

Technological properties of pork thawed in the atmospheric air or in the microwave oven as determined during a six-month deep-freeze storage

Jacek Kondratowicz, Iwona Chwastowska-Siwiecka, Ewa Burczyk

Department of Commodity Science of Animal Raw Materials,
University of Warmia and Mazury in Olsztyn,
Oczapowskiego 5, 10-957 Olsztyn, Poland

(Received May 30, 2008; accepted August 1, 2008)

The study aimed at determining the effect of the deep-freeze storage time (two weeks, three months and six months) and thawing method on weight loss and the physicochemical properties of pork. Thawing in a microwave oven was compared with the traditional method of thawing in the atmospheric air. After two weeks of deep-freeze storage, the weight losses in *longissimus lumborum* muscle samples thawed in a microwave oven were found significantly lower than those observed in samples thawed in the atmospheric air. Weight losses increased during prolonged deep-freeze storage, but after six months the differences between samples thawed in a microwave oven and in the air became less pronounced. Changes in the technological properties of pork were found related to the duration of deep-freeze storage. With no reference to thawing method, deep-frozen pork stored for two weeks was darker in colour than that stored for six months.

KEY WORDS: deep-freezing / pork / storage / technological properties / thawing /

Pork should have high technological quality as it is used mostly for processing. This concerns primarily the raw material processed at particular stages of chilling. Many authors [e.g. Mitrus 2000, Kondratowicz and Matusevičius 2002, 2003] are of opinion that freezing method is not essential as regards the final quality of meat products after thawing. Two key factors are critically important: deep-freeze storage conditions and thawing method. Thawing is the final stage of chilling, aimed at restoring the best quality attributes of meat, similar to those typical of fresh meat [Kondratowicz and Chwastowska 2006b]. Thawing process is affected by a variety

of factors, the most important being relative air humidity and effective thawing time dependent upon the temperature of the thawing medium [Mitrus 2000]. The thawing process is doubtlessly more difficult to control than freezing and deep-freeze storage. Thawing drip loss reflects the extent of irreversible changes taking place both in the histological structure of muscular tissue and in the properties of meat proteins, including denaturation [Sobina and Kondratowicz 1999]. Those changes affect not only the colour of meat, but also the water-holding capacity of protein structures [Kortz 2001].

Meat used for industrial purposes is most often thawed naturally, in the atmospheric air. This process, lasting several dozen hours, may lead to considerable weight losses and alter the technological properties of meat [Kondratowicz and Chwastowska 2006a]. The increasing market share of deep-frozen meat products and the disadvantages of conventional thawing methods have prompted the development of modern thawing techniques permitting full control over the process parameters [Mitrus 2000].

The objective of this study was to determine the effect of the duration of deep-freeze storage (two weeks, three months and six months) and thawing method on weight losses and changes of the physico-chemical properties of pork. Thawing in a microwave oven was compared with the traditional method of thawing in the atmospheric air.

Material and methods

The material comprised 60 hybrid (PIC) growing-finishing pigs with body live weight of 100-110 kg and sex ratio 1:1. Throughout the fattening period all animals were kept under similar feeding and maintenance conditions. The slaughter and post-slaughter processing of carcasses followed by grading them into conformation classes E and U in the official EUROP scheme were carried out in accordance with the regulations currently in force. Carcass-sides were chilled in a two-stage system. In a quick-chill tunnel, ambient temperature was -5°C and air velocity ranged from 1 to 3 m/s. After 3.5 hours the carcasses were further chilled at 4°C for 24 hours.

Samples of the *longissimus lumborum* (LL) muscle were excised from left and right carcass-sides of normal quality. The criterion of carcass normality was the value of pH₁ and pH₂₄ determined in the LL muscle with a WTW 340 i pH-meter, 45 min and 24 h post-slaughter, respectively. Normal-quality samples, referred to as RFN (red, firm, normal), were those with pH₁ > 6.3 (elimination of PSE meat) – Kortz [2001] – and pH₂₄ 5.6-5.8 (elimination of DFD meat) – Koćwin-Podsiadła *et al.* [1998], Strzelecki [2004]. A total of 120 samples, each weighing about 500 g, were obtained from the left (60 samples) and right (60 samples) carcass-side. The samples, packaged in HD-PE foil at 4°C under standard conditions of a Meat Processing Plant, were deep-frozen in an air blast freezer, at -18°C and a air velocity of 1-2 m/s. The mean temperature of samples was about 4°C at the beginning of freezing and -18°C

after 18 hours. Deep-frozen samples were placed in cardboard containers and stored in a chilling chamber at -18°C for two weeks, three months or six months.

