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Microbiological status of pig carcasses in mobile chilling vehicles

Mikrobiologischer Status von Schweineschlachtkörpern in mobilen Kühlfahrzeugen

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Summary

Reg. (EC) No. 853/2004 requires chilling of slaughtered animals immediately after post mortem inspection to a temperature of ≤ 7 °C, to be maintained during transport. In this study, the aerobic plate count (APC) of pig carcasses in a stationary and mobile unit was compared under various chilling conditions. Three trials were performed by directing one half of a carcass into the stationary unit and the other half into the mobile unit: I) chilling of one half of split carcasses to 7 °C in the chilling room and simultaneously of the other half in the mobile unit; II) chilling of all split carcasses to 20 °C in the chilling room, followed by separate chilling of one half of the investigated carcasses to 7 °C in the stationary unit and the other half in the mobile unit; III) chilling of all split carcasses to 20 °C in the chilling room, with further chilling to 7 °C in the stationary unit and to 10 °C in the mobile unit.

Carcasses were sampled i) at the beginning of the chilling period; ii) at 20 °C; iii) at the end of chilling (7 °C or 10 °C). For trial I, only the start and the end of the chilling period were investigated.

Results: Temperatures of 7 °C can be reached in a mobile unit during transport under conditions similar to those in a stationary chilling room. In both chilling units microbiological results on the surfaces of carcasses were similar. In every trial and in both chilling units, APC decreased, resulting in APC within the range of requirements of Reg. (EC) No. 1441/2007.

Keywords: chilling, pig carcasses, temperature, microbiological status, abattoir

Zusammenfassung

Die VO (EG) 853/2004 fordert eine sofortige Kühlung von geschlachteten Tieren nach der post mortem Untersuchung auf Temperaturen ≤ 7 °C, die auch beim Transport gewährleistet sein müssen. In dieser Studie wurden die mikrobiologischen Belastungen (Gesamtkeimzahl; GKZ) von Schweineschlachtkörpern in einer stationären und einer mobilen Kühleinrichtung unter verschiedenen Kühlbedingungen miteinander verglichen. In drei Teilversuchen wurde jeweils eine Hälfte des Tierkörpers in eine stationäre Kühleinheit und die andere in eine mobile Einheit verbracht, sodass jeder Tierkörper in beiden Kühlsystemen untersucht wurde: I) Kühlung der Tierkörperhälften auf 7 °C, jeweils aufgeteilt auf stationäre Kühleinheit im Schlachtbetrieb und mobile Kühleinheit; II) Kühlung aller Tierkörper auf 20 °C, anschließende Verteilung der Hälften und jeweils Kühlung auf 7°C; III) Kühlung aller Tierkörper auf 20 °C, anschließende Verteilung der Hälften auf 7 °C (stationäre Einheit) und auf 10 °C (mobile Einheit).

Die Tierkörper wurden zu drei Zeitpunkten beprobt: i) zum Beginn der Kühlung; ii) bei 20 °C; iii) am Ende der Kühlung (7 °C bzw. 10 °C). Bei Teilversuch I wurden nur zu Beginn und am Ende der Kühlung beprobt.

Ergebnisse: Die rechtlich vorgeschriebene Temperatur von 7 °C kann in einem Kühl-LKW unter Transportbedingungen ebenso erreicht werden wie im Kühlhaus eines Schlachtbetriebes. Die mikrobielle Belastung blieb in beiden Kühlsystemen vergleichbar. Bei allen Teilversuchen sank in beiden Kühlsystemen die GKZ. Die finale GKZ lag unterhalb der rechtlichen Grenzwerte der VO (EG) 1441/2007.

Schlüsselwörter: Kühlung, Schweineschlachtkörper, Temperatur, mikrobiologischer Status, Schlachtbetrieb

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Introduction

Fresh meat must be considered highly perishable, chilling of carcasses is an important critical control point (CCP). Immediately after post mortem examination, carcasses must be chilled to 7 °C and offal to 3 °C which must be maintained during cutting, boning and packaging. Ambient temperatures should not exceed 12 °C (Reg. (EC) No.853/2004, Annex III Section I Chapter V No. 2b and VII). However, meat might be cut before reaching these temperatures when cutting rooms and abattoir are located at the same site (Reg. (EC) No.853/2004, Annex III Section I Chapter V No. 4).

