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# QUALITY OF SOPOCKA PORK LOIN WRAPPED DIRECTLY POST THERMAL TREATMENT OR AFTER CHILLING AND STORED AT NEAR CRYOSCOPIC TEMPERATURE

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Key words: sopocka pork loins, time of packaging, cryoscopic storage, quality

The purpose of the study was to assess the quality of sopocka pork loin, packed into thermo-shrinkable bags directly after production (group H) or after 12-h chilling (group C). The pork loins of both the groups were stored at near cryoscopic temperature (n.c.t.), -3.0ºC, for 84 days. In spite of the increase in free amino group concentration, the twelve-week storage of sopocka loin from both the groups (H and C) at near cryoscopic temperature reflected neither in the decrease of color stability nor in the significant loss of general sensory value. The product examined remained also microbiologically safe.

## INTRODUCTION

The stability of meat products depends on numerous factors including the microbiological quality of raw material [Borch & Arinder, 2002; Huffman, 2002; Lahr, 1996; Nutsch *et al*., 1998], the sanitary conditions during production [Brewer *et al*., 1993; John *et al*., 2005; Lahr, 1996], the efficiency of preservation [John *et al*., 2005; Leistner, 1992, 1995; Lucke, 1995], the technology of wrapping and storage conditions [Borch & Arinder, 2002; Gill, 1996; John *et al*., 2005; Leistner, 1995; Majczyna & Białasiewicz, 2001; Pikul, 2001]. Secondary microbiological contamination of products during their post production chilling or in the course of storage and distribution constitutes a significant risk factor of decreased stability [Gill, 1996; Holley, 1997; Rywotycki, 2000a, b, 2001a, b, 2002]. The present paper deals with the question of shelf life of food products. The aim of the experiment was to assess the quality of sopocka loin vacuum packed with/without the previous chilling and stored at -3ºC for 84 consecutive days.

## MATERIAL AND METHODS

Sopocka loins, each of *ca.* 350 g, manufactured in 3 series under laboratory conditions, were subject of the study. The products were made of *longissimus thoracis* muscle (pH=6.3) of Polish Large White pigs free from PSE. The meat was cured with standard brine containing salt, polyphosphates, carrageen, sucrose, sodium glutamate, isoascorbate and water. After 40% injection with the brine, the meat was massaged in PEK-mont type machine for 17 h and smoked at 60ºC for 120 min. Subsequently the pork loins were scalded at 85ºC to the end-point temperature of 72ºC. Directly after thermal treatment one half of experimental products was vacuum packed hot into thermo-shrinkable bags (group H), (Figure 1). The bags were water-shrunk at

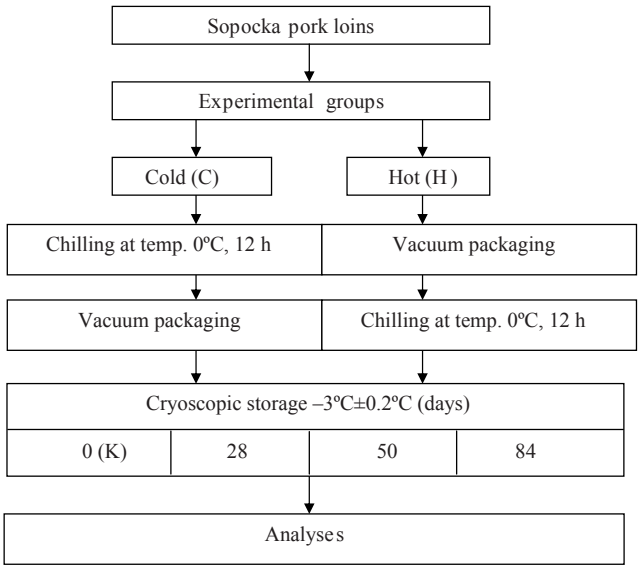


FIGURE 1. Scheme of experiment organization.

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95ºC (60 sec) and chilled in the air (0ºC) for 12 h. Remaining loins (group C), after thermal treatment, were chilled in the air (0ºC) for 12 h and packed into thermo-shrinkable bags as described for products from group H. The pork loins of both the groups were subsequently stored at -3.0±0.2ºC for 84 days.

Physicochemical and microbiological analyses and the total sensory evaluation of control loins were performed 12 h after production (K). The remaining samples were evaluated after 28, 56 and 84 days of storage.