At the completion of deep-freeze storage the samples were thawed in a microwave oven (60 samples) or in the atmospheric air (60 samples). In the former case the samples put in a microwave oven (TEC) were exposed to electromagnetic waves, at a power of 260 W for 14 min, and then at 120 W for 30 min. After thawing, the inner temperature of samples reached about 0°C and about 10°C in the outer layer. After two hours of temperature equalization, the samples were thawed to 4°C. In the latter case the samples were thawed for 24 hours in a production hall, at air temperature of 4°C and relative air humidity of 85%, until their inner temperature reached about 4°C.

Thawed LL samples were successively taken for quantitative and qualitative analyses. In order to prepare the samples for laboratory analyses, the outer fatty and connective tissues were removed from their surface.

LL samples were assayed for:

- total weight loss 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 – according to the procedure given by Polish Standard PN-ISO 1442 [2000];
- ultimate (post-thawing) pH (pH_u) of water homogenates (meat to distilled water ratio of 1:1), with a glass combined electrode (HAMILTON-Double Pore) and a POL-EKO-APARATURA pH-meter;
- colour brightness – based on the percentage of light reflection against the surface of minced meat samples, with the use of a SPEKOL spectrometer and an R45/O remission attachment, at a wavelength of 560 nm (with a magnesium oxide plate as a reference standard of whiteness);
- water-holding capacity – with the Grau-Hamm method [1952];
- cooking loss – as described by Janicki [1970].

The results were verified statistically, computing arithmetical means and their standard deviations. The significance of differences between and among means for groups was estimated with Duncan's test, using STATISTICA 8.0 software.

Results and discussion

Changes in weight (weight loss) and physico-chemical properties of LL muscle as related to freeze-storage time and method of subsequent thawing are presented in Table 1. Natural weight losses are one of the consequences of low-temperature preservation of meat. They affect the chemical composition and water content-dependent technological properties of thawed meat [Kondratowicz and Chwastowska 2006b]. The volume of thawing drip may be a measure of damage made to the structure of muscle tissue by the freezing process, informing about the effectiveness of different thawing methods [Sobina and Kondratowicz 1999].

The data from Table 1 indicate that after two weeks of deep-freeze storage total weight loss in LL muscle thawed in a microwave oven was significantly (by 1.87 per cent points) lower than that occurring in samples thawed in the atmospheric air. Weight loss during prolonged deep-freeze storage was more pronounced in microwave-thawed samples. After six months of storage the differences in weight loss between LL samples thawed quickly in a microwave oven or slowly in the air became less pronounced (6.64% vs. 5.76%). It can be concluded that when the short-term deep-freeze storage is applied, microwave thawing – as compared to air thawing – reduces weight losses.

Dry matter content of LL was significantly affected by the duration of deep-freeze storage and thawing method (Tab. 1). As the freeze storage time was prolonged to three months, the dry matter content increased to a greater extent in samples thawed in the air than in those thawed in a microwave oven. No significant differences in dry matter content were identified between deep-frozen samples stored for six months, regardless of the thawing method. The increase in relative dry matter concentration in LL samples, as dependent on the duration of deep-freeze storage and thawing method, seems natural in light of changes in weight loss recorded in the groups.

Table 1. Means and their standard deviations (SD) for physico-chemical properties of porcine *longissimus lumborum* samples as related to the length of deep-freeze storage and thawing method

