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# SENSORY QUALITY OF SELECTED RAW RIPENED MEAT PRODUCTS

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## ABSTRACT

**Background.** A demand on raw fermented meat products depends on their availability, price and the culture. In Poland, raw meat products have a several hundred years, although limited to the Podlasie region, tradition of manufacturing. Therefore, in spite of widening of Italian, Spanish, Portuguese, German and recently even the Czech Republic products assortment on the Polish market, the consumption of them increases slowly. The aim of the study was to compare the sensory quality of raw ripened smoked products and sausages, sold on the Polish foodstuffs market as "traditional".

**Material and methods.** The study included the basic chemical content, water activity, pH, the amount of lactic acid bacteria and coagulase-negative cocci, as well as selected texture and sensory parameters. The analysis was conducted in compliance with Polish Standards, and the cutting strength was measured with the use of the TA-XT2 texture-meter. The sensory analysis was conducted by a 12-person panel using the 5-point method.

**Results.** The differences in the amount of water, protein, fat and salt resulted from the wide variability of ingredients among both groups of the analysed cold meats. The smoked products were characterised by a higher pH (5.6-5.9), smaller amount of bacilli (2-5.5 log cfu/g) and lactic cocci (3.3 to 6.6 log cfu/g) in comparison with the sausages. The amount of both populations of bacteria in the sausages of a pH of 4.5-5.5 ranged from 6.8-8.9 log cfu/g and 5.9-7.7 log cfu/g, respectively. Among the analysed smoked products and sausages the greatest TPA hardness (respectively 128.6-140.3 N and 91.3-139.7 N), TPA chewiness (28.9-54.2 N and 16.1-36.0 N) and cutting strength (11.0-12.9 kG and 8.2-8.5 kG) was observed in those with a 0.81-0.86 water activity. The overall quality of the analysed cold meats was at a good level (3.9-4.1 pt).

**Conclusions.** Distinguishing features which determined the quality of products are hardness, juiciness as well as odour. The specific odour of the yeast cultures present on the surface of the products, the high fat content which undergoes oxidation during ripening, a high salt content, the domination of pepper among the range of spices as well as the detection of lactic and acetic acid are not accepted by Polish consumers.

**Key words:** ripened meat products, microflora, texture, sensory quality

## INTRODUCTION

The sensory quality of ripened meat products is dependent on their chemical content, the presence of acidifying and denitrificating microflora, as well as on the pH value. The presence of fat influences the texture, oral sensation as well as the juiciness of the evaluated cold meats [Olivares et al. 2010]. Fat oxidation and the coagulase-negative cocci and micrococci activity is the main source of compounds which are flavour and aroma precursors [Spaziani et al. 2009, Wójciak and Dolatowski 2012]. Salt determines the flavour,

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hydrophilicity and the colour of the products [Olivares et al. 2010]. An appropriately low pH creates the environment for biochemical changes which change the microstructure and water activity [Lücke 2000]. The development of bacteria which ferment saccharides while producing lactic acid, the accumulation of free fatty acids which are created through lipolysis as well as the products of proteolysis of an alkaline nature, modify the pH during ripening [Lücke 2000, Węsierska et al. 2012, Kołożyn-Krajewska and Dolatowski 2009]. Consumers from the countries around the Mediterranean Sea area do not accept cold meats with too sour of a flavour (pH 4.6-5.2), which is connected with average- or short-term ripening. They prefer traditional cold meats which ripen for a minimum of 6-8 weeks, with a finishing pH higher than 5.3 [Spaziani et al. 2009]. Long-term ripening is done in appropriate climatic conditions, in a temperature of 15-18°C and a relative humidity of 85-90%, lowered to 70-80% at the further stage of ripening. The temperature of the curing smoke at the time of cold smoking which lasts for several days should not be higher than 18-25°C [Konieczny et al. 1996]. Long-term ripening sausages and smoked products constitute an important segment of regional products in Italy, Spain, Portugal and France and recently even the Czech Republic [Rason et al. 2007, Roseiro et al. 2008, Salgado et al. 2005, Spaziani et al. 2009]. The aim of this work was to compare the basic chemical content, water activity, pH, amount of lactic acid bacteria and coagulase-negative cocci, texture and sensory quality of selected traditional smoked products and raw ripened sausages.

## MATERIAL AND METHODS

**Materials.** The materials for the study were traditional pork smoked products (W1-W8) and raw ripened sausages (K1-K8), available in retail trade (Table 1).

**Collection and preparation of samples.** The purchased cold meats were stored in cooling conditions of 4-6°C and sent to the laboratory within 24 hours from the moment of purchase. After separating the material for sensory analysis, 10 g of each product were aseptically weighed, homogenized (Stomacher 80, Seward) and distilled in compliance with European Standards [PN-EN ISO 6887-2:2005, PN-EN ISO 7218:2008/Ap1:2010]. The rest of the material was minced using a kitchen mixer (Multiquick Professional, Braun) and sent to physico-chemical analysis.

