The effect of freezing and thawing on the microbiology of pork sides

J J SHERIDAN and J SHERINGTON

The Agricultural Institute, Meat Research Department, Dunsinea Research Centre, Castleknock, Co Dublin, Ireland
and
The Agricultural Institute, Statistics Department, HQ, 19 Sandymount Avenue, Dublin, 4, Ireland.

Introduction

In general, freezing is used to facilitate the long distance transportation or long-term storage of meat. In the case of pork production, freezing is used as a means of overcoming large variations in throughput. This ensures a constant supply of product in times of scarcity. It is used in particular by the home trade to guarantee a supply of pork for ham production at Christmas. Pork sides may also be frozen for later processing into bacon (Gardner, 1980). The transportation of pork as sides or boxed primals from Ireland to Japan, a journey of about five weeks duration, is facilitated by freezing the meat (Sheridan, 1982).

Whatever the reason for processing meat in this way, the quality of the product will depend on a number of factors both before and after freezing. The most important of these are the initial hygiene of the product and the thawing temperature. According to other workers the most advantageous thawing conditions are a low initial bacterial count coupled with a thawing temperature in air of 10°C (Bailey *et al.*, 1974). The present work was carried out to determine the effect of initially high and low bacterial numbers, combined with a number of different thawing temperatures, on the keeping quality of frozen pork sides.

Materials and Methods

Pork sides with a mean side weight of 65 kg ($\pm$ 3 kg) were obtained from pigs slaughtered in the Industry Development Unit (IDU) of the Meat Research Department at Dunsinea.

Copper constantan thermocouples from a Honeywell temperature recorder were used to measure the internal and surface temperatures on pork sides during freezing and thawing. The probes were attached to the sides as described by Sheridan and Lynch (1979). Surface and internal probes were placed at each of four sites (1) at the hind leg; (2) on the inside near the diaphragm; (3) the inside of the neck near the spine and (4) the front leg. These sites represented the

thickest and thinnest portions of the side.

The sides were frozen in a blast freezer, set at $-40^{o}C$, to an internal temperature of $-35^{o}C$. Frozen sides were hung on a rail in a small experimental chill, four or five at a time and allowed to thaw at chill temperatures of 0, 5 or $10^{o}C$ ($\pm 1^{o}C$). The ambient temperatures of the freezer and chill were recorded during freezing and thawing. The fans in the chill were turned off to simulate the static air conditions in cellars or other areas used in a number of older factories lacking modern controlled thawing facilities. Temperature control during thawing may also be deficient in these cases, but for the present study this was considered as a minimum requirement. Thawing was considered to be complete when the internal temperature of the deep leg had risen to $0^{o}C$.

Thin pieces of lean meat of approximately 25 cm^2 were exised from three sites on each side. These were (1) at the exposed top surface on the inside of the leg, (2) exposed lean surface of the diaphagm after removal of the kidney fat and (3) the lean meat at the shoulder along the spine. A 1 g sample was taken from each of the excised pieces and these were pooled in 17.0 ml of 0.1% Oxoid peptone water in McCartney bottles. These were shaken vigorously before serial dilution and plating out of 0.025 ml quantities on quartered plates of Oxoid TGYA and CFC media. The latter was used as a means of assessing the presumptive *Pseudomonas* count (Mead and Adams, 1977) and the former the total plate count. Plates were incubated at $25^{o}C$ for 4 days and at $4^{o}C$ for 14 days.

In order to obtain sides with high and low initial bacterial counts, indicative of good and poor hygiene standards during processing, sides were either (1) frozen one day after slaughter, representing animals with low initial counts or (2) kept in a chill ($1^{o}C$) for seven days to give high initial counts. The data were statistically analysed as a two-factor experiment (initial count (2 levels) X temperature (3 levels)). For each side the increase in count was calculated and analysed. The statistical significance of the increase for each treatment was determined with a t-test, based on the residual standard deviation from the analysis of variance. The difference between 25^{o} and 4^{o} incubation was similarly tested.

Results

The overall total counts from pork sides with high initial bacterial numbers ($\log_{10}$ 6.80/g) were significantly different from those with low ($\log_{10}$ 3.83/g) initial counts ($P<.001$). A similar result was observed with presumptive Pseudomonads where the overall counts from sides with high and low contamination levels were $\log_{10}$ 6.71 and $\log_{10}$ 3.23/g respectively. Further analysis of the initial counts from sides to be frozen and subsequently thawed at 0, 5 and $10^{o}C$ indicated only small differences in numbers (Table 1).