Trait		Freeze storage time (months)					
		0.5		3		6	
				thawing method			
		microwave (n=20*)	air (n=20*)	microwave (n=20*)	air (n=20*)	microwave (n=20*)	air (n=20*)
Weight loss (%)	mean	3.74 ^a	5.61 ^b	5.15	6.98 ^b	6.64 ^b	5.76
	SD	1.71	2.68	2.04	4.18	2.19	2.47
Dry matter content (%)	mean	26.20 ^a	26.34 ^a	26.83 ^a	28.31 ^b	26.62 ^a	26.66 ^a
	SD	0.84	0.76	0.89	1.14	0.83	0.47
pH ₁	mean	6.30	6.32	6.37	6.39	6.38	6.40
	SD	0.17	0.22	0.20	0.16	0.26	0.08
pH ₂₄	mean	5.69	5.74	5.72	5.73	5.71	5.70
	SD	0.08	0.07	0.09	0.11	0.06	0.10
pH _u	mean	5.64 ^a	5.66 ^a	5.56 ^b	5.63 ^a	5.52 ^b	5.60 ^a
	SD	0.05	0.10	0.06	0.11	0.06	0.07
Colour brightness (%)	mean	19.70 ^b	20.90 ^b	26.55 ^a	26.95 ^a	27.65 ^a	24.00 ^c
	SD	3.70	4.52	3.30	2.70	2.64	2.25
Water-holding capacity (cm ²)	mean	8.53 ^a	7.14 ^b	8.74 ^a	7.89	8.02 ^a	8.07 ^a
	SD	0.97	0.90	0.83	0.89	1.12	0.99
Thermal shrinkage (%)	mean	25.77 ^a	22.29 ^b	31.45 ^c	30.68 ^c	13.82 ^d	14.52 ^d
	SD	1.43	1.86	2.13	1.88	0.41	0.35

^{ab...} Within lines means bearing different superscripts differ significantly at $P \leq 0.05$.

*10 samples from the left and 10 samples from the right carcass-sides, five male and five female carcass-sides in each subgroup.

The technological properties of thawed LL samples investigated in this study included acidity, colour, water-holding capacity and cooking loss. Acidity is one of the most objective criteria of meat quality. The values of pH_1 (measured 45 min post-slaughter) – Table 1 – showed that *longissimus lumborum* muscles were characterized by good quality. The values of pH_1 were consistent with the methodological assumption and did not differ significantly between groups. They remained within the normal ranges of RFN meat (above 6.3) with no symptoms of exudation [Kortz 2001]. The values of pH_{24} (measured 24 h post-slaughter) varied from 5.69 to 5.74 and were also typical of RFN meat (pH_{24} 5.5-5.8) [Kortz 2001]. As regards the ultimate pH of LL samples (pH_u measured post-thawing), a significant difference was identified only between samples stored for 3 and 6 months, thawed in a microwave oven (pH 5.56 and 5.52 respectively). In the other groups meat acidity remained at a stable, relatively low level (pH 5.6), and the observed intergroup differences were not found significant.

According to Koćwin-Podsiadła *et al.* 1998, and Strzelecki 2004], meat colour is influenced by two key factors: acidity and fat content responsible for marbling. In the present investigation pork stored for two weeks and thawed in a microwave oven or in the atmospheric air was characterized by the lowest per cent of light reflection (19.70 and 20.90%, respectively), *i.e.* had a darker colour in comparison with meat of the other groups. The colour of LL samples became significantly brighter as freeze storage was prolonged from two weeks to three months, irrespective of the thawing method. Therefore, color brightness measurements performed on LL samples stored for three months did not indicate which of the thawing methods tested had a more beneficial impact on colour preservation. After six months of deep-freeze storage, LL samples thawed in the atmospheric air had a darker colour than microwave-thawed samples.

The water-holding capacity (forced drip) and cooking loss were both related to weight loss in the freezing process. Greater water loss during deep-freeze storage limited the forced drip and cooking loss, which apparently could be indicative of better water-holding capacity of meat stored for longer periods of time, regardless of the thawing technique applied.

The majority of the investigated technological properties of pork underwent changes during six-month deep-freeze storage. The positive impact of microwave thawing was confirmed by significantly lower weight loss noted in LL samples stored for two weeks, compared to those thawed in the atmospheric air. No differences in the technological quality of LL muscle between the thawing methods were observed as the duration of deep-freeze storage was prolonged to six months.

This study, investigating the effect of the duration of deep-freeze storage and thawing method on technological properties of pork can be summarized as follows. Weight losses in *longissimus lumborum* muscle samples thawed in a microwave oven after two weeks of deep-freeze storage occurred significantly lower than those observed in samples thawed in the atmospheric air. Weight losses increased during

prolonged deep-freeze storage, but after six months the differences between samples thawed in a microwave oven and in the air became less pronounced. Changes in the technological properties of LL muscle depended on the duration of deep-freeze storage. Muscle samples freeze-stored for two weeks, thawed in a microwave oven or in the atmospheric air had a darker colour than those stored for three or six months. Microwave thawing of LL muscle samples stored at -18°C for short periods of time had a more beneficial effect on their quality, stability and processing suitability than atmospheric air thawing.