**Analysis.** In the analysed products water [PN ISO 1442:2000], protein [PN-75-A-04018/Az3:2002], fat [PN ISO 1444:2000] as well as the salt [PN-73-A--82112:1973] was determined. A measurement of the water activity (LabMaster-$a_w$, Novasina), as well as a pH was performed (pH-metr CP-411 with a PP-3 electrode, Elmetron). The pH was measured in a water homogenate, the proportion to mass being 1:3. The number of milk fermentation mesophile bacteria was determined in compliance with Polish standards PN ISO 15214:2002. The number of lactobacilli was determined on the MRS agar plate (Merck) with the addition of acetic acid (pH 5.4 at 25°C). The plates were incubated at 30°C for 24-48 hours in an atmosphere enriched with 20% of $CO_2$ ($CO_2$ incubator, Sheldon Manufacturing, Inc.) The number of lactic streptococci was determined on the M17 agar plate (Merck) (pH 7.2 at 25°C). The plates were incubated at 30°C for 24 hours (Water-insulating Culture Box, model GH 4500). Coagulase-negative staphylococci and micrococci were determined as in compliance with European standards PN-EN ISO 6888:2001/A1:2004 on a Baird Parker Lab-Agar plate with the addition of a chicken egg yolk emulsion and sodium tellurite (Biocorp), as well as with the Oxi Test (Plisa-Lachema Diagnostica). The plates were incubated at 37°C for 24 hours. The analysis of the overall texture profile (TPA) was conducted with the use of the TA-XT2 Stable Micro Systems texture-meter. The measurements were carried out using a compressing element in the shape of a cylinder, the diameter of its base being 50 mm. 7 samples in the shape of a cylinder with a 14 mm diameter and height of 10 mm were cut out from the slices of meat, along the muscle fibres. The samples were put through the double compression test up to 70% of their height. The speed of the cylinder's movement during the measurements was 2 mm/s, stops between presses of the compression element were 3 seconds long. The results of the measurements were compiled with the use of the Stable Micro Systems Texture Expert for Windows program, version 1.05. The hardness and chewiness were calculated. Cutting strength was measured using the TA-XT2 Stable Micro Systems texture-meter with a Warnera-Bratzler tester. Samples

**Table 1.** Characteristics of the analysed raw ripening meat products given by the producer on the product label

| Symbol | Meat materials | Additives | Technological characteristics | Origin |
|---|---|---|---|---|
| W1 | pork | sea salt, potassium nitrate | raw ham | Italy |
| W2 | pork | salt, natural aromas, protein milk, glucose syrup, sugar, dextrose, sodium nitrite, sodium acetate, sodium ascorbate, monosodium glutamate | raw ham | Germany |
| W3 | pork | salt, sugar, dextrose, sodium nitrite, potassium nitrate, sodium ascorbate | raw ham | Spain |
| W4 | pork | salt, natural aromas, sodium nitrate, potassium nitrate | raw ham | Italy |
| W5 | pork | salt, spices, natural aromas, potassium nitrate | raw ham | Italy |
| W6 | pork | salt, mix of spices, starch, soy protein, carrageenan, sodium nitrite, sodium isoascorbate, disodium pyrophosphate, monosodium glutamate | raw ham | Germany |
| W7 | pork | salt, pepper, garlic, glucose, sucrose, natural aromas, sodium nitrite, potassium nitrite, ascorbic acid | raw tenderloins | Italy |
| W8 | pork | salt, spices, dextrose, lactose, sodium nitrite, potassium nitrate, sodium ascorbate | raw tenderloins | Portugal |
| K1 | pork | salt, cayenne pepper, garlic, oregano, dextrose, lactose, whey, casein, potato starch, cochineal, carotene, natamycin, sodium ascorbate, sorbitol, monosodium glutamate | raw, medium ground, dried | Spain |
| K2 | pork | salt, herbs de provence, spices, lactose, dextrin, milk protein, sodium nitrite, potassium nitrate, sorbitol, monosodium glutamate | raw, medium ground, dried | Spain |
| K3 | pork | salt, spices, pepper, garlic, glucose, sodium nitrite, potassium nitrite, sodium ascorbate | raw, finely minced, dried | Italy |
| K4 | pork-beef | salt (maximum content 4.2%), spices, sucrose, glucose, lactose, cochineal, sodium nitrite, sodium ascorbate, sodium isoascorbate, red beets, starter cultures | raw, finely minced, dried | Czech Republic |
| K5 | pork | salt, skimmed milk, natural aromas, lactose, dextrose, sucrose, sodium nitrite, potassium nitrate, ascorbic acid, sodium ascorbate | raw, finely minced, dried | Italy |
| K6 | pork | salt, garlic, spices, glucose, sodium nitrite, potassium nitrite, sodium ascorbate | raw, finely minced, dried | Italy |
| K7 | pork-beef | salt (maximum content 4.8%), mustard, spice extracts, dextrose, sugar, sodium nitrate, potassium nitrate, potassium malate, starter cultures | raw, finely minced, dried | Czech Republic |
| K8 | pork | salt, spices, spice extracts, glucose, sodium nitrite, sodium isoascorbate, monosodium glutamate, starter cultures | raw, finely minced, dried | Italy |