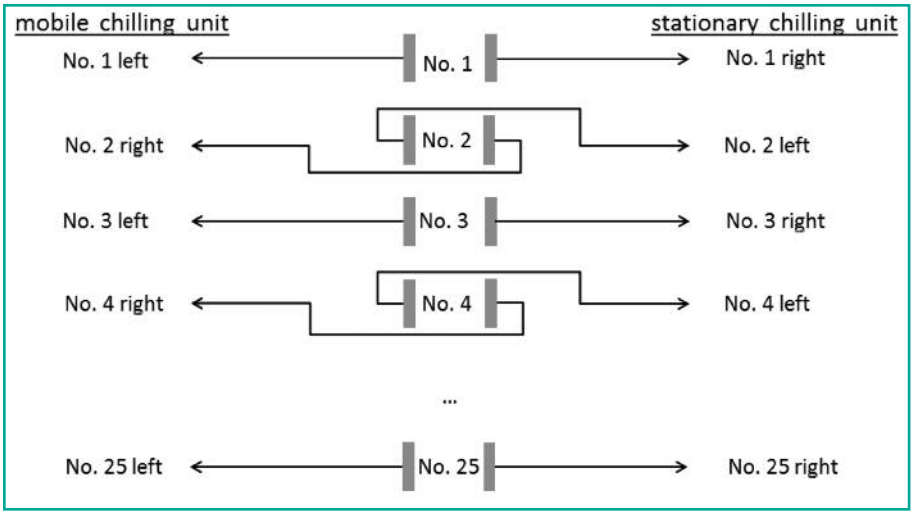

FIGURE 1: *Loading of carcasses for trial II and trial III.*

Transport of meat raises concerns regarding safety and stability (Moerman, 1983). Hence, meat must remain at ≤ 7°C during transportation. For specific purposes, such as scalded, cooked or fermented sausages, exceptions are possible (Deutz et al. 2011; Reg. (EC) No. 853/2004, Annex III Section I Chapter VII No. 3).

The generation time of microbial agents is determined by extrinsic (temperature, atmosphere, partial gas pressures, humidity) and intrinsic (water activity, pH value, redox potential, ingredients / texture) factors and agents (implicit factors) (Fehlhaber, 2004; Fries, 2009). Low temperatures control microbial metabolism, preventing abundant growth and spoilage (Olson & Nottingham, 1980).

It was the aim of this study to compare hygienic consequences of chilling in a mobile unit and the stationary unit of an abattoir under various temperature conditions.

Materials and Methods

Three trials were performed with chilling taking place in a chilling room (25 split carcasses per trial) and a chilling vehicle (25 split carcasses from the same individuals as those in the chilling room).

The chilling vehicle was chilled prior to loading, with the truck remaining on the parking area of the abattoir and being plugged into the electric system of the plant. In the truck (internal length 7200 mm, internal width 2460 mm, internal height 2500 mm) a Mitsubishi TU 73 chilling machine was installed.

Temperature measuring

In both chilling units, the air temperature was adjusted to 2 °C and measured continuously every 15 minutes with a temperature logger (ebro Temperaturüberwachungssystem EBI, Version 1.5 E).

For carcass temperature, the logger was placed in the muscles 5 cm below the surface and approximately 10 cm from the end of the caudal pelvic base at an angle of 105°. The time interval of measuring the carcass temperature was 15 minutes, too.

Study design

Three trials (I, II, III) were performed (with 50 split carcasses). One half of each carcass was directed into the stationary unit and the other one into the mobile unit, while maintaining their identity. For trial I, all left halves remained in the chilling room and all right halves were loaded into the chilling vehicle. In trials II and III, carcass halves were chilled together in the stationary unit until a core temperature of 20 °C was reached. Then, the left half of the first carcass was loaded into the mobile chilling unit and the other half remained in the chilling room. The process continued alternating with the other carcasses as indicated in Figure 1.

