

## SENSORY QUALITY OF PORK AND TOTAL MICROBIAL COUNT DEPENDING ON DEEP-FREEZE STORAGE TIME AND THAWING METHOD

Jacek Kondratowicz<sup>1</sup>, Iwona Chwastowska<sup>1</sup>, Paulius Matusevičius<sup>2</sup>

<sup>1</sup>*Department of Commodity Science of Animal Raw Materials, University of Warmia and Mazury in Olsztyn, M. Oczapowskiego 5, PL 10-719 Olsztyn, Poland*

<sup>2</sup>*Department of Animal Husbandry, Lithuanian Veterinary Academy, Tilžės st. 18, LT-47181 Kaunas, Lithuania, E-mail: paulius@lva.lt*

**Abstract.** The aim of the present study was to determine the effects of deep-freeze storage time and thawing method on the sensory quality of pork and total microbial count. Microwave thawing was compared with traditional thawing in the atmospheric air. The results of the study showed that the sensory quality (juiciness, palatability) of pork thawed in a microwave oven was higher compared to pork stored in the deep freeze for a long period of time and afterwards thawed in the atmospheric air. The microbiological contamination of pork thawed in a microwave oven was lower, by one log cycle, compared to pork thawed under natural conditions.

**Keywords:** pork, deep-freeze storage, thawing, sensory quality, microbiological quality.

## GILIAI UŽŠALDYTOS KIAULIENOS SENSORINĖS KOKYBĖS IR BENDRO BAKTERIJŲ SKAIČIAUS PRIKLAUSOMYBĖ NUO LAIKYMO TRUKMĖS IR ATŠILDYMO METODO

Jacek Kondratowicz<sup>1</sup>, Iwona Chwastowska<sup>1</sup>, Paulius Matusevičius<sup>2</sup>

<sup>1</sup>*Olštyno Varmijos-Mozūrų universitetas, Plataus vartojimo gyvulinės kilmės žaliavų katedra, M. Oczapowskiego 5, PL 10-719 Olštynas, Lenkija*

<sup>2</sup>*Lietuvos veterinarijos akademija, Gyvulininkystės katedra, Tilžės g. 18, LT-47181 Kaunas, Lietuva; el. paštas: paulius@lva.lt*

**Santrauka.** Bandymo tikslas buvo nustatyti laikymo giliai užšaldžius trukmės ir atšildymo metodo poveikį sensorinei kiaulienos kokybei ir bendram bakterijų skaičiui. Kiaulienos atšildymas mikrobangų krosnelėje buvo lyginamas su tradiciniu atšildymu atmosferos ore. Tyrimo rezultatai parodė, jog kiaulienos, atšildytos mikrobangų krosnelėje, sensorinės savybės (vandens rišlumas, skoninės savybės) buvo geresnės už kiaulienos, kuri buvo ilgai laikoma giliai užšaldyta ir atšildyta atmosferiniame ore. Mikrobiologinis užterštumas kiaulienos, atšildytos mikrobangų krosnelėje, buvo mažesnis nei kiaulienos, atšildytos natūraliomis sąlygomis.

**Raktažodžiai:** kiauliena, laikymas giliai užšaldžius, atšildymas, sensorinė kokybė, mikrobiologinė kokybė.

**Introduction.** A marketable surplus of pork is usually deep-frozen and stored for long periods of time (Kondratowicz, Matusevičius, 2002). Control over the quality of deep-frozen pork is determined by a variety of interrelated factors found at all stages of livestock and meat production. The quality of pork is also altered by the freezing process and deep-freeze storage (Sobina, 1998). The biological, physical and chemical processes that occur in meat can be limited by freezing, but their complete elimination is impossible. During freezing meat ripening is considerably inhibited, whereas the rate of processes related (directly or indirectly) to the freezing out of water increases (Sobina, Kondratowicz, 1999). Thawing is the final stage of chilling technology, aimed at restoring the best properties of meat, similar to those typical of fresh meat (Lechowski et al., 2002). The thawing process is affected by numerous factors. The most important among them are relative air humidity and effective thawing time dependent upon the temperature of the thawing medium (Góral, 2003). It follows that thawing is more difficult to control than freezing. Inappropriate thawing of deep-frozen meat and meat stored at low temperatures may result in significant quality deterioration. Thawing drip loss reflects the extent of irreversible changes taking place in the histological