were cut out of the slices in the shape of a cylinder with a 14 mm diameter and length of 15 mm. The samples of the smoked products were cut perpendicularly to the run of the muscle fibres. The speed of the movements of the cutting element during the measurements was 1.5 mm/s. The results of the measurements were compiled using the Stable Micro Systems Texture Expert for Windows program, version 1.05. The cold meats were evaluated based on a 5 point scale, assuming the following levels of quality: 4.51-5.00 (very good); 3.51-4.50 (good); 2.51-3.50 (satisfactory); 1.00-1.50 (unsatisfactory). The evaluation was conducted by a trained sensory panel of 9 people. The evaluated distinguishing features were assigned the following significance coefficients: 0.08 (overall impression), 0.08 (cross-section colour), 0.08 (cross-section structure), 0.12 (odour-intensity), 0.12 (odour-desirability), 0.08 (juiciness), 0.10 (tenderness), 0.10 (saltiness), 0.12

(flavour-intensity), 0.12 (flavour-desirability). Three products of each type were analysed. The results of the analysis, as an average of three repetitions, were compiled statistically using the Statistica 8.0 program conducting a 1-factor analysis of variations. The significance of differences between the average values was verified using the Scheffe and Duncan tests on the materiality level of $P < 0.05$.

## RESULTS

**Physico-chemical evaluation.** Smoked products contained from 41.8 (W3) to 61.7% (W6) of water, whereas sausages from 26.3 (K3) to 43.9% (K1), while the Polish standards PN-A-82007:1996/Az1:1998, as well as PN-A-82031:2005 (PN) accept water content at a level no higher than 69.0% for hams, 78% for tenderloins, 59% for finely minced and 66% for medium ground raw sausages (Table 2). The protein content of the analysed products was higher than the PN specify – in smoked products it was from 27.1 (W2) to 40.6% (W3) whereas in sausages from 18.9 (K5) to 28.0% (K7). In comparison, PN accept a minimal content of protein no lower than 17% for hams, 18% for tenderloins, 9% and 12% for finely minced and medium ground raw sausages. In comparison to the PN requirements, a lower fat content was observed in most analysed products, i.e. in smoked products up to 12.0% (according to PN up to 30% in hams and 8% in tenderloins). The fat content in raw sausages was from 28.1 (K1) to 40% (K3) (according to PN up to 30%). In smoked products W1, W2, W5, W7-8 and in the analysed sausages, the content of salt

**Table 2.** Physico-chemical properties of raw ripened meat products (mean, standard deviation, n = 3)

| Products | Physico-chemical properties | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | water, % | | protein, % | | fat, % | | salt, % | | $a_w$ | | pH | |
| | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD |
| Raw smoked products | | | | | | | | | | | | |
| W1 | 52.22[a] | 0.11 | 32.24[a] | 0.12 | 5.33[a] | 0.11 | 8.14[a] | 0.03 | 0.86[a] | 0.01 | 5.92[a] | 0.06 |
| W2 | 59.77[b] | 0.12 | 27.10[b] | 0.01 | 3.92[b] | 0.09 | 7.16[b] | 0.07 | 0.90[b] | 0.01 | 5.76[b] | 0.05 |
| W3 | 41.83[c] | 0.02 | 40.62[c] | 0.02 | 11.03[c] | 0.02 | 6.45[c] | 0.03 | 0.83[c] | 0.01 | 5.75[b] | 0.04 |
| W4 | 49.48[d] | 0.03 | 30.62[d] | 0.02 | 12.01[d] | 0.06 | 6.33[d] | 0.06 | 0.86[a] | 0.01 | 5.90[c] | 0.04 |
| W5 | 45.34[e] | 0.09 | 33.69[e] | 0.30 | 9.22[e] | 0.18 | 10.70[e] | 0.04 | 0.81[d] | 0.01 | 5.86[d] | 0.05 |
| W6 | 61.68[f] | 0.06 | 28.18[f] | 0.02 | 3.06[f] | 0.03 | 5.25[f] | 0.05 | 0.93[e] | 0.01 | 5.89[d] | 0.02 |
| W7 | 52.82[a] | 0.05 | 32.15[a] | 0.05 | 3.28[f] | 0.11 | 10.20[g] | 0.06 | 0.85[a] | 0.01 | 5.63[e] | 0.03 |
| W8 | 42.76[g] | 0.02 | 38.58[g] | 0.10 | 11.91[d] | 0.03 | 4.78[h] | 0.03 | 0.86[a] | 0.01 | 5.76[b] | 0.01 |
| Raw sausages | | | | | | | | | | | | |
| K1 | 43.86[a] | 0.07 | 22.65[a] | 0.02 | 28.15[a] | 0.12 | 3.49[a] | 0.04 | 0.86[a] | 0.03 | 5.46[a] | 0.04 |
| K2 | 31.86[b] | 0.04 | 27.01[b] | 0.03 | 37.07[b] | 0.05 | 3.25[b] | 0.05 | 0.87[a] | 0.01 | 4.60[b] | 0.02 |
| K3 | 26.26[c] | 0.04 | 27.75[c] | 0.05 | 40.00[c] | 0.05 | 5.31[c] | 0.03 | 0.82[b] | 0.01 | 5.53[c] | 0.02 |
| K4 | 36.82[d] | 0.18 | 20.69[d] | 0.15 | 37.75[d] | 0.56 | 4.21[d] | 0.03 | 0.89[c] | 0.01 | 4.52[d] | 0.01 |
| K5 | 36.40[d] | 0.05 | 18.93[e] | 0.06 | 38.65[e] | 0.05 | 5.37[c] | 0.03 | 0.88[d] | 0.01 | 5.24[e] | 0.04 |
| K6 | 42.58[a] | 0.04 | 23.53[f] | 0.03 | 29.01[f] | 0.01 | 4.42[e] | 0.03 | 0.90[e] | 0.01 | 4.74[f] | 0.02 |
| K7 | 28.33[e] | 0.09 | 27.98[c] | 0.03 | 37.70[d] | 0.07 | 5.34[c] | 0.06 | 0.81[f] | 0.02 | 5.18[g] | 0.05 |
| K8 | 34.94[f] | 0.08 | 25.20[g] | 0.08 | 35.16[g] | 0.07 | 4.47[e] | 0.03 | 0.85[g] | 0.01 | 4.81[h] | 0.02 |

