses, the application of enzymes, calcium salts, magnesium salts, lactates) and other (Panea, 2003; Ruiz de Huidobro, 2005; Sañudo et al., 2003). The texture of meat is determined to the greatest extent by myofibrillar and connective tissue proteins which are an integral part of muscle tissue structure (Bajley and Light, 1989). Meat texture is also affected by cytoskeletal proteins and intracellular muscle water (Jeleníková et al., 2008; Pospiech and Grzes, 1997). Changes in the structure of sarcomeres, observed particularly upon heating, also determine the texture of meat products (Palka, 2000; Ruiz de Huidobro, 2005; Sañudo et al., 2003). Finally, the texture of meat and meat products is influenced by storage methods and the composition of modified atmosphere (Eilers et al., 1996; Grobbel et al., 2008; Kim et al,. 2010; Lund et al., 2007; Lund et al., 2009; Oliete et al., 2006; Seyfert et al., 2005).

The aim of this study was to determine the effect of storage time and the composition of modified atmosphere on changes in the following texture parameters of scalded sausages: hardness, elasticity, gumminess and chewiness.

Materials and methods

Materials

The experimental materials comprised scalded sausages with varying degrees of coarseness and various processing parameters to differentiate the rate of gas diffusion from the outside to the inside of the product. The sausages were produced from class I pork (lean, non-stringy, with a fat content of up to 15 %), class IIA pork (with a fat content of up to 25 %), class III pork (with a fat content of up to 35 %), class I beef (lean, non-stringy, with a fat content of up to 15 %), class II beef (with a fat content of up to 25 %). The meat was diced into 50 mm/50 mm cubes, dry cured for 24 hours at a temperature of 4 °C±1 with the addition of 2 % curing salt mixture with the following composition: 99.4 % NaCl, 0.6 % $NaNO_2$.

Coarsely-ground sausages (CG) had the following composition: class I pork – 60 %, class I beef – 15 %, class III pork – 15 %, class II beef – 5 %, cutting fat – 5 %, water – 9 %, spices: natural pepper – 0.10 %, coriander – 0.01 %, nutmeg – 0.01 %, sugar – 0.20 %.

Finely-ground sausages (FG) had the following composition: class IIA pork – 15 %, class III pork – 20 %, class I beef – 30 %, pork chap without skin – 30 %, skin – 5 %, water – 32 %, spices: natural pepper – 0.08 %, nutmeg – 0.04 %, sugar – 0.20 %.

The following process parameters were applied in the production of coarsely-ground sausages: class I pork was diced into 40 mm/40 mm cubes, class I beef was ground in a grinder, mesh size 20 mm, and the remaining raw materials were ground in a grinder, mesh size 3 mm. The following process parameters were applied in the production of finely-ground sausages: meat was ground in a grinder, mesh size 3 mm. The ingredients were mixed with spices and were cooled with water. Artificial protein casings which provided optimal steam, meat juice and smoke permeability were filled with the stuffing using a piston stuffer to produce links with a diameter of 85 mm (coarsely-ground sausages) and 18 mm (finely-ground sausages).

The sausages were subjected to hanging at a temperature of 25 °C±5 °C for around 45 minutes, curing with hot smoke at a temperature of 50 °C±10 °C for around 75 minutes (coarsely-ground sausages) and for around 15 minutes (finely-ground sausages), and scalding at a temperature 75 °C until the inside of the link reached a temperature of 72 °C±1 (coarsely-ground sausages). At the next stage of the production process, the sausages were cooled under a stream of cold water until the inside of the link reached a temperature of 20 ºC. After 24 hours of cooling at around 4 ºC±1 ºC, the products were packaged under modified atmosphere with the following composition:

P – vacuum,
A1 – 20 % CO_2, 80 % N2,
A2 – 50 % CO_2, 50 % N2,
A3 – 80 % CO_2, 20 % N2.

The sausages were packaged in polyamide and polyethylene bags with the following permeation rates: oxygen – 35 cm^3/ (m^2 x 24 h x Pa), nitrogen – 6 cm^3 / (m^2 x 24 h x Pa), carbon dioxide – 158 cm^3 / (m^2 x 24 h x Pa), water steam – 15 g / (m^2 x 24 h). The products were packaged with the use of the Multivac A300 (Wolfertschwenden, Germany) device and were stored at around 4 ºC (±1 °C) for 15 days.