The microbiological status was examined three times:

- sampling position 1: commencing of chilling (initial temperature = initial status)
- sampling position 2: core temperature of the carcass at 20 °C was reached
- sampling position 3: end of chilling (7 °C or 10 °C, depending on the trial)

For trial I, the final temperature in both chilling units was 7 °C. Sampling took place at positions 1 and 3.

For trial II, the final temperature in both chilling units was 7°C. Sampling took place at all three sampling positions.

For trial III, the final internal temperature of carcass halves in the chilling vehicle was 10 °C. In contrast, halves in the chilling room were chilled to an internal temperature of 7 °C. Sampling took place at all three sampling positions.

Bacteriological examination

From each split carcass, 4 skin samples of 5 cm^2 (jowl, back, belly and ham) following Reg. (EC) No. 1441/2007 were taken and pooled resulting in one sample / half. In total, 400 samples (100 in trial I and 150 in trials II and III) were analysed. Three samples get lost (two in trial II and one in trial III).

Samples were added to 100 ml buffered peptone water (BPW, Merck, Darmstadt, Germany). After stomaching (Seward Medical, London, GB; 1 min., normal speed), the broth was diluted in decimal dilution steps and then analysed for aerobic plate count (APC).

APC from duplicate agar plates was obtained by using the spread plating procedure according to German Standards DIN 10161-1 (DIN 1984) and DIN EN ISO 6887-1 (ISO 1999). Colony forming units (cfu) from both plates of

TABLE 1: *APC mean values (log_{10}) and standard deviation (trial I–III).*

	sampling position 1		sampling position 2		sampling position 3	
	chilling room	chilling vehicle	chilling room	chilling vehicle	chilling room	chilling vehicle
trial I						
mean value (log)	log 3.7	log 3.4	n. d.	n. d.	log 3.5	log 3.3
standard deviation	0.55015	0.50714	n. d.	n. d.	0.45253	0.39374
trial II						
mean value (log)	log 3.6	log 3.5	log 3.5	log 3.5	log 3.4	log 3.4
standard deviation	0.50688	0.32523	0.60169	0.44989	0.53132	0.34826
trial III						
mean value (log)	log 3.4	log 3.7	log 3.3	log 3.3	log 3.0	log 3.0
standard deviation	0.50365	0.52274	0.50992	0.5069	0.28227	0.39857

n. d. = not done; N = 25 samples for each sampling position

2 consecutive dilutions with a number between 30 and 300 / plate were counted and recorded. APC per cm^2 was calculated with respect to the dilution step and multiplied by a factor of 10.

Statistics

For each trial, the mean value and standard deviation were calculated for both chilling units. For each chilling unit, APC from carcasses at the various sampling positions were compared by using the paired t-test and for comparison of the chilling systems the independent t-test.

As a null hypothesis, no difference was supposed between various carcasses at the sampling positions and in the two chilling systems as well. In case of $p \leq 0.05$, the null hypothesis was rejected, i.e. a difference was observed.

Results

Air temperature and internal temperature of the carcasses

Trial I: Temperature measurement commenced at 8 °C (stationary chilling unit) and at 9.5°C (mobile chilling unit). In both systems, temperature decreased continuously, in the mobile chilling unit more rapidly than in the stationary unit. The final temperature after 18 hours was 4.9 °C (stationary unit) and 2.4 °C (mobile unit).

Trial II: Temperature measurement commenced at an ambient temperature of 3.5 °C in both chilling units. The temperature dropped continuously, again with a more rapid decrease in the mobile unit. The final temperature after 15 hours was 2.8°C in both chilling systems.

Trial III: Temperature measurement started at 6.3 °C (stationary unit) and at 4.9 °C (mobile unit). For the stationary unit, a slight decrease was observed (final temperature after 15 hours 3.8 °C). For the mobile unit, an increase of temperature was observed (final temperature 12 °C).