[abc]Different letters in the same column indicate significant differences between means at $P < 0.05$ in the group of smoked products, as well as in the group of sausages.

was too high – according to PN the acceptable amount should not exceed 7% in hams, 3.5% in tenderloins and 3% in sausages. Smoked products were characterised by a water activity (Table 2) in the range from 0.81 (W5) to 0.93 (W6) and similar pH values i.e. from 5.6 (W7) to 5.9 (W1). In the sausage group, a smaller dispersion of water activity was observed: $a_w$ values – from 0.81 (K7) to 0.90 (K6) but a high pH – from 4.5 (K4) to 5.5 (K3) in comparison with smoked products.

**Microbiological evaluation.** The results of the microbiological analysis are presented in Table 3. The number of lactobacilli and lactococci in the smoked products, with the exception of product W1 and W3, was from 3.2 (W8) to 5.5 log cfu/g (W4) as well as from 3.7 (W8) to 6.6 log cfu/g (W5), respectively. The number of both populations in sausages, with the exception of K1, was similar and ranged from 7.0 (K5) to 8.9 log cfu/g (K7) as well as from 7.3 (K4) to 7.7 log cfu/g (K2 and K7). The presence of coagulase-positive *Staphylococcus aureus* was not observed in any of the analysed cold meats. The most coagulase-negative cocci were observed in smoked products W4 and W8 (6.0-6.1 log cfu/g) as well as in the sausages K7 (5.3 log cfu/g) and K3-4 (4.8 log cfu/g).

**Evaluation of selected texture parameters.** The results of the instrumental analysis of the texture profile, as well as the cutting strength are presented in Table 4. W5 – 140.3 and 54.2 N, as well as K8 – 139.7

**Table 3.** Count of the mesophilic lactic acid bacteria of the raw ripened meat products (mean, standard deviation, n = 3)

| Products | Microflora composition, log cfu/g | | | | | |
|---|---|---|---|---|---|---|
| | lactobacilli | | lactococci | | coagulase--negative cocci | |
| | *M* | SD | *M* | SD | *M* | SD |
| Raw smoked products | | | | | | |
| W1 | <2 | – | 4.02 | 0.19 | 5.11 | 0.15 |
| W2 | 5.43 | 0.04 | 5.92 | 0.07 | 4.56 | 0.11 |
| W3 | 2.78 | 0.06 | 3.28 | 0.04 | 3.94 | 0.20 |
| W4 | 5.49 | 0.09 | 6.13 | 0.01 | 6.04 | 0.34 |
| W5 | 3.62 | 0.02 | 6.64 | 0.03 | 4.62 | 0.03 |
| W6 | 3.62 | 0.11 | 4.49 | 0.02 | 3.87 | 0.07 |
| W7 | 3.68 | 0.14 | 4.74 | 0.02 | <2 | – |
| W8 | 3.24 | 0.12 | 3.73 | 0.15 | 6.07 | 0.12 |
| Raw sausages | | | | | | |
| K1 | 6.85 | 0.09 | 5.86 | 0.06 | 3.42 | 0.02 |
| K2 | 7.58 | 0.08 | 7.70 | 0.19 | 3.66 | 0.18 |
| K3 | 7.51 | 0.17 | 7.60 | 0.08 | 4.84 | 0.09 |
| K4 | 7.07 | 0.11 | 7.29 | 0.11 | 4.81 | 0.14 |
| K5 | 7.02 | 0.01 | 7.52 | 0.07 | 3.51 | 0.07 |
| K6 | 7.49 | 0.12 | 7.56 | 0.15 | 4.41 | 0.05 |
| K7 | 8.94 | 0.03 | 7.72 | 0.02 | 5.27 | 0.22 |
| K8 | 8.63 | 0.09 | 7.51 | 0.11 | 3.89 | 0.10 |

Explanatory notes as in Table 2.