Physicochemical analyses included: pH value, minimal temperature of subcooling (m.t.sc.), cryoscopic temperature (c.t.), free nitrate(III) concentration, free amino acid group content, colour parameters (L*, a*, b*) and colour stability (E6, E12, E24).

Microbiological analyses considered the following parameters: total plate count, the count of psychrotrophic bacteria, the presence of coliforms, *Escherichia coli*, lactic acid fermentation bacteria and yeasts and moulds (in 1 g), coagulase-positive staphylococci and sporogenic anaerobic bacilli (in 0.1 g) and *Salmonella* spp. (in 25 g).

The pH values were determined using a Microcomputer CP-551 pH-meter. Cryoscopic temperatures and minimal temperatures of subcooling were measured by means of the thermographic method described by Szmańko [1998]. Free nitrate(III) concentrations were determined according to Polish Standard [PN-74/A-82114] method, and free amino group content – using the method of Kuchroo *et al.* [1983]. Colour parameters were recorded in L*, a*, b* system. Particular color variables were measured on freshly-cut 10 mm slices of loin, using a CR-200b reflection colorimeter (Minolta). The stability of color Δ(E) in loin slices was determined after 6, 12 and 24 h of exposure to white glow light (250 lx). The following formula was used:

$$\Delta E_6 = \sqrt{\Delta(L_o^* - L_6^*)^2 + \Delta(a_o^* - a_6^*)^2 + \Delta(b_o^* - b_6^*)^2}$$

where: $\Delta E_6$, $\Delta E_{12}$, $\Delta E_{24}$ – stability o colour after 6, 12 or 24-h of pork loins exposure to light; $L_o^*$, $a_o^*$, $b_o^*$ - values of parameters $L^*$, $a^*$, $b^*$ colour of pork loins with no exposure to light; $L_6^*$, $a_6^*$, $b_6^*$ - values of parameters $L^*$, $a^*$, $b^*$ colour of pork loins after 6-h of pork loins exposure to light.

The total sensory value of experimental loins was determined using the method of multiple comparisons following the guidelines of Polish Standard [PN-ISO 6564:1999] with 5-point scale employed.

Microbiological parameters were analysed following the current Polish Standards: total plate count and the count of psychrotrophic bacteria – PN-EN ISO 4833:1998, coliforms – PN-ISO 4832:1998 [1998], *Escherichia coli* – PN-ISO 6391:2000, lactic acid fermentation bacteria – PN-A-82055 [1997], *Salmonella* spp. – PN-EN ISO 6579:2003, coagulase-positive staphylococci PN-A-82055-9:1994, anaerobic sporogenic bacilli – PN-A-82055-12:1997, yeasts and moulds – PN-ISO 7954:1999.

Statistical analysis of the results was carried out using ANOVAN software. Univariant analysis was performed and the differences between mean values were considered significant at $p<0.05$.

## RESULTS AND DISCUSSION

The concentration of hydrogen ions in products stored is a consequence of their chemical and microbiological changes [Romans *et al*., 1994]. The pH of smoked meats usually ranges from 5.90 to 6.40 [Olszewski, 1999]. The concentration of hydrogen ions in the material studied fits within the aforementioned range (Table 1).

The initial pH of sopocka loins amounted to 6.22 and 6.25 for the products packed traditionally (cooled) and hot (H), respectively. The pH of the loins of group H was significantly higher than that of the ones packed after chilling. The higher pH might result from the wrapping of hot products directly after thermal treatment. The decrease of pressure in the package containing hot loin resulted in transitory boiling of water inside the meat. Consequently, the thermal treatment of group H products was prolonged. Since the exposure of meat and its products to high temperature is known to increase pH [Roberts & Lawrie, 1974; Szmańko, 1998; Webb, 1967], the additional thermal treatment might result in the higher hydrogen ion concentration in hot packed loins.

After 28-day storage, the pH slightly decreased to 6.21 and 6.20 for products packed cooled and without chilling, respectively. The further storage was reflected in a significant decrease in the parameter discussed to 6.11 (C), 6.12 (H) and 6.03 (C), 6.04 (H) after 56 and 84 days, respectively. The tendency to pH decrease during the storage of smoked meats was already demonstrated in our previous studies [Szmańko,1998].

The storage of meat products at near cryoscopic temperature is connected with the risk of their freezing. The hazard might be decreased by the standardization of product m.t.sc. and c.t. and the limitation of temperature amplitude inside the cryocooler. The knowledge on changes in m.t.sc. and c.t. occurring during the storage of food products is of high importance as well. The tendency of changes in m.t.sc. and c.t. might be, however, difficult to predict. Generally, it is assumed that the values of m.t.sc. and c.t. decrease with storage, particularly in the case of unpacked food. The aforementioned changes reflect the condensation of product ingredients resulting from the loss of water [Bald, 1991; Gołowkin *et al.,* 1987].