Tests were performed in eight replications. Three samples were collected and analyzed each time. Sausage samples were collected at three-day intervals: on the day of packaging (day 0) and after 3, 6, 9, 12 and 15 days of storage.

Instrumental Analysis

Texture profile analysis was performed with a Universal TA-XT2 Texture Analyzer. The Texture Expert, version 1.22 (Godalming, Surrey, UK), a computer program by Stable MicroSystems was used for data collection and calculations. Cylindrical samples, 10 mm in diameter and

height, were compressed twice to 50 % of the original height with a piston with a diameter of 75 mm. Crosshead speed was 5 mm/s. The following texture parameters were determined:

- hardness (N),
- elasticity (mm),
- gumminess (N),
- chewiness (J), (Bourne, 1978).

Statistical analysis

The results were processed statistically. Arithmetic means ($\bar{X}$) and the standard error of the mean (SEM) were calculated. The effect of atmosphere type, storage time and the atmosphere x time interaction on changes in the quality attributes of the studied products was determined by a two-factorial analysis of variance (Fisher F-test). Mean values were compared by the Newman-Keuls test at a significance level of α=0.05. Calculations were performed with the use of STATISTICA 6.0 PL software (Stanisz, 1998).

Results and discussion

Hardness

The hardness of coarsely-ground sausages before packaging was 14.63 N, and it varied non-significantly over storage. An increase was noted in the hardness of experimental sausages packaged under various atmospheric conditions. On day 15 of storage, vacuum-packaged sausages were characterized by higher hardness values that sausages packaged in modified atmosphere (Tab. 1).

The hardness of finely-ground sausages before packaging was 4.37 N. Changes in the values of this parameter observed during storage were found to be statistically non-significant, irrespective of the packaging method. After 15 days of storage, a minor increase in hardness was noted in all samples packaged under modified atmosphere. Similarly as in coarsely-ground sausages, the highest increase in hardness was reported for vacuum-packaged products (Tab. 1).

As shown by a two-factorial analysis of variance, changes in the hardness of coarsely-ground sausages were significantly affected by the type of the applied atmosphere and storage time. There was a significant interaction between the experimental factors. The above factors had no significant effect on hardness in the remaining samples (Tab. 1).

The obtained results are indicative of a higher increase in the hardness of sausages packaged under vacuum, compared with gas atmosphere. Similar observations were made by Pikul (2000). Liaros et al. (2009) demonstrated that the hardness of fermented sausages was significantly affected by packaging film permeability and drip loss. The cited authors observed a high correlation between the hardness and weight loss of low-fat fermented sausages. Vacuum packaging, in comparison with storage in the air, contributed to a decrease in drip loss and sausage hardness. In a study by Lorenzo et al. (2012), the hardness of dry-cured foal salchichón was negatively correlated with a moisture content. Zarys-Waliwander et al. (2010) studied the quality of modified atmosphere packed beef steaks (experimental gas atmospheres used in packs consisted of 40 %, 50 %, 60 %, 70 % and 80 % oxygen, with all packs containing 20 % CO_2 and the remainder being provided by the filler gas N_2). Carcasses were hung for 24 or 48 h. The cited authors noted no statistically significant changes in steak hardness during chill storage. Lund et al. (2007) demonstrated that high oxygen concentrations in modified atmosphere contribute to a decrease in the hardness and juiciness of beef. Similar results were reported by Seyfert et al. (2005) and Zarys-Waliwander et al. (2010).

Elasticity

The elasticity of chilled coarsely-ground and finely-ground sausages was 0.71 mm and 0.65 mm, respectively. Neither modified atmosphere nor storage time had a significant effect on changes in the elasticity of experimental sausages. After 15 days of storage, the initial and final values of the above parameter were similar in all samples (Tab. 2).