**Table 4.** Selected parameters of TPA and cutting strength of the raw ripened meat products (mean, standard deviation, n = 3)

| Products | TPA and cutting strength | | | | | |
|---|---|---|---|---|---|---|
| | hardness, N | | chewiness, N | | cutting strength, kG | |
| | *M* | SD | *M* | SD | *M* | SD |
| Raw smoked products | | | | | | |
| W1 | $137.48^{a}$ | 0.14 | $34.54^{a}$ | 0.11 | $11.65^{a}$ | 0.05 |
| W2 | $60.56^{b}$ | 0.12 | $7.53^{b}$ | 0.15 | $5.19^{b}$ | 0.05 |
| W3 | $57.52^{c}$ | 0.12 | $5.95^{c}$ | 0.12 | $4.75^{c}$ | 0.05 |
| W4 | $83.70^{d}$ | 0.41 | $13.96^{d}$ | 0.06 | $5.65^{d}$ | 0.06 |
| W5 | $140.30^{e}$ | 0.16 | $54.22^{e}$ | 0.08 | $12.94^{e}$ | 0.12 |
| W6 | $78.08^{f}$ | 0.41 | $13.64^{f}$ | 0.20 | $7.55^{f}$ | 0.05 |
| W7 | $134.88^{g}$ | 0.11 | $28.89^{g}$ | 0.17 | $10.98^{g}$ | 0.03 |
| W8 | $128.57^{h}$ | 0.52 | $35.92^{h}$ | 0.11 | $11.87^{h}$ | 0.04 |
| Raw sausages | | | | | | |
| K1 | $49.64^{a}$ | 0.64 | $7.43^{a}$ | 0.28 | $3.65^{a}$ | 0.02 |
| K2 | $79.43^{b}$ | 0.61 | $9.31^{b}$ | 0.35 | $3.88^{a}$ | 0.04 |
| K3 | $91.27^{c}$ | 0.68 | $16.12^{c}$ | 0.17 | $8.16^{b}$ | 0.19 |
| K4 | $60.52^{d}$ | 0.33 | $9.51^{b}$ | 0.19 | $3.13^{c}$ | 0.15 |
| K5 | $15.22^{e}$ | 0.13 | $1.90^{d}$ | 0.02 | $2.58^{d}$ | 0.19 |
| K6 | $47.74^{f}$ | 0.32 | $8.06^{a}$ | 0.40 | $3.23^{e}$ | 0.24 |
| K7 | $118.26^{g}$ | 0.85 | $18.69^{e}$ | 0.38 | $8.49^{f}$ | 0.19 |
| K8 | $139.69^{h}$ | 0.38 | $35.99^{f}$ | 0.20 | $8.49^{f}$ | 0.09 |

Explanatory notes as in Table 2.