Mean initial internal temperature of the measured carcasses in the stationary unit was 30.1°C (trial I), 32.9 °C (trial II), and 37 °C (trial III). In the mobile unit, 35.5 °C, 35.5 °C and 34 °C, respectively, were observed (Fig. 2).

After duration of 3.5 to 6.5 hours, a temperature of 20 °C in trials II and III was obtained. Final temperature (7 °C or 10 °C; trial III, mobile unit) was obtained after 14 hours 15 minutes and 18 hours, respectively. In both units and in all trials, the drop of temperature was nearly identical (Fig. 2).

Decrease of Aerobic Plate Count

In both chilling systems, a decrease of bacteriological load was observed. Final APC was nearly the same in both units, even with a chilling temperature of 10°C in the mobile chilling unit and of 7 °C in the chilling room (trial III) (Tab. 1).

Trial I:
Initial APC was log 3.7 in the chilling room, decreasing to log 3.5. In the chilling vehicle, the initial APC was log 3.4 decreasing to log 3.3.

Trial II and III:
In trial II, APC decreased from log 3.6 to log 3.4 (stationary) and from log 3.5 to log 3.4 in the chilling vehicle.
In trial III, APC decreased from log 3.4 to log 3.0 in the stationary unit and from log 3.7 to log 3.0 in the mobile unit.

The two chilling units

At each sampling position, APC in both chilling units was compared.

In trial I, mean values of the stationary and mobile chilling units were different at sampling positions 1 and 3 (with a lower APC in the mobile unit) (Tab. 2).

For trial II, no difference was observed between the stationary and mobile chilling units (Tab. 2).

At sampling position 1 in trial III split carcasses in the mobile unit started with a higher APC. However, at the end (sampling position 3), no difference was observed (Tab. 2).

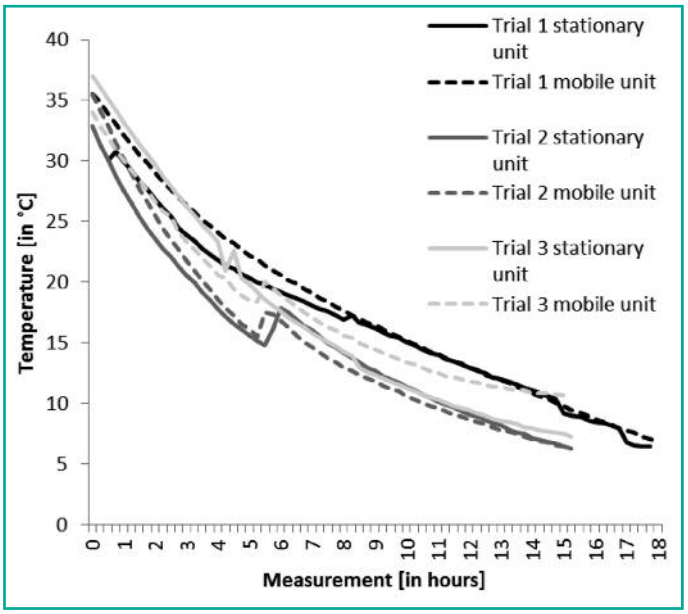

FIGURE 2: *Temperature profile of carcasses in stationary and mobile chilling unit for trial I–III.*

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TABLE 2: *Difference between APC of stationary and mobile unit.*

trial	sampling position	chilling room		chilling vehicle	observed difference
trial I	position 1	log 3.7	⟷	log 3.4	significant p = 0.030
	position 3	log 3.5	⟷	log 3.3	significant p = 0.030
trial III	position 1	log 3.4	⟷	log 3.7	significant p = 0.012
	position 3	log 3.0	⟷	log 3.0	not significant p = 0.842

