

## Summary of Some Danish Experiments on the Chilling of Hog Carcasses

By Mogens Jul

### Introduction

Traditionally the meat industries in most countries have used hanging floors for the chilling of carcasses after killing. Early experiments with the use of mechanically cooled rooms were often not successful, presumably due to the use of rooms with insufficient air circulation and refrigeration capacity, resulting in too high temperatures between carcasses and high humidity of the air which caused a high frequency of slimy meat surfaces.

For many years, therefore, mechanical cooling of carcasses was under suspicion and said to cause sliminess. Later, it was realized that this had been due to inefficient coolers and better designs were introduced. Next, however, the question was raised whether the quick cooling of the meat allowed sufficient possibility for ripening.

One reason for preferring quick cooling in mechanical coolers is the somewhat lower shrinkage which is often obtained in these as compared with hanging floors. However, it has been suspected that this saving would result in a reduction in keeping quality due to insufficient drying of the surface layers of the meat which would make it more susceptible to bacterial determination later. The low initial shrinkage might also simply lead to increased shrinkages in later stages of cooler storage or processing which might offset any initial saving.

Some experiments which have been carried out in Denmark and which were aimed at throwing light on some of these problems are reviewed in the following.

### Some details regarding hanging floors and chilling rooms

#### Hanging floors

These are generally fairly large halls with a ceiling height of about 4 to 7 meters and with provisions for air intake through louvers near the floor, generally in at least two of the walls. Exhaust is provided through vents in the ceiling leading directly to the open air.

A reasonable distance is kept between the carcasses on the floor. After chilling on these floors for up to 24 hours, the carcasses are trimmed and stored in coolers until curing is begun.

#### Traditional coolers

These are generally fairly large rooms divided into two sections by the installation of a coil bank. The coils are generally brine cooled and the air circulated lengthwise over the coils by fairly large fans. The direction of rotation of the fans can sometimes be reversed during chilling.

### Unit coolers

These are generally finned coil, direct expansion coolers with forced air circulation of high velocity. In earlier installations the coils were sprayed with brine. Since brine often causes serious corrosion problems, several bacon factories have switched to using a solution of propylene glycol in water. Since this is a fairly expensive medium, it requires a separate condensing unit in which the liquid is reconcentrated.

### Finned coil coolers or dry coolers

These are much like the unit coolers, only the finned coil area is somewhat larger. Since no defrosting medium is used, defrosting takes place during the later stages of the cooling operation, generally referred to as the equalization period, when the room is maintained at about +5° C. with reduced air circulation. To save floor space, the coolers are often installed above the overhead rails (see fig. 2).

### Experimental data

#### Experiment No. 22

This experiment, comparing hog carcasses chilled on hanging floors with carcasses cooled in traditional coolers, was carried out by the Danish Bacon Control (Baconkontrollen) in various plants during the months of February to July. The end temperature in the carcass was 5° C. The carcasses were split and trimmed after chilling and made into Wiltshire bacon by the usual Danish manufacturing method.

A check on weight and yields was made throughout the experiments. Initial weighing was carried out on an overhead rail scale with an accuracy of  $\pm 50$  g. Later weighing was done by placing each side on the pan of a manually operated double beam balance weighing with an accuracy of about  $\pm 50$  g.

Keeping quality was determined by visual evaluation of the finished Wiltshire bacon after one week's maturation and subsequent shipment to England where the weights were determined before and after smoking and after three days of storage of the smoked product.

#### Experiment no. 236

This experiment was carried out by the Danish Bacon Control and the Danish Meat Products Laboratory (Slagteriernes Laboratorium). The experimental procedure was about the same as that used in experiment no. 22. Each series involved 60 pigs - 30 male and 30 female. The carcasses were chilled ~~after~~ splitting. Alternating, left and right sides were placed in each group. The two groups were cured in separate tanks and the tank pickles kept apart.

The cured bacon was matured for 4 days and then baled and stored at 10° C. for 5 days. After this, the surface condition of the sides was evaluated by visual observation by three judges working as a group.

A bacterial count of the tank pickle was taken by culturing on meat peptone agar immediately after the end of tank curing.

Experiment no. 458

This and the following experiments were carried out by the Danish Meat Research Institute (Slagteriernes Forskningsinstitut). Each group consisted of 40 animals. One group was chilled on hanging floors for 27 hours after which it was placed in a cooler for 17 hours. Then the animals were split, trimmed and cured. The other group was quick cooled in a mechanical cooler of the unit cooler type for 19-26 hours prior to splitting, trimming and curing.

After maturation for three days the bacon was baled and shipped to the U.K. under controlled conditions. In England, it was visually inspected for appearance by three judges working as a group. The bacon was then smoked and the smoked bacon inspected visually by two judges as whole sides, and also during slicing in a retail outlet, here by one judge.

The gammons were separated from some of the sides before smoking and manufactured into cooked green hams. The colour of these were evaluated by two judges using individual scoring. The colour was evaluated immediately and after 5½ hours' exposure to daylight (no sun) at room temperature.