**Table 5.** Sensory quality of the raw smoked ripened cold meats (mean, standard deviation, n = 10)

| Sensory attributes | Products | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W1 | | W2 | | W3 | | W4 | | W5 | | W6 | | W7 | | W8 | |
| | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD |
| Overal impression | 4.15$^{a}$ | 0.25 | 4.30$^{b}$ | 0.17 | 4.07$^{c}$ | 0.26 | 4.60$^{d}$ | 0.46 | 3.96$^{e}$ | 0.29 | 4.31$^{b}$ | 0.45 | 4.20$^{f}$ | 0.25 | 4.65$^{d}$ | 0.58 |
| Cross-section colour | 3.86$^{a}$ | 0.38 | 4.15$^{b}$ | 0.25 | 3.96$^{c}$ | 0.38 | 4.61$^{d}$ | 0.50 | 4.01$^{e}$ | 0.41 | 4.52$^{f}$ | 0.45 | 4.07$^{e}$ | 0.18 | 4.85$^{g}$ | 0.33 |
| Cross-section structure | 4.10$^{a}$ | 0.37 | 4.21$^{b}$ | 0.13 | 3.88$^{c}$ | 0.06 | 4.08$^{a}$ | 0.20 | 3.82$^{c}$ | 0.24 | 3.88$^{c}$ | 0.19 | 4.12$^{a}$ | 0.12 | 4.31$^{d}$ | 0.17 |
| Odour | | | | | | | | | | | | | | | | |
| intensity | 3.74$^{a}$ | 0.15 | 4.20$^{b}$ | 0.42 | 4.01$^{c}$ | 0.44 | 3.66$^{d}$ | 0.17 | 3.85$^{e}$ | 0.25 | 4.30$^{f}$ | 0.45 | 3.66$^{d}$ | 0.17 | 4.12$^{b}$ | 0.57 |
| desirability | 4.23$^{a}$ | 0.45 | 4.42$^{b}$ | 0.19 | 4.00$^{c}$ | 0.17 | 4.12$^{d}$ | 0.14 | 4.03$^{c}$ | 0.16 | 4.02$^{c}$ | 0.58 | 3.97$^{c}$ | 0.58 | 3.86$^{e}$ | 0.18 |
| Juiciness | 3.71$^{a}$ | 0.18 | 3.91$^{b}$ | 0.38 | 3.68$^{a}$ | 0.29 | 3.46$^{c}$ | 0.50 | 3.53$^{c}$ | 0.58 | 3.90$^{b}$ | 0.34 | 3.48$^{a}$ | 0.44 | 3.48$^{a}$ | 0.28 |
| Tenderness | 4.31$^{a}$ | 0.17 | 4.06$^{b}$ | 0.50 | 3.98$^{b}$ | 0.29 | 4.02$^{b}$ | 0.27 | 3.88$^{c}$ | 0.49 | 4.05$^{b}$ | 0.28 | 3.92$^{b}$ | 0.22 | 3.90$^{d}$ | 0.17 |
| Saltiness | 4.07$^{a}$ | 0.26 | 3.67$^{b}$ | 0.17 | 3.71$^{b}$ | 0.38 | 3.73$^{b}$ | 0.30 | 3.89$^{c}$ | 0.49 | 3.75$^{b}$ | 0.29 | 3.41$^{d}$ | 0.24 | 4.01$^{a}$ | 0.32 |
| Flavour | | | | | | | | | | | | | | | | |
| intensity | 3.71$^{a}$ | 0.33 | 4.41$^{b}$ | 0.19 | 4.11$^{c}$ | 0.24 | 3.91$^{d}$ | 0.24 | 4.20$^{e}$ | 0.25 | 3.85$^{d}$ | 0.38 | 4.16$^{c}$ | 0.25 | 3.62$^{a}$ | 0.36 |
| desirability | 3.72$^{a}$ | 0.19 | 3.66$^{a}$ | 0.32 | 4.03$^{b}$ | 0.22 | 3.83$^{c}$ | 0.53 | 3.60$^{a}$ | 0.17 | 3.98$^{d}$ | 0.14 | 3.66$^{a}$ | 0.16 | 3.85$^{c}$ | 0.37 |
| Overall evaluation | 3.95 | | 4.10 | | 3.95 | | 3.98 | | 3.88 | | 4.05 | | 3.86 | | 4.03 | |

$^{abc}$Different letters in the same row indicate significant differences between means at $P < 0.05$ in the group of smoked products as well as in the group of sausages.

and 36.0 N were characterised by the highest value of TPA hardness and TPA chewiness. The biggest value of cutting strength for these products was noted to be 12.9 and 8.5 kG, respectively.

**Sensory evaluation.** The results of the sensory evaluation are presented in Tables 5 and 6. Products W2 (4.1 pt), W6 (4.0 pt) and W8 (4.0 pt), as well as K1, K4-7 (4.1 pt) were given the highest overall evaluation. Smoked products with the biggest hardness TPA, chewiness TPA and cutting strength (products W5, W7-8) were noted to be the hardest (3.9 pt) and the least tender (3.5 pt). It was similar in the group of sausages – products K3, K7-8 were stated to be too hard (3.3-3.7 pt) and unsatisfactorily tender (3.3-3.6 pt). Smoked products W2 and W6, as well as sausage K5-7 were characterised by the most intense odour (4.0-4.3 pt) and flavour (3.8-4.8 pt).

## DISCUSSION

Most of the analysed products met the standards of the Polish standards PN-A-82007:1996/Az1:1998, as well as PN-A-82031:2005 for raw ripening cold meats when it comes to the content of water, protein and fat. The differences in the content of water, protein, fat and salt were the result of the wide variability of ingredients used among both groups of the analysed cold meats. Due to the drying process, the amount of fat could even increase by up to about 18% whereas protein and salt by 6% [Olivares et al. 2010]. The increase of the amount of particular chemical elements during the ripening process as well as during the post-production storage was a natural phenomenon and effected the sensory quality of ready-to-eat products. The marks of the flavour intensity were higher than