structure of meat, as well as degradation of compounds responsible for water binding. Microbiological changes manifest themselves by intensive growth of psychrophilic and psychrotropic microorganisms on the surface of meat. Both the color and consistency of meat also change substantially (Kondratowicz et al., 2004). Meat used for industrial purposes is most often thawed in the atmospheric air, under uncontrolled climate conditions. This process may take as long as several days, and lead to considerable weight loss, changes in the sensory properties of meat, and microbiological contamination. Due to the increasing market share of deep-frozen meat products, as well as numerous disadvantages of traditional thawing methods, more and more attention has been paid recently to fast thawing methods, enabling full control over the process parameters.

The aim of the present study was to determine the effects of deep-freeze storage time and thawing method on the sensory properties of pork and total microbial count.

**Materials and Methods.** The experimental materials comprised hybrid fatteners (PIC) with live weights of about 100 to 110 kg, purchased from one producer. The sex ratio was 1:1. Over the fattening period all animals were kept under similar feeding and husbandry

conditions. Slaughter and post-slaughter processing of the carcasses graded into classes E and U of the EUROP classification system were carried out in accordance with the regulations currently in force. Half-carcasses were chilled in a two-stage system. In a quick-chill tunnel ambient temperature was  $-5^{\circ}\text{C}$ , and air velocity was approx. 1 - 3 m/s. After 3.5 hours the carcasses were further chilled at  $4^{\circ}\text{C}$  for 24 hours.

Samples of the lumbar muscle (*musculus longissimus lumborum*) were taken from left and right half-carcasses of normal quality. The criterion of quality assessment was the value of  $\text{pH}_1$  and  $\text{pH}_{24}$  determined in the lumbar muscle with a WTW 340 pH-meter, 45 min. and 24 hours after slaughter. Normal-quality samples, referred to as RFN (red, firm, normal), were those with  $\text{pH}_1 > 6.3$  (elimination of PSE meat) and  $\text{pH}_{24}$  5.6 – 5.8 (elimination of DFD meat) (Wirth, 1972; Kortz, 2001). A total of 80 samples, each weighing about 500 g, were collected. The packaging was performed at  $4^{\circ}\text{C}$  under standard conditions of a Poultry Plant. HD-PE foil was used. Then the samples were deep-frozen in a ventilation chamber, at  $-18^{\circ}\text{C}$  and forced air flow of 1-2 m/s. The mean temperature of samples at the beginning of freezing was about  $4^{\circ}\text{C}$ , and the final temperature after 18 hours -  $18^{\circ}\text{C}$ . Deep-frozen samples were packed into cardboard containers and stored in a chamber at  $-18^{\circ}\text{C}$  for two weeks and three months.

After the completion of deep-freeze storage the samples were thawed in a microwave oven (40 samples) or in the atmospheric air (40 samples). In the former case the samples were placed in a microwave oven (TEC) and exposed to electromagnetic waves, at a power of 260 W for 14 min., and then at 120 W for 30 min. After thawing the temperature inside the muscles was about  $0^{\circ}\text{C}$ , and in the outer layer – about  $10^{\circ}\text{C}$ . After two hours of temperature equalization, the samples were thawed to  $4^{\circ}\text{C}$ . In the latter case the samples were thawed in a production hall, at air temperature of  $4^{\circ}\text{C}$  and relative air humidity of approx. 85%, for 24 hours.

After thawing samples of the lumbar muscle were successively taken for quantitative and qualitative analyses. In order to prepare the samples for laboratory analyses, the outer fatty and tendinous tissues were removed from the surface of thawed samples. Then meat was passed through a meat grinder with a 2 mm mesh sieve. The following determinations were made:

total weight losses in the processes of freezing, storage and thawing, by weighing the samples at particular stages of chilling technology, accurate to 0.1g;

dry matter content, by the method described by Rak and Morzyk (2002);

meat reaction (after thawing), on the basis of pH measurement in water homogenates (quantitative ratio of meat to distilled water 1:1), using a glass-combination electrode (Hamilton – Double Pore) and a pH-meter (Pol-Eko-Aparatura);

sensory properties of meat, by the method described by Baryłko-Pikielna (1975). The samples, each weighing about 200 g, were cut out across fibers and cooked in a 0.62% NaCl solution at  $75^{\circ}\text{C}$  (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  $20^{\circ}\text{C}$ . 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;

total count of aerobic bacteria, by the flooding method, in accordance with PN-A-82055-2 (1994), on plate count agar. The cultures were incubated at  $30^{\circ}\text{C}$  for 72 hours. The results are given in cfu/g of meat.