The F-test showed that changes in the elasticity of coarsely-ground sausages were significantly affected by storage

TABLE 1: *Changes in the hardness of experimental sausages during storage at 4 °C for 15 days (N).*

Packaging method	Storage (4 °C) period (days) 0	3	6	9	12	15
Coarsely-ground sausages						
P	14.63±0.34^{a}	15.31±0.50^{ABa}	14.86±0.80^{Aa}	15.70±0.52^{Aa}	15.15±0.62^{Aa}	17.85±0.68^{Bb}
A1	14.63±0.34^{ab}	17.95±0.67^{Ca}	17.75±0.65^{ABa}	17.45±0.32^{ABa}	13.29±0.27^{Bb}	15.67±0.52^{Ac}
A2	14.63±0.34^{a}	14.33±0.48^{Aa}	15.42±0.63^{ABa}	15.70±0.61^{Aa}	15.89±0.53^{Aa}	14.83±0.57^{Aa}
A3	14.63±0.34^{a}	16.9±0.72^{BCab}	16.71±0.68^{Bab}	17.74±0.48^{Bb}	16.44±0.52^{Aab}	16.20±0.6^{Aab}
Results of analysis of variance (F)	Atmosphere	F=8.86	p<0.001*			
	Time	F=7.18	p<0.001*			
	Interaction	F=5.21	p<0.001*			
Finely-ground² sausages						
P	4.37±0.64	4.37±0.47	4.80±0.53	5.40±0.50	4.74±0.55	5.32±0.53
A1	4.37±0.64	4.13±0.50	4.93±0.39	4.44±0.38	4.37±0.45	4.94±0.73
A2	4.37±0.64	5.01±0.63	4.18±0.51	5.23±0.22	4.68±0.37	5.19±0.43
A3	4.37±0.64	5.07±0.57	4.43±0.52	4.90±0.38	4.87±0.36	4.86±0.61
Results of analysis of variance (F)	Atmosphere	F=0.39	p=0.761			
	Time	F=1.05	p=0.393			
	Interaction	F=0.37	p=0.984			

arithmetic mean ± SEM – standard error of the mean (n=8), A, B – mean values in columns denoted with different letters are statistically significantly different (α=0.05), a, b – mean values in lines denoted with different letters are statistically significantly different (α =0.05), z – mean values in the Table are not significantly different (α=0.05), P – vacuum, A1 – atmosphere containing 20 % CO_2, 80 % N_2, A2 – atmosphere containing 50 % CO_2, 50 % N_2, A3 – atmosphere containing 80 % CO_2, 20 % N_2, * – significant at a level α=0.05, F – Fisher's F test, p – probability on level of significance p<0.05.

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TABLE 2: *Changes in the elasticity of experimental sausages during storage at 4 ºC for 15 days (mm).*

Packaging method	Storage (4 °C) period (days) 0	3	6	9	12	15
Coarsely-ground[z] sausages						
P	0.71±0.01	0.71±0.01	0.75±0.01	0.71±0.02	0.74±0.02	0.73±0.02
A1	0.71±0.01	0.73±0.01	0.71±0.01	0.73±0.02	0.75±0.02	0.75±0.01
A2	0.71±0.01	0.74±0.03	0.71±0.01	0.74±0.01	0.75±0.03	0.74±0.02
A3	0.71±0.01	0.73±0.02	0.70±0.02	0.72±0.01	0.73±0.01	0.75±0.03
Results of analysis of variance (F)	Atmosphere	F=0,15	p<0.932			
	Time	F=2.44	p<0.038			
	Interaction	F=0.67	p<0.813			
Finely-ground[z] sausages						
P	0.65±0.01	0.65±0.01	0.65±0.02	0.64±0.01	0.66±0.01	0.66±0.03
A1	0.65±0.01	0.67±0.01	0.67±0.02	0.64±0.01	0.65±0.01	0.67±0.02
A2	0.65±0.01	0.66±0.01	0.64±0.01	0.64±0.01	0.66±0.02	0.66±0.02
A3	0.65±0.01	0.66±0.01	0.64±0.01	0.64±0.02	0.66±0.01	0.67±0.01
Results of analysis of variance (F)	Atmosphere	F=0.35	p=0.786			
	Time	F=2.26	p=0.065			
	Interaction	F=0.31	p=0.993			

arithmetic mean ± SEM – standard error of the mean (n=8), z – mean values in the Table are not significantly different (α=0.05), P – vacuum, A1 – atmosphere containing 20 % CO_2, 80 % N_2, A2 – atmosphere containing 50 % CO_2, 50 % N_2, A3 – atmosphere containing 80 % CO_2, 20 % N_2, F – Fisher's F test, p – probability on level of significance p<0.05.

time. The type of the applied atmosphere and storage time had no significant influence on changes in the elasticity of finely-ground sausages (Tab. 2).