The lowest value of c.t. (-3.82ºC) was demonstrated in the control loins of group C (Table 1). The significant increase in c.t. values was observed during the subsequent storage. At the end of the experiment, on the 84$^{th}$ day, c.t. was the highest, reaching –2.79ºC. The value of c.t. was not influenced by the packaging technique at any of the storage periods.

Conversely, the values of m.t.sc. were the highest in control samples C and H (-4.09 and –4.10ºC, respectively). Subsequently, the values of m.t.sc. decreased systematically and significantly, to reach –7.96 (C) and –7.99ºC (H) by the 84$^{th}$ day of storage (Table 1). Similarly to c. t., the value of m.t.sc. was not influenced by the method of packaging.

There is the logical interpretation for the observed values of c.t. and m.t.sc. Shortly after production, electrolyte distribution within the meat is probably highly disturbed. In the compartments of meat with a lower electrolyte concentration, relatively lower temperatures might cause freezing and consequently the value of m.t.sc. is decreased. Only few cen-

TABLE 1. Physicochemical and sensory parameters of sopocka pork loins wrapped directly post thermal treatment (H) or after chilling (C) and stored at -3ºC.

| Method of packaging | | Time of storage (days) | | | |
|---|---|---|---|---|---|
| | | 0(K) | 28 | 56 | 84 |
| | | Value of pH | | | |
| C* | $\bar{X}$ | $6.22a^{C}$ | $6.22^{C}$ | $6.11^{B}$ | $6.03^{A}$ |
| | Sd | 0.03 | 0.03 | 0.04 | 0.05 |
| H | $\bar{X}$ | $6.25b^{D}$ | $6.21^{C}$ | $6.12^{B}$ | $6.04^{A}$ |
| | Sd | 0.02 | 0.03 | 0.02 | 0.02 |
| | | Free amino group content (µg Gly/g) | | | |
| C | $\bar{X}$ | $4076.4^{A}$ | $4613.1^{B}$ | $5098.8^{C}$ | $5892.4^{D}$ |
| | Sd | 129.84 | 233.12 | 149.6 | 228.7 |
| H | $\bar{X}$ | $4120.5^{A}$ | $4587.1^{B}$ | $5145.0^{C}$ | $5903.9^{D}$ |
| | Sd | 193.3 | 131.0 | 216.9 | 118.5 |
| | | Free nitrate (III) concentration (ppm) | | | |
| C | $\bar{X}$ | $82.45^{D}$ | $60.71^{C}$ | $30.81^{B}$ | $15.49^{A}$ |
| | Sd | 2.61 | 2.86 | 4.51 | 3.13 |
| H | $\bar{X}$ | $82.06^{D}$ | $58.79^{C}$ | $30.19^{B}$ | $15.94^{A}$ |
| | Sd | 3.5 | 2.89 | 3.36 | 2.49 |
| | | Minimal subcooling temperature (ºC) | | | |
| C | $\bar{X}$ | $-4.09^{D}$ | $-5.57^{C}$ | $-6.79^{B}$ | $-7.96^{A}$ |
| | Sd | 0.03 | 0.06 | 0.10 | 0.08 |
| H | $\bar{X}$ | $-4.10^{D}$ | $-5.59^{C}$ | $-6.82^{B}$ | $-7.99^{A}$ |
| | Sd | 0.03 | 0.07 | 0.11 | 0.08 |
| | | Cryoscopic temperature (ºC) | | | |
| C | $\bar{X}$ | $-3.82^{A}$ | $-3.38^{B}$ | $-3.07^{bC}$ | $-2.79^{D}$ |
| | Sd | 0.07 | 0.03 | 0.02 | 0.03 |
| H | $\bar{X}$ | $-3.79^{A}$ | $-3.39^{B}$ | $-3.09^{aC}$ | $-2.82^{D}$ |
| | Sd | 0.03 | 0.10 | 0.02 | 0.03 |
| | | Total sensory value (points) | | | |
| C | $\bar{X}$ | $4.68^{C}$ | $4.72^{C}$ | $4.49^{bB}$ | $4.12^{A}$ |
| | Sd | 0.25 | 0.31 | 0.22 | 0.20 |
| H | $\bar{X}$ | $4.60^{B}$ | $4.63^{B}$ | $4.21^{aA}$ | $4.07^{A}$ |
| | Sd | 0.20 | 0.33 | 0.28 | 0.27 |

C – pork loins packed after chilling, H – pork loins packed hot, $\bar{X}$ – mean value, Sd – standard deviation, n – number of pork loins

ters of crystallization are formed under such conditions and the generated energy of crystallization is low. Accordingly, the impact of cooling medium temperature on the temperature of crystallization environment would be higher than the effect of energy. As a result, the c.t. would be lower.