**Table 6.** Sensory quality of the raw ripened sausages (mean, standard deviation, n = 10)

| Sensory attributes | Products | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | K1 | | K2 | | K3 | | K4 | | K5 | | K6 | | K7 | | K8 | |
| | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD |
| Overal impression | 3.89$^{a}$ | 0.49 | 3.75$^{b}$ | 0.29 | 3.73$^{b}$ | 0.30 | 4.00$^{c}$ | 0.44 | 3.86$^{a}$ | 0.33 | 4.41$^{d}$ | 0.24 | 4.60$^{e}$ | 0.20 | 4.15$^{f}$ | 0.44 |
| Cross-section colour | 4.56$^{a}$ | 0.18 | 4.15$^{b}$ | 0.35 | 4.36$^{c}$ | 0.23 | 4.20$^{d}$ | 0.13 | 3.62$^{e}$ | 0.21 | 4.17$^{d}$ | 0.32 | 4.05$^{f}$ | 0.18 | 4.05$^{f}$ | 0.26 |
| Cross-section structure | 3.91$^{a}$ | 0.27 | 3.78$^{b}$ | 0.42 | 4.41$^{c}$ | 0.22 | 4.60$^{d}$ | 0.20 | 4.02$^{e}$ | 0.24 | 4.21$^{f}$ | 0.16 | 4.30$^{g}$ | 0.32 | 4.47$^{c}$ | 0.27 |
| Odour | | | | | | | | | | | | | | | | |
| intensity | 4.38$^{a}$ | 0.17 | 3.85$^{b}$ | 0.34 | 4.06$^{c}$ | 0.25 | 4.10$^{c}$ | 0.24 | 4.26$^{d}$ | 0.35 | 4.26$^{d}$ | 0.35 | 4.30$^{a}$ | 0.17 | 4.30$^{a}$ | 0.32 |
| desirability | 3.61$^{a}$ | 0.47 | 3.40$^{b}$ | 0.26 | 3.77$^{c}$ | 0.32 | 3.99$^{d}$ | 0.10 | 4.38$^{e}$ | 0.09 | 4.28$^{f}$ | 0.14 | 3.87$^{g}$ | 0.11 | 3.66$^{a}$ | 0.44 |
| Juiciness | 4.41$^{a}$ | 0.44 | 4.05$^{b}$ | 0.23 | 3.36$^{c}$ | 0.31 | 4.20$^{d}$ | 0.14 | 3.82$^{e}$ | 0.53 | 3.61$^{f}$ | 0.35 | 3.56$^{f}$ | 0.48 | 3.35$^{c}$ | 0.50 |
| Tenderness | 4.10$^{a}$ | 0.34 | 4.10$^{a}$ | 0.17 | 3.70$^{b}$ | 0.17 | 4.21$^{c}$ | 0.13 | 3.92$^{d}$ | 0.50 | 3.81$^{e}$ | 0.25 | 3.31$^{f}$ | 0.17 | 3.28$^{f}$ | 0.31 |
| Saltiness | 4.08$^{a}$ | 0.20 | 4.08$^{a}$ | 0.12 | 4.01$^{a}$ | 0.27 | 3.85$^{b}$ | 0.17 | 3.76$^{b}$ | 0.29 | 4.16$^{c}$ | 0.21 | 4.25$^{c}$ | 0.29 | 3.84$^{b}$ | 0.37 |
| Flavour | | | | | | | | | | | | | | | | |
| intensity | 4.00$^{a}$ | 0.12 | 4.18$^{b}$ | 0.14 | 3.91$^{a}$ | 0.25 | 3.95$^{a}$ | 0.16 | 4.81$^{c}$ | 0.28 | 4.30$^{d}$ | 0.17 | 4.31$^{d}$ | 0.48 | 3.95$^{a}$ | 0.58 |
| desirability | 3.88$^{a}$ | 0.35 | 3.62$^{b}$ | 0.16 | 3.98$^{a}$ | 0.28 | 3.73$^{c}$ | 0.65 | 3.95$^{a}$ | 0.26 | 3.93$^{a}$ | 0.29 | 4.02$^{a}$ | 0.40 | 3.62$^{b}$ | 0.48 |
| Overall evaluation | 4.06 | | 3.88 | | 3.93 | | 4.06 | | 4.08 | | 4.12 | | 4.06 | | 3.86 | |

Explanatory notes as in Table 5.

the marks of the flavour desirability in the sensory examination of raw smoked products and sausages. The implication of it was that there were no tolerance for the high fat content, the oxidation, a high salt content, the domination of pepper among the range of spices as well as for the detection of lactic and acetic acid. The character of the examined products does not match what Polish consumers expect. The chemical compounds obtained on the way of enzymatic (about 20%) and non-enzymatic (about 80%) oxidation of unsaturated fatty acids are accountable for the aroma bouquet of raw ripened meat products. The salt concentration of 3-4% may also increase the enzymatic oxidation and impart the negative flavour in fermented meat products [Wójciak et al. 2012]. The presence of starter cultures (among others *Pediococcus acidilactici*, *Lactobacillus*, *plantarum*, *Staphylococcus carnosus* strains), as well as protective antioxidants (ascorbic acid, sodium ascorbate, sodium isoascorbate) may sufficiently stabilize and protect the meat products during ripening [Casaburi et al. 2007, Kołożyn-Krajewska and Dolatowski 2009]. However, the composition of individual strains has to be well-advised. The high levels of saccharides (15 g/kg or higher) and excessive growth of lactic acid bacteria may result in the inhibition of staphylococci cells multiplication (which produce catalase and peroxidase) and loss of the meat colour at the end of the ripening [Wójciak and Dolatowski 2012]. Fermenting bacteria with the formation of lactic acid as well as odour and colour forming coagulase-negative cocci were noted in all analysed meats, though the count of staphylo- and micrococci was about 3-4 lower then lactic acid bacteria in sausages. The comparison of the amount of lactobacilli and lactococci as well as the presence of saccharides in the recipe composition (glucose,