Liaros et al. (2009) reported that neither packaging method nor ripening time had a significant effect on the elasticity of low-fat and high-fat fermented sausages stored under vacuum and in the air. According to Lorenzo et. al. (2012), the elasticity of meat products is affected by moisture content, and it tends to decrease as a result of water loss.

Gumminess

The gumminess of coarsely-ground and finely-ground sausages before packaging was 7.12 N and 1.92 N, respectively. Modified atmosphere had a significant effect on changes in the gumminess of coarsely-ground sausages, whereas the gumminess of finely-ground sausages did not change significantly throughout storage. On day 15 of storage, gumminess values were similar in all samples, irrespective of the packaging method (Tab. 3).

The analysis of variance revealed that storage time, atmosphere type and the interaction between these factors had no significant effect on changes in the gumminess of sausages (Tab. 3).

Liaros et al. (2009) noted no significant changes in the gumminess of low-fat (10 % initial fat) and high-fat (30 % initial fat) fermented sausages packaged under vacuum and in the air during a ripening period of 7, 12 and 17 days. The above authors found that the gumminess and chewiness of sausages were affected by film permeability. Sausages packaged in films with high and medium permeability were characterized by higher values of gumminess and chewiness than sausages packaged in film with low permeability.

TABLE 3: *Changes in the gumminess of experimental sausages during storage at 4 ºC for 15 days (N).*

Packaging method	Storage (4 °C) period (days) 0	3	6	9	12	15
Coarsely-ground sausages						
P	7.12±0.39	7.49±0.28	7.07±0.42	7.05±0.43	7.14±0.31^{AB}	7.85±0.49
A1	7.12±0.39^{ab}	7.54±0.51^{ab}	7.42±0.38^{ab}	8.07±0.22^{b}	6.72±0.21^{Aa}	7.59±0.41^{ab}
A2	7.12±0.39	7.45±0.40	7.48±0.28	7.50±0.30	8.36±0.43^{B}	7.35±0.54
A3	7.12±0.39	7.77±0.75	7.42±0.33	7.87±0.39	7.21±0.43^{AB}	7.42±0.60
Results of analysis of variance (F)	Atmosphere	F=0,40	p<0.757			
	Time	F=0.82	p<0.539			
	Interaction	F=0.82	p<0.649			
Finely-ground[z] sausages						
P	1.92±0.25	2.32±0.56	2.02±0.26	2.18±0.22	2.13±0.31	2.34±0.26
A1	1.92±0.25	1.99±0.29	2.23±0.26	1.89±0.14	1.75±0.24	2.13±0.35
A2	1.92±0.25	2.19±0.33	1.89±0.26	2.23±0.16	1.95±0.13	2.20±0.19
A3	1.92±0.25	2.25±0.30	1.97±0.26	2.20±0.24	2.12±0.14	2.06±0.27
Results of analysis of variance (F)	Atmosphere	F=0.39	p=0.763			
	Time	F=0.66	p=0.651			
	Interaction	F=0.23	p=0.999			

arithmetic mean ± SEM – standard error of the mean (n=8), A, B – mean values in columns denoted with different letters are statistically significantly different (α=0.05), a, b – mean values in lines denoted with different letters are statistically significantly different (α =0.05), z – mean values in the Table are not significantly different (α=0.05), P – vacuum, A1 – atmosphere containing 20 % CO_2, 80 % N_2, A2 – atmosphere containing 50 % CO_2, 50 % N_2, A3 – atmosphere containing 80 % CO_2, 20 % N_2, * – significant at a level α=0.05, F – Fisher's F test, p – probability on level of significance p<0.05.