Throughout the experiment weights and yields were followed. Weighing before chilling was carried out on an overhead rail scale having an accuracy of  $\pm 100$  g. During the subsequent processing, a double beam manually operated scale with a special pan on which the sides were placed was used. It weighed with an accuracy of about  $\pm 10$  g. Measurements in the U.K. related to shrinkages during shipment, smoking and ham preparation were carried out on an even arm scale with an accuracy of about  $\pm 7$  g.

Experiment no. 469

Weight measurements were made under actual operating conditions in a Danish bacon factory. Weighing before and after chilling was done on an overhead rail scale with an accuracy of  $\pm 100$  g. After chilling and during processing a double beam manually operated scale was used, equipped with a pan on which the sides were placed during weighing. Its accuracy was  $\pm 10$  g. The experiment involved two cooling rooms equipped with finned coil coolers, with automatic defrosting every 20 minutes and two rooms of the traditional type. Further, it involved two groups of whole hogs, each comprising about 40 animals, and two groups of split carcasses, each comprising about 40 animals.

Experiment no. 55-52

The purpose of this experiment was to compare the quality of bacon made from hogs chilled in the hanging floors with that of bacon cooled in quick coolers. The experiment was carried out by the Danish Meat Research Institute in cooperation with the Danish Bacon Company, London.

Six hogs were used in the experiment. They were split prior to chilling. Three left and three right sides were chilled on the hanging floors and the corresponding sides quick cooled in a room equipped with unit coolers.

The experiment was carried out in the month of October. The temperature on the hanging floors was  $15 - 9^{\circ}$  C.

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After chilling, the sides were trimmed and cured as Wiltshire bacon according to the usual Danish manufacturing method.

Taste evaluation was carried out on fried samples by the usual taste panel of the Danish Meat Research Institute, then consisting of five experienced judges, who worked independently. Simultaneously, the bacon was tested in England by the experts of the Danish Bacon Company. In neither case did the judges have any knowledge of the meaning of the codes under which the samples were presented.

#### Experiment nos 56-63

The purpose of this experiment was to investigate shrinkage during various stages of cooling and equalization. The weighing technique was the same as mentioned above for experiment 469 except that during the cooling operation the weight changes of one carcass was recorded on a special scale equipped for reading outside of the cooler room. The accuracy of this reading was  $\pm 5$  g.

In addition, temperature and relative humidity were recorded in several places in the cooler. The temperature in various parts of various carcasses was also recorded.

These experiments were carried out in a room with dry finned coil coolers (see fig. 2).

For temperature recording, resistance thermometers were used, giving readings with an accuracy of  $\pm 0.1^\circ \text{C}$ .

For relative humidity measurements, hair hygrometers of a special manufacture obtained from Wilh. Lambrecht, Göttingen, Germany, were used. They were checked before and after each 16 hours use and it is believed that an accuracy of about  $\pm 2\%$  was obtained.

Air speeds as indicated in fig. 2 were measured on a fan type velocity meter. The accuracy of this instrument is not known.

#### Experiment 5 - S - 1

The purpose of this experiment was to determine how yield during bacon curing may be affected by the initial weight loss during cooling. The experiment was carried out using the cooling rooms of a special design at the Danish Meat Research Institute. The rooms have an air treatment chamber using a propylene glycol spray. This chamber is placed above the room. To obtain lower humidities the air



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may be heated after it has passed through the spray. The air thus treated sinks down into the cooler. The air is returned through hollow walls with openings into the room, about 50 cm. above the floor. The hogs were cooled after splitting. One group of sides was cooled at a relative humidity of 95-98%, the other at a relative humidity of 70-75%.

Weighing before and after cooling was carried out on an overhead rail single beam scale with an accuracy of  $\pm 10$  g. Corrections were made for differences in the weight of the hooks.

The carcasses were subsequently used for bacon curing using the usual Danish method of production. Weighing between each operation was carried out on a double beam manually operated scale with an accuracy of  $\pm 10$  g. Temperature and other conditions were identical for the two groups. A period of three days maturation at 90% relative humidity was used.

Each group consisted of 18 sides. The experiment was repeated five times and the results given below are averages of the five comparative series.

To ascertain keeping quality, a bacteriological count was made on the sides from the last two experiments. A thin piece of surface layer, 100 cm<sup>2</sup> in area, was separated from the side and placed in a flask with sterile water. The count was made on meat peptone agar plates incubated for 4 days at 20° C. Samples of surface layer were taken on 10 places of the skin side and 10 places of the meat side.

A count was also made of the bacteria in the pickle from the last two experiments both before and after salting, using dilution in salt solution and spreading on meat peptone agar.