TABLE 1: Initial bacterial numbers (log_{10}/g) on pork sides before freezing and thawing

Initial bacterial numbers	High			Low			Standard error of difference between means (D.F. 10)	F-test for differences between temperatures	F-test for interaction between temperatures & high or low bacterial numbers
Thawing temperature (°C)	0	5	10	0	5	10			
Incubation temperature (°C)	Total viable count (TGYA)								
25	6.77	6.67	6.96	4.15	3.64	3.70	0.28	1.18	1.32
4	6.27	6.49	7.13	4.07	2.92	3.53	0.31	4.21*	6.47**
	Pseudomonas (CFC)								
25	6.76	6.52	6.85	3.61	2.79	3.29	0.30	3.57*	1.02
4	6.20	6.12	6.76	3.71	2.49	3.16	0.34	4.94*	3.66*

N.S. = not significant; D.F. = degrees of freedom; Significant level * P<.05 **P<.01

A t-test showed that when plates were incubated at 4 or 25°C, differences were generally small or non-significant. When sides were frozen and thawed at temperatures of 0, 5 or 10°C, there was a gradual increase in survival with rising temperature, on sides with high initial counts (Table 2). This was evident for both the total and *Pseudomonas* counts. With low initial counts the largest increases were at 0°C. The actual increase of decrease in bacterial numbers after thawing at different temperatures is shown in Table 3. Sides thawed at 0°C, with initially high total and *Pseudomonas* counts, and the latter on sides thawed at 5°C, showed a decrease in bacterial numbers. All other thawing regimes caused an increase in bacterial counts over the initial levels present. Generally the increases or decreases were not significantly different on sides with initially high bacterial numbers. With low initial counts the increases were significant, particularly when the thawing temperature was 0 or 10°C. As already noted for the initial counts most of the differences between 4 and 25°C were non-significant, except for 0°C thawing temperature. As the thawing temperature was lowered there was a gradual increase in the time required to thaw the sides (Figs 1 & 2). When sides were thawed at 0°C the time taken to raise the internal temperature to this value was over 6 days. At this stage the sides were removed from the chill and sold, since by this time there was a noticeable deterioration in appearance.

Discussion

Depending on weight, when frozen meat is thawed in air, there is either a small reduction in bacterial count, as with lamb carcasses (17 - 22 kg), shoulders (2 - 6 kg) or pork legs (3 - 7 kg), (Vanichseni *et al.*, 1972; Bailey *et al.*, 1974; Creed *et al.*, 1979) or an increase as with beef blocks (25 - 27 kg) or quarters (65 kg) (Roberts, 1974; James *et al.*, 1977). The difference in these results is related to the thawing time, which is extended with increasing weight. In turn, the surface temperature is at or above 0°C for varying lengths of time. The data referred to in the above references are for meat that has been thawed in air at 3 or 10°C. Where an increase did occur it was usually greater at 10 than at 5°C and this has been observed in the present work. In general the increase in bacterial counts between 5 and 10°C is not considered of any practical significance and the higher temperature is preferred since thawing time is reduced (James *et al.*, 1977). Temperatures in excess of 10°C are to be avoided since increases in bacterial counts are too high (Bailey *et al.*, 1974).

In the present study thawing at 0°C showed a decrease in bacterial numbers when the initial counts were high, irrespective of incubation temperature or media. When the initial counts were low however, a large increase in total counts occurred on thawing at 0°C, particularly on plates incubated at 25°C. This rise could be accounted for by an increase in the *Pseudomonas* counts. Indeed, even with thawing at 5 or 10°C, increases in counts were usually higher when the initial levels of contamination were lower.

TABLE 2: Bacterial numbers on pork sides (log_{10}/g) after freezing and thawing

Initial bacterial numbers	High			Low			Standard error of difference between means (D.F. 10)	F-test for differences between temperatures	F-test for interaction between temperatures & high or low bacterial numbers
Thawing temperature (°C)	0	5	10	0	5	10			
Incubation temperature (°C)	Total viable count (TGYA)								
25	6.34	6.91	7.69	6.21	4.11	5.03	0.35	7.31**	18.95***
4	5.99	6.79	7.59	4.41	3.42	4.32	0.29	10.12***	11.86***
	Pseudomonas (CFC)								
25	6.03	6.43	7.56	5.87	3.17	4.71	0.41	12.18***	16.62***
4	5.83	6.87	7.10	4.46	2.53	4.16	0.28	10.80***	27.42***

N.S. = not significant; D.F. = degrees of freedom; Significance level ** P<.01; ***P<.001

TABLE 3: The increase in initial bacterial numbers (log_{10}/g) on frozen pork sides after thawing at 0, 5 and 10°C

Initial bacterial numbers	High			Low			LSI	Standard error of difference between means (D.F. 10)	F-test for differences between temperatures	F-test for interaction between temperatures & high or low bacterial numbers
Thawing temperature (0°C)	0	5	10	0	5	10				
Incubation temperature (0°C)	Total viable count (TGYA)									
25	-0.44	0.23	0.74	2.06	0.47	1.33	.48	0.34	4.20*	12.88***
4	-0.28	0.30	0.46	0.35	0.50	0.79	.48	0.34	3.18*	0.42
	Pseudomonas (CFC)									
25	-0.73	-0.08	0.71	2.27	0.34	1.42	.55	0.39	5.73**	12.69***
4	-0.37	0.75	0.34	0.75	0.05	1.01	.38	0.27	3.20*	12.16

N.S. = not significant; D.F. = degrees of freedom; Significance level *P<.05; **P<.01; ***P<.001
LSI = least significant increase - an increase larger than this figure is significantly different from 0 at the 5% level.