The electrolyte concentration, however, is balanced during the storage, which results in the homogenous distribution of m.t.sc. within the product. Consequently, the values of m.t.sc. are lower than those directly post production. After chilling to the minimal temperature of subcooling numerous crystallization centers are formed in the product. Accordingly, the energy needed to the phase transition of water is relatively higher compared with the initial period of storage, which results in a higher cryoscopic temperature.

The increase in c.t. value in the course of storage was not related to the risk of freezing since simultaneously the minimal subcooling temperature of experimental loins decreased nearly twice compared to the controls. It is known that the freezing of meat will not begin until it is chilled to m.t.sc.

The concentration of free nitrates(III) in experimental products was not influenced by the mode of wrapping (Table 1). The changes in the concentration of substance discussed followed the same manner in both the experimental groups and the differences observed between the consecutive periods of storage were statistically significant (Table 1). A highly desirable, over 5-fold decrease in free nitrate(III) concentration was demonstrated after 84 days of storage. The reduction of free nitrate level occurring over the storage period was previously described in literature [Szmańko, 1984, Szmańko *et al*., 2004b].

The storage-related changes in free amino group concentrations were similar for sopocka loins C and H and the differences observed between the groups were insignificant (Table 1). The considerable increase was, however, noted during each period of storage. The degradation of proteins in a stored product is widely known and described [Szmańko, 1984; Szmańko *et al*., 1988]. The concentrations of free amino groups measured in the present study were similar to those reported in literature [Szmańko *et al*., 2005].

The influence on food coloration is an important evaluation criterion for new methods of packaging [John *et al*., 2005; Szmańko, 1984]. Both the analyzed techniques of

TABLE 2. Color of sopocka pork loins wrapped directly post thermal treatment (H) or after chilling (C) and stored at -3ºC.

| Method of packaging | | Time of storage (days) | | | |
|---|---|---|---|---|---|
| | | 0(K) | 28 | 56 | 84 |
| | | | L* | | |
| C | $\bar{X}$ | 70.60 | 68.85 | 67.33 | 71.07 |
| | Sd | 3.67 | 3.87 | 4.06 | 6.15 |
| H | $\bar{X}$ | $70.71^{AB}$ | $66.67^{A}$ | $68.01^{AB}$ | $71.63^{B}$ |
| | Sd | 2.03 | 4.20 | 2.61 | 6.95 |
| | | | a* | | |
| C | $\bar{X}$ | 6.78 | 5.91 | 6.37 | 7.27 |
| | Sd | 2.14 | 1.73 | 1.94 | 1.98 |
| H | $\bar{X}$ | 5.66 | 6.03 | 7.11 | 6.64 |
| | Sd | 2.66 | 1.86 | 2.18 | 2.32 |
| | | | b* | | |
| C | $\bar{X}$ | $4.37^{B}$ | $4.62^{B}$ | $2.51^{a\bullet A\bullet\bullet}$ | $4.49^{B}$ |
| | Sd | 1.65 | 1.72 | 0.79 | 1.68 |
| H | $\bar{X}$ | $3.37^{B}$ | $3.87^{B}$ | $3.9^{bB}$ | $4.27^{B}$ |
| | Sd | 1.43 | 1.55 | 2.11 | 1.99 |

Explanations: see Table 1; • - values marked with different small letters are significantly different within the same column ($p \leq 0.05$); •• - values marked with different capital letters are significantly different within the same line ($p \leq 0.05$)

wrapping did not influence the L*, a* and b* color parameters of control products (Table 2), which amounted to: 70.6 (L*); 6.78 (a*); 4.37 (b*) for group C and 70.71 (L*); 5.66 (a*); 3.37 (b*) for group H. The changes in L* and b* values were, however, noted during the storage of loins packed hot (L*) and chilled (b*). Six-, 12- or 24-h exposure after 28-, 56-, 84-day storage did not deteriorate the color stability of loins studied. The stability was not influenced by the technique of packaging either.