TABLE 4: *Changes in the chewiness of experimental sausages during storage at 4 °C for 15 days (J).*

Packaging method	Storage (4 °C) period (days) 0	3	6	9	12	15
Coarsely-ground[z] sausages						
P	5.29±0.39	6.05±0.57	5.56±0.40	5.30±0.47	5.11±0.47	6.57±0.75
A1	5.29±0.39	6.51±0.66	5.46±0.44	6.35±0.55	5.55±0.60	5.75±0.48
A2	5.29±0.39	5.44±0.21	5.89±0.55	5.25±0.43	6.35±0.57	5.06±0.46
A3	5.29±0.39	6.14±0.44	6.00±0.64	5.82±0.35	5.76±0.36	6.49±0.60
Results of analysis of variance (F)	Atmosphere	F=0,67	p<0.571			
	Time	F=1.12	p<0.351			
	Interaction	F=0.92	p<0.545			
Finely-ground[z] sausages						
P	1.22±0.19	1.48±0.35	1.33±0.22	1.36±0.08	1.46±0.22	1.56±0.22
A1	1.22±0.19	1.51±0.35	1.45±0.23	1.26±0.13	1.21±0.18	1.48±0.25
A2	1.22±0.19	1.48±0.22	1.15±0.17	1.47±0.13	1.26±0.09	1.46±0.15
A3	1.22±0.19	1.51±0.20	1.25±0.19	1.44±0.20	1.41±0.11	1.36±0.21
Results of analysis of variance (F)	Atmosphere	F=0.09	p=0.963			
	Time	F=1.03	p=0.402			
	Interaction	F=0.21	p=0.999			

arithmetic mean ± SEM – standard error of the mean (n=8), z – mean values in the Table are not significantly different (α=0.05), P – vacuum, A1 – atmosphere containing 20 % CO_2, 80 % N_2, A2 – atmosphere containing 50 % CO_2, 50 % N_2, A3 – atmosphere containing 80 % CO_2, 20 % N_2, F – Fisher's F test, p – probability on level of significance p<0.05.

Chewiness

The initial value of chewiness of coarsely-ground and finely-ground sausages was 5.29 J and 1.22 J, respectively. Non-significant changes in chewiness were observed during storage. The average values of this parameter, determined for coarsely-ground and finely-ground sausages, did not change significantly throughout storage. On day 15, the highest chewiness values were reported for vacuum-packaged products – 6.57 J and 1.56 J in coarsely-ground and finely-ground sausages, respectively. The higher increase in chewiness noted in vacuum-packaged products resulted from greater drip formed inside the package. Other authors (Liaros et al. 2009) also found that greater drip loss was correlated with higher chewiness of meat products.

Coarsely-ground sausages were characterized by higher chewiness values than finely-ground sausages, most probably because the former contained less fat and water (5 % fat, 9 % water) than the latter (30 % fat, 32 % water) (Tab. 4). According to reference data, fat and water contained in meat products improve their elasticity and gumminess (Dransfield 2008, Keeton 1994, Lorenzo et al. 2012, Summo et al 2010).

A two-factorial analysis of variance showed that storage time, atmosphere type and the interaction between these factors had no significant effect on changes in the chewiness of sausages (Tab. 4).

The obtained results indicate that modified atmospheres composed of various gas mixtures exerted a similar effect on the texture of sausages, which was determined by the composition of the investigated products. MAP affects the texture attributes of sausages to a slight degree, thus enabling to extend the shelf-life and preserve the quality of the packaged products. Chang et al. (2002) also demonstrated that the texture of sausages stored in modified atmosphere (50 % CO_2, 50 % N_2) at a temperature of 6–8 °C for 13 days changed non-significantly. Liaros et al (2009) analyzed fermented sausages with a fat content of 10 % and 30 %, stored in the air and under vacuum for 11, 16 and 21 days, and found that vacuum packaging contributed to a decrease in hardness. Sausages with a lower fat content were harder. Throughout storage, there were no significant differences (<0.005) in texture parameters between the products packaged by various methods (vacuum, control).

The non-significant changes in the texture attributes of experimental sausages, observed during storage in modified atmosphere with various gas proportions, suggest that the applied packaging methods and storage conditions were adequate. Thus the methods and storage conditions described above are possible to be applied in the production process without any negative effects on the quality of the products.

Conclusions

One of the advantages of MAP is that this preservation technique does not significantly modify the texture parameters of scalded sausages. The hardness, gumminess and chewiness of vacuum-packaged sausages increased throughout storage, while sausages packaged under gas atmospheres were characterized by stable values of the above parameters. It seems that the above was due to greater drip formed inside the vacuum package during storage. The elasticity values of experimental sausages varied non-significantly over storage, regardless of the packaging method.

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