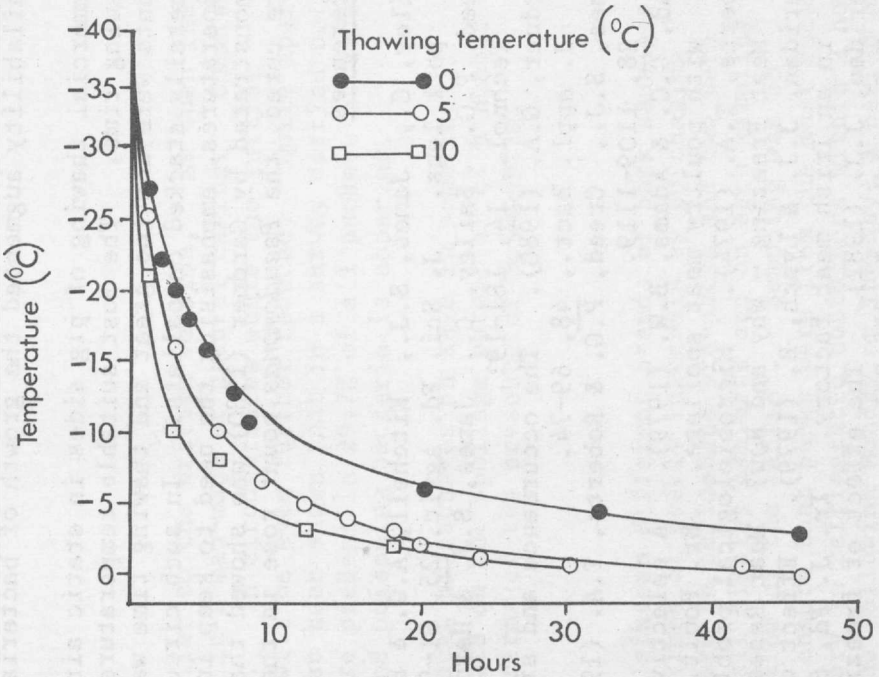

Fig. 1: The relationship of internal temperature to time on frozen pork carcasses being thawed at 0, 5 and 10°C

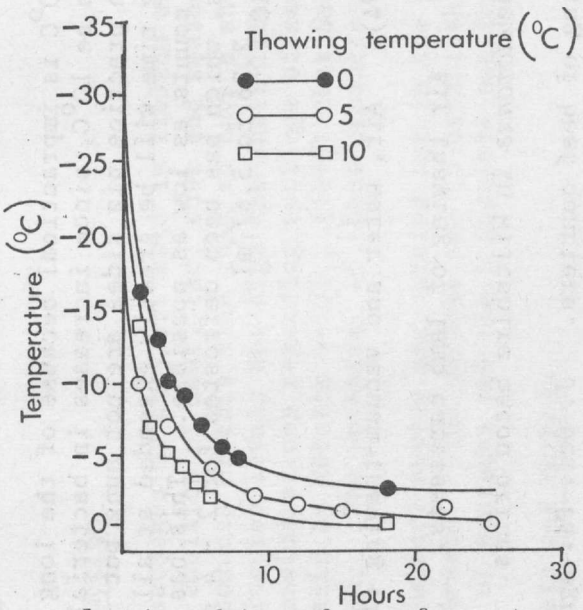

Fig. 2: The relationship of surface temperature to time on frozen pork carcasses being thawed at 0, 5. and 10°C

The differences between sides with high and low counts cannot be accounted for in terms of temperature or thawing times. It may be however, that because sides had initially higher counts as a result of a longer growth period, there was a greater depletion of nutrients from the surface compared to sides with low numbers where very little growth took place prior to freezing. On thawing a greater nutrient availability augmented the growth of bacteria on sides with initially low counts.

Commercial thawing of pig sides in static air conditions at $0^{o}C$ is impractical because of the long thawing time. The most suitable temperature would appear to be $10^{o}C$, since increases in bacterial counts were not too great and thawing time was shortest. In practice pig sides are not hung but generally stacked on pallets. In such circumstances thawing time will be greatly extended at all temperatures, emphasising the need to keep initial bacterial counts as low as possible. This has been demonstrated by Gardner (1980) who showed that when pig sides, which has been defrosted for 2 - 4 days, were cured, the *Pseudomonas* count rose in the brine from $\log_{10}$ 2.26 to 5.67/ml.

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