REFERENCES

1. GRAU R., HAMM R., 1952 – Eine Einfache Methode zur Bestimmung der Wasserbindung in Fleisch. *Fleischwirtschaft*, 4, 295-297.
2. JANICKI M.A., 1970 – Mięso wodniste, jego znaczenie i występowanie. In Polish, summary in English. *Zeszyty Problemowe Postępów Nauk Rolniczych* 1, 13-20.
3. KOĆWIN-PODSIADŁA M., PRZYBYLSKI W., KACZOREK S., KRZĘCIO E., 1998 – Quality and technological field of PSE (pale, soft, exudative), acid and normal pork. *Polish Journal of Food and Nutrition Science* 7/48, 2, 217-222.
4. KONDRATOWICZ J., CHWASTOWSKA I., 2006a – Effect of deep-freeze storage time and thawing method on the sensory and microbiological quality of pork. *Animal Science Papers and Reports* 24(2), 151-158.
5. KONDRATOWICZ J., CHWASTOWSKA I., 2006b – Technological quality of pork deep-frozen direct post-slaughter or after 24 h chilling, measured during 12-months of storage. *Animal Science Papers and Reports* 24(3), 131-140.
6. KONDRATOWICZ J., MATUSEVIČIUS P., 2002 – Use of low temperatures for food preservation. *Veterinarija ir Zootechnika* 17(39), 88-92.
7. KONDRATOWICZ J., MATUSEVIČIUS P., 2003 – Właściwości technologiczne mięsa wieprzowego zamrożonego przy użyciu ciekłego azotu i metodą owiewową w różnym czasie od uboju. In Polish. *Żywność. Nauka. Technologia. Jakość* 4(37), 173-183.
8. KORTZ J., 2001 – The chief defects of meat and methods of detection. *Polish Journal of Food and Nutrition Science* 10/51, 3, 6-10.
9. MITRUS M., 2000 – Zastosowanie mikrofal w technologii żywności (Using microwaves in food technology). In Polish, summary in English. *Postępy Nauk Rolniczych* 4, 99-113.
10. Polish Standard PN-ISO 1442, 2000 – Mięso i przetwory mięsne. Oznaczanie zawartości wody (metoda odwoławcza). Meat and Meat Products. Determination of Water (reference method).
11. SOBINA I., KONDRATOWICZ J., 1999 – Ultrastruktureller Bau der Schweinemuskeln. Morphologische Unterschiede zwischen normalen und Fleisch mit PSE- und DFD- Merkmalen. *Fleischwirtschaft* 11, 98-100.
12. STRZELECKI J., 2004 – Badania nad anatomiczno-przestrzennym rozkładem wad jakościowych mięsa w tuszach wieprzowych uwarunkowanych szybkością i stopniem zakwaszenia mięśni (Anatomic-spacial distribution of quality faults in porcine carcasses as affected by muscle acidification speed and rate). In Polish, summary in English *Roczniki Instytutu Przemysłu Mięsnego i Tłuszczowego*. XLI, Supplement 2, 7-56.

Jacek Kondratowicz, Iwona Chwastowska-Siwiecka, Ewa Burczyk

**Jakość technologiczna mięsa wieprzowego rozmrażanego
w powietrzu atmosferycznym lub metodą mikrofalową, mierzona
podczas 6-miesięcznego przechowywania w głębokim zamrożeniu**

Streszczenie

Celem pracy było określenie wpływu czasu zamrażalniczego przechowywania i metody rozmrażania mięsa wieprzowego na ubytki jego masy i właściwości fizykochemiczne. Porównano mikrofalową technologię rozmrażania mięsa z rozmrażaniem tradycyjnym dokonywanym w powietrzu atmosferycznym. Wykazano, że po dwóch tygodniach zamrożenia ubytki masy mięsa rozmrażanego metodą mikrofalową były istotnie niższe niż ubytki masy mięsa rozmrażanego w powietrzu. Straty masy mięsa rosły w miarę wydłużania czasu przechowywania, jednakże po sześciu miesiącach stwierdzono zacieranie się różnic w wielkości ubytków masy mięsa między metodą mikrofalową a tradycyjnym rozmrażaniem w powietrzu. Zmiany właściwości technologicznych mięsa zależały od czasu jego zamrażalniczego przechowywania. Po dwóch tygodniach przechowywania w zamrożeniu, mięso rozmrażane obiema metodami charakteryzowało się barwą ciemniejszą niż mięso przechowywane w zamrożeniu przez sześć miesięcy.