Twelve-week storage at n.c.t. resulted in the decrease of the total sensory of sopocka loins value by *ca.* 0.5 points (Table 1). Nevertheless, the quality was still described as good. The sensory value was not influenced by the method of packaging. Similar dynamics of changes in the total sensory value was demonstrated in our previous studies [Szmańko, 1998; Szmańko *et al*., 2004a].

Besides the sensory value, microbiological safety is one of the most important criteria of food acceptability [Brewer *et al*., 1993; Borch & Arinder, 2002; Szmańko *et al*., 2004a].

Microbiological contamination of experimental loins after 84 days of storage was similar to that of the controls and did not exceed 500 CFU/g (Figure 2). Packaging of hot pork loins was positively reflected in the higher fraction of aseptic samples by the 56th day of storage. Coliforms, *Escherichia coli* and lactic acid fermentation bacteria were not isolated from 1 g the experimental material, likewise *Salmonella* spp. (25 g), coagulase-positive staphylococci and sporogenic bacilli (0.1 g) and yeasts and moulds (1 g). Similar microbiological parameters of sopocka loins stored at n.c.t. were demonstrated in another experiment of our research group [Szmańko *et al*., 2004b, 2005].

Concluding, the study revealed that the hot packaging directly post thermal treatment is not necessary to provide the high quality pork of loins desired for 12-week storage at n.c.t. A similar effect might be obtained if the products were chilled intensively and subsequently vacuum packed into thermo-shrinkable bags. It is very likely that the transitory treatment of packed loins with 95ºC water (in order to shrink the bags) works antibacterially and neutralizes potential contamination at chilling. The packaging of hot loin might, however, be profitable in the case of prolonged storage.

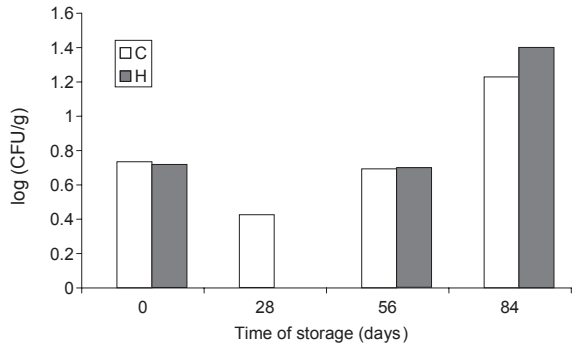


FIGURE 2. Total plate count in sopocka pork loins wrapped directly post thermal treatment (H) or after chilling (C) and stored at -3ºC.

## CONCLUSIONS

1. The 84-day storage of sopocka loin is reflected in a gradual decrease in the minimal temperature of subcooling and a simultaneous increase in cryoscopic temperature.
2. The cryoscopic storage of sopocka loin results in a highly desirable decrease of free nitrite(III) concentration.
3. Sopocka loin stored at near cryoscopic temperature for 84 days exhibited good sensory value and satisfactory microbiological quality, irrespective of packaging technique.
4. The quality of sopocka loins packed hot or chilled before wrapping was not different after 12-week storage at -3ºC.

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## JAKOŚĆ POLĘDWICY SOPOCKIEJ PRZECHOWYWANEJ W TEMPERATURZE BLISKIEJ KRIOSKOPOWEJ W ZALEŻNOŚCI OD SYSTEMU PAKOWANIA

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Celem badań było określenie jakości przechowywanych polędwic sopockich zapakowanych próżniowo w folię termokurczliwą, bezpośrednio po zakończonej obróbce cieplnej (H), lub po 12-godzinnym wychładzaniu (C). Wędzonki przechowywano w temperaturze bliskiej krioskopowej (n.c.t.), w –3°C, przez 0, 28, 56, 84 doby. Składowanie krioskopowe doświadczalnych przetworów (C i H) pomimo, że wiązało się ze zwiększeniem zawartości wolnych grup aminowych, nie miało niekorzystnego wpływu na barwę, pH, poziom wolnych azotanów(III) oraz ogólną ocenę sensoryczną. Dwunastotygodniowe przechowywanie polędwic sopockich (C,H) w temp. -3°C nie powodowało również niebezpiecznego wzrostu ich zanieczyszczenia mikrobiologicznego. Zastosowanie pakowania ciepłych polędwic, po 84 dobach ich przechowywania w temperaturze bliskiej krioskopowej, nie miało wpływu na ich jakość.