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.** The data presented in Table 1 show that the total weight losses in pork samples thawed in a microwave oven after two weeks of deep-freeze storage were significantly lower (by 1.87%), compared with those thawed in the atmospheric air. Weight losses increased as the time of deep-freeze storage was prolonged to three months, but their rate was faster in microwave-thawed meat than in air-thawed meat. After three months of storage the differences in weight loss between pork samples thawed quickly in a microwave oven and slowly in the air became less distinct (5.15% vs. 6.98%). It follows that in the case of short-term storage below freezing point, microwave thawing allows to reduce weight losses, compared with the commonly applied method of air thawing.

It was found (Table 1) that the time of deep-freeze storage and thawing method had a significant effect on the dry matter content of pork. Air-thawed meat, stored for two weeks, contained more dry matter than meat thawed in a microwave oven. As the time of deep-freeze storage was extended to three months, the percentage of dry matter in pork increased, and this increase was higher in air-thawed samples than in microwave-thawed ones. The increase in the relative concentration of dry matter in meat, dependent upon storage time and thawing method, seems natural taking into account changes in weight loss in the experimental groups.

The values of  $\text{pH}_1$  measured 45 minutes post-slaughter (Table 1) show that samples of the lumbar muscle had good quality. The values of  $\text{pH}_1$  in all experimental groups were consistent with methodological assumptions and remained within the limits typical of RFN meat ( $\text{pH}_1$  above 6.3) with no symptoms of exudation (Pospiech, 2000). The values of  $\text{pH}_{24}$  determined 24 hours post-slaughter ranged from 5.56 to 5.66, and were also typical of RFN meat ( $\text{pH}_{24}$  5.5 – 5.8) (Pospiech, 2000). As for the final acidity of pork, measured after thawing, a significant difference in pH was observed only in samples stored for three months and thawed in a microwave oven ( $\text{pH}$  5.56). In the other groups meat acidity was at a stable, rather low level ( $\text{pH}$  5.6), and the differences were statistically non-significant.

Table 1. Quantitative and qualitative changes in pork, as dependent upon deep-freeze storage time and thawing method (n=20)

Specification	Statistical measure	Deep-freeze storage time (months)				Statistical significance of differences
		0,5		3		
		Thawing method				
		Microwave A	Air B	Microwave C	Air D	
Total weight loss [%]	$\bar{x}$ s	3.74 $\pm 1.71$	5.61 $\pm 2.68$	5.15 $\pm 2.04$	6.98 $\pm 4.18$	D>A**,B,C* B,C>A**
Dry matter [%]	$\bar{x}$ s	26.42 $\pm 0.97$	27.54 $\pm 1.04$	26.83 $\pm 0.89$	28.31 $\pm 1.14$	D>A,C**B* B>A**, C*
pH <sub>1</sub>	$\bar{x}$ s	6.32 $\pm 0.20$	6.32 $\pm 0.22$	6.37 $\pm 0.20$	6.43 $\pm 0.15$	-
pH <sub>24</sub> (before storage)	$\bar{x}$ s	5.69 $\pm 0.08$	5.74 $\pm 0.07$	5.72 $\pm 0.09$	5.73 $\pm 0.11$	-
pH <sub>u</sub> (after storage)	$\bar{x}$ s	5.64 $\pm 0.05$	5.66 $\pm 0.10$	5.56 $\pm 0.06$	5.63 $\pm 0.11$	A,B,D>C**

\* statistically significant differences at  $p \leq 0.05$ \*\* statistically significant differences at  $p \leq 0.01$ 