Discussion

In this study, three separate trials were performed

- Immediate chilling after slaughter and processing (trial I): Here, the chilling capacity of the mobile and the stationary chilling unit was recorded and the microbiological status was examined (baseline study). The decrease of temperature was comparable in both chilling rooms. No difference was seen in the microbiological status of the carcasses at 7 °C in the two units. The decrease of initial APC in the stationary chilling room was significant.
- After (stationary) chilling to a core temperature of 20 °C (5 cm below the surface) (trial II), carcasses were loaded into the mobile unit. Here, transport was simulated before the carcasses had reached the mandatory internal temperature of 7 °C. APC in the mobile unit was not significantly higher than the initial one.
- Under conditions comparable with those of trial II, the chilling procedure was stopped at 10 °C (trial III) in the mobile unit in order to simulate a situation in which the required internal temperature of 7 °C was not reached before transport. Simultaneously, stationary chilling continued to an internal temperature of 7 °C. No difference of APC on carcasses in the mobile and the stationary unit was observed (null hypothesis accepted).

Technical chilling / temperature profiles

In both chilling systems temperature targets (20 °C and 10 °C / 7 °C) were reached nearly within the same period.

Temperature curves of carcasses corroborate results of Moerman (1983), who found that the temperature curves of pork in experimental transports were similar to the curves obtained by conventional chilling. However, different chilling patterns should be expected from different animal categories and animals sites, e.g. the internal temperature of beef hindquarters decreases more slowly than forequarters, because of the higher muscle mass in the hindquarter (Holzer & Ring, 1998). Also different loading will result in different temperature profiles. Frequently, transports proceed with a higher load than 5 halves / m (during transport, carcasses must be prevented from swinging).

Chilling in a mobile unit

According to Scott and Vickery (1939), the flow of cool air over a carcass can dry out the surface, an event impacting on the metabolism of bacteria. Nottingham (1982) has shown that the adjustment of humidity, speed of the air or temperature can result in an increase, decrease or constant level of APC.

In the light of microbial generation times, a temperature-time-combination of 10 °C / 8 h for the chilling of carcasses during transport is considered as safe and technically realistic (SCVPH, 1999) under the following conditions:

- Air temperature in the mobile unit should be always < 7 °C, which should be reached prior to loading.
- The cold chain should be maintained throughout all procedures including loading and unloading; transporters should dock on the loading gate immediately after opening of doors.
- The chilling vehicle must have a regularly calibrated temperature-recording system during the whole period of transport.

Results indicate that the microbiological status does not worsen in a mobile unit. Alternatively, even with higher end temperatures, the significant difference of APC between the beginning and the end of chilling can be maintained in the mobile unit (Tab. 2).

The APC decrease in the chilling room is a long known phenomenon as the microflora has to adapt to lower temperatures (Hurst, 1980) which occurred in the mobile unit, too. In trial III, a clear decrease of APC was observed.

The initial APC was different between the stationary and the mobile unit in trials I and III, data from sampling position 3 indicate that APC values of mobile chilled carcasses were at a comparable level with those in the stationary unit.

Results corroborate those of Moerman (1983) indicating that surfaces remain in accordance with requirements of Reg. (EC) No. 1441/2007, setting a mean APC of < 4.0 log cfu / cm^2 for pigs. Results are also in accordance with those of Ellouze et al. (2011) who investigated the microbiology of surfaces after the transport of carcasses loaded at a (simulated) core temperature of > 12 °C.

Summarizing, our data show that the efficacy of temperature decrease of both chilling systems is comparable. APC remains stable and in the regulative ranges for both systems, even when the final temperature is higher than legislation requires (trial III, chilling vehicle). Data indicate that the general rule on chilling during transport is too general and should ask for more detailed exceptions.

Conclusions for practice

Temperature limits are meaningful and practicable criterion for supervision and verification: temperature is easy to check with the help of a thermometer. These data show that a temperature higher than 7 °C does not necessarily result in higher APC.

Worker's safety

The temperature limit of 7 °C internal temperature might cause problems during cutting. Work is more laborious with tissues at low temperatures, possibly resulting in a higher risk of accidents. Thus, from a technical point of view, cutting might be more convenient at higher temperatures. In addition, identical temperatures of both surface and ambient air might prevent the condensation of air humidity onto the meat surface, a consideration taken into account by Reg. (EC) No. 853/2004, which allows a higher temperature at the time of cutting.

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