sucrose, lactose, dextrose) proved the use of mixed starter cultures, although uncommon, they have been reported by producers. Nitrates added to protect the colour and aroma were not found only in K1 product. From the analysis of the ingredients, chemical content as well as the sensory quality it can be deduced that the most popular smoked products when it came to odour (3.9-4.4 pt) and flavour (3.7-4.0 pt) contain the highest nutritional value in animal protein (30.6--40.6%) and fat (6.3-12.0%) as well as the least water (41.8-52.2%). What is more, they are characterized by the smallest water activity (0.81-0.86) and the greatest hardness TPA (128.6-140.3 N), TPA chewiness (28.9-54.2 N) as well as cutting strength (4.5-12.9 kG). The sausages are evaluated differently – products containing the most protein (25.2-28.0%) and fat (37.7-40.0%), the least water (25.3-35.9%), the smallest water activity (0.81-0.85) and the greatest TPA hardness (91.3-139.7 N), TPA chewiness (16.1--36.0 N), as well as cutting strength (8.2-8.5 kG) obtained the lowest general grade (3.9-4.1 pt).

## CONCLUSION

Distinguishing features which determined the quality of products are: hardness, juiciness as well as odour. The specific odour of the yeast cultures presents on the surface of the products, the high fat content which undergoes oxidation during ripening, a high salt content, the domination of pepper among the range of spices, as well as the detection of lactic and acetic acid are not accepted by Polish consumers. The most popular raw smoked products when it came to odour and flavour contain the highest nutritional value in animal protein and fat, as well as the least water. The same products are characterised by the smallest water activity and the greatest TPA hardness, TPA chewiness and cutting strength. The sausages are evaluated differently – products containing the most protein and fat, the least water, the smallest water activity and the greatest TPA hardness, TPA chewiness as well as cutting strength obtained the lowest general grade in the sensory evaluation.

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## JAKOŚĆ SENSORYCZNA WYBRANYCH SUROWYCH WĘDLIN DOJRZEWAJĄCYCH

### STRESZCZENIE

**Wstęp.** Popyt na surowe wędliny fermentowane jest uzależniony od ich dostępności, ceny oraz kultury. W Polsce surowe wyroby mięsne mają kilkusetletnią, choć ograniczoną do terenów Podlasia, tradycję wytwarzania. Może dlatego ich spożycie wzrasta powoli, mimo zwiększenia na rynku polskim asortymentu produktów włoskich, hiszpańskich, portugalskich, niemieckich, a ostatnio nawet czeskich. Celem pracy było porównanie jakości sensorycznej wędzonek i kiełbas surowych dojrzewających oferowanych na rynku żywnościowym w Polsce jako wyroby „tradycyjne".

**Materiał i metody.** Określono podstawowy skład chemiczny, aktywność wody, pH, liczbę bakterii kwasu mlekowego i ziarniaków koagulazo-ujemnych oraz wybrane parametry tekstury. Analizy wykonano według obowiązujących polskich norm, siłę cięcia mierzono z użyciem teksturometru TA-XT2. Analizę sensoryczną przeprowadził 12-osobowy panel metodą 5-punktową.

**Wyniki.** Różnice w zawartości wody, białka, tłuszczu oraz soli wynikały z dużej zmienności surowcowej w obrębie obu badanych grup wędlin. Wędzonki charakteryzowało wyższe pH (5,6-5,9), mniejsza liczba pałeczek (2-5,5 log jtk/g) oraz ziarniaków mlekowych (od 3,3 do 6,6 log jtk/g) w porównaniu z kiełbasami. Liczebności obu populacji bakterii w kiełbasach o pH 4,5-5,5 mieściły się w zakresach odpowiednio 6,8-8,9 log jtk/g i 5,9-7,7 log jtk/g. Przebadane wędzonki i kiełbasy o aktywności wody 0,81-0,86 charakteryzowały się największą twardością TPA (odpowiednio 128,6-140,3 N i 91,3-139,7 N), żujnością TPA

(28,9-54,2 N i 16,1-36,0 N) oraz siłą cięcia (11,0-12,9 kG i 8,2-8,5 kG). Jakość ogólna analizowanych wędlin była na poziomie dobrym (3,9-4,1 pkt).
**Wnioski.** Wyróżnikami decydującymi o jakości wędlin są twardość, soczystość oraz zapach. Specyficzny zapach kultur drożdży obecnych na powierzchni wyrobów, wysoki udział tłuszczu podlegającego oksydacji w czasie dojrzewania, duża zawartość soli, dominacja pieprzu w zestawie przypraw oraz wyczuwalność kwasu mlekowego i octowego nie znajduje akceptacji u polskich konsumentów.

**Słowa kluczowe:** wyroby mięsne, mikroflora, tekstura, jakość sensoryczna

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