Table 2. Sensory quality of pork and total microbial count, as dependent upon deep-freeze storage time and thawing method (n=20)

Specification	Statistical measure	Deep-freeze storage time (months)				Statistical significance of differences
		0,5		3		
		Thawing method				
		Microwave A	Air B	Microwave C	Air D	
Aroma – intensity (points)	$\bar{x}$ s	5.00 0.00	5.00 0.00	5.00 0.00	5.00 0.00	-
Aroma – desirability (points)	$\bar{x}$ s	5.00 0.00	5.00 0.00	5.00 0.00	5.00 0.00	-
Juiciness (points)	$\bar{x}$ s	4.72 $\pm 0.38$	4.50 $\pm 0.43$	4.60 $\pm 0.35$	4.35 $\pm 0.37$	A>D**
Tenderness (points)	$\bar{x}$ s	4.47 $\pm 0.62$	4.43 $\pm 0.57$	4.63 $\pm 0.39$	4.40 $\pm 0.50$	-
Palatability– intensity (points)	$\bar{x}$ s	4.83 $\pm 0.24$	4.75 $\pm 0.38$	4.85 $\pm 0.24$	4.55 $\pm 0.39$	A,C>D**
Palatability– desirability (points)	$\bar{x}$ s	4.83 $\pm 0.24$	4.75 $\pm 0.38$	4.85 $\pm 0.24$	4.55 $\pm 0.39$	A,C>D**
Total microbial count (jtk/g)	$\bar{x}$ s	5.09E+02 $\pm 3.28E+02$	1.33E+03 $\pm 0.35E+02$	5.87E+02 $\pm 0.06E+02$	1.29E+03 $\pm 1.48E+02$	B,D>A,C*

\* statistically significant differences at  $p \leq 0.05$ \*\* statistically significant differences at  $p \leq 0.01$ 

Table 2 presents the scores for the sensory quality of pork, in relation to deep-freeze storage time and thawing method. It was found that neither three-month deep-freeze storage, nor microwave- or air-thawing had a significant effect on the aroma (intensity and desirability) of pork. All samples received the highest scores (5.0) for aroma intensity and desirability. The juiciness of pork decreased as the time of deep-freeze storage was prolonged. It was the highest in samples stored for two weeks and thawed in a microwave oven. The rate of juiciness deterioration was

faster in air-thawed samples stored for three months – 4.35 points. Pork tenderness was not considerably affected by the thawing method. A slight decrease in this attribute was recorded in both microwave- and air-thawed samples stored for three months. Pork stored for two weeks and three months, thawed in a microwave oven, had the best palatability, in terms of both intensity and desirability. A significant decrease in this attribute was observed in air-thawed samples after three months of deep-freeze storage. To sum up, most of the sensory

properties of pork underwent slight changes during three months of deep-freeze storage. The positive effect of microwave thawing on the sensory quality of pork was confirmed by higher scores for juiciness and palatability, in comparison with pork thawed in the atmospheric air after three months of storage.

The microbiological contamination of pork (total microbial count per g of muscular tissue) was also determined in the study. Table 2 includes the results of a microbiological analysis of meat, depending on deep-freeze storage time and thawing method. Regardless of the time of storage below freezing point, the microbiological contamination of pork thawed in a microwave oven was lower, by one log cycle, compared with air-thawed pork. This suggests a longer shelf-life of microwave-thawed meat.

**Conclusions.** The results of a study on the effects of deep-freeze storage time and thawing method on the sensory quality and total microbial count in pork enabled to formulate the following conclusions:

1. Weight losses in pork samples thawed in a microwave oven after two weeks of deep-freeze storage were significantly lower, compared with those thawed in the atmospheric air. Weight losses increased as the time of deep-freeze storage was prolonged to three months. After three months of storage the differences in weight loss between pork samples thawed the above two methods became less distinct.

2. The sensory quality of pork was related to the thawing method and deep-freeze storage period. The positive effect of microwave thawing on the sensory properties of pork was confirmed by higher scores for juiciness and palatability, in comparison with pork thawed in the atmospheric air after three months of storage.

3. The microbiological contamination of pork thawed in a microwave oven was lower, by one log cycle, compared with pork thawed under natural conditions.

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