### Results and discussion

#### Organoleptic quality

Experiment no. 236. The condition of the sides was evaluated organoleptically, using a score from 1 to 10, 10 representing perfect. The average scores were:

	<u>After maturation</u>	<u>After 5 days at 10° C.</u>
Quick cooled	8.81	8.17
Hanging floor	8.42	7.54

Thus bacon from quick cooled carcasses showed slightly better appearance after 5 days storage.

Experiment no. 458. The bacon sides were scored in the U.K. for wetness. The results were, in number of sides:

	Very wet	Wet	Normal	Dry	Very dry
Quick cooled	7	13	13	7	0
Hanging floor	5	18	17	13	5

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The results seem to indicate that there was no difference of any importance in this respect. Also, the check on wetness of the cut surfaces revealed no difference at all between the two groups.

The colour of the cooked gammons was evaluated, using a score from 1 to 10, 10 representing perfect. The surface was evaluated when freshly cut and after 5½ hours exposure to daylight and air with the following result.

	<u>Fresh surface</u>	<u>After 5½ hours</u>	<u>Loss</u>
Quick cooled	6.3	2.5	60%
Hanging floors	5.9	2.3	61%

Thus, the tendency seemed to be a slightly better colour in gammons from quick cooled sides.

Experiment 55-52. Bacon made from sides chilled on hanging floors was compared with bacon made from quick cooled sides. Taste was evaluated in England by the Danish Bacon Company and in Denmark by the Danish Meat Research Institute. A scoring system from 0 to 10 was used, 10 representing perfect. The following average results were obtained for taste scores.

	<u>England</u>	<u>Denmark</u>
Hanging floors	8.50	8.20
Quick cooled	8.66	8.28

The scores for texture were:

	<u>England</u>	<u>Denmark</u>
Hanging floors	8.07	8.10
Quick cooled	8.29	8.03

The scores for saltiness were as follows (10 indicates perfect, lower scores the degree of imperfection whether it be due to too little or too much salty taste):

	<u>England</u>	<u>Denmark</u>
Hanging floors	8.97	8.40
Quick cooled	9.25	8.20

The correlation coefficient for scoring in England and in Denmark for taste was 0.66, indicating fairly good agreement. Thus there seemed to be a definite preference for the taste of bacon made from quick cooled sides.

The correlation coefficient for the texture score was 0.21 and that for saltiness 0.01. Thus, in these respects, no difference could be found between the two groups.

The results seem to indicate that the opinion often held in the trade that the use of hanging floors is to be preferred over quick cooling rooms is an erroneous one, insofar as taste, texture, etc. are concerned.

Bacteriological investigations

Experiment 236. A count of bacteria in the pickle showed the following average results.

	<u>Count before cure</u>	<u>Count after cure</u>	<u>Increase</u>
Quick cooled	8,500	22,000	260%
Hanging floors	8,500	75,000	890%

This is thought to indicate that the quick chilled sides introduce fewer bacteria into the brine and that they will show a better keeping quality of the finished bacon. The latter was confirmed by the organoleptic tests mentioned above.

Experiment 5-S-1. Counts of the surface layer of Wiltshire bacon after two weeks' refrigerated storage gave the following average results (Log. bacterial count):

	<u>Skin side</u>	<u>Meat side</u>
Quick cooled in normal cooler	7.29	6.93
Quick cooled in dry cooler	7.20	6.80

Here, no significant difference was found.

Shrinkages and yields

Experiment no. 22. The following are averages from 8 series of experiments. Data on shrinkages up to maturation are given in per cent of hot dressed carcass weight. Other shrinkages are given in per cent of the weight immediately before the type of treatment indicated.

	<u>Quick cooled</u>	<u>Hanging floors</u>
Chilling	1.74%	2.58%
Trimming and offal	19.05%	18.71%
Curing	= 3.70%	= 4.06%
Maturation	0.78%	0.63%
Total	<u>17.87%</u>	<u>17.86%</u>
Shipment to England	0.79%	0.70%
Smoking	4.83%	4.70%
Storage of smoked sides	1.52%	1.46%

While quick cooling results in lower chilling shrinkage than that obtained by the use of hanging floors, this is offset by greater shrinkage during trimming and curing.

Shrinkages during shipment to England, smoking, etc. are the same for the two groups which was as one might expect when the other results are considered.

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Experiment no. 236. The following shrinkages were found during processing. Q indicates quick cooled and H indicates hanging floors. All figures refer to per cent of hot dressed carcass weight.

Experiment	A		B		C		D		Average	
	Q	H	Q	H	Q	H	Q	H	Q	H
Chilling	1.14	2.61	1.64	2.56	1.85	2.86	1.69	2.52	1.58	2.64
Salting and maturation	-2.26	-3.04	-2.46	-3.60	-2.35	-3.39	-3.27	-4.19	-2.59	-3.56
Total	-1.12	-0.43	-0.82	-1.04	-0.50	-0.53	-1.58	-1.67	-1.01	-0.92
3 days' storage at 10°C.	1.63	1.62	0.43	0.46	0.38	0.48	0.38	0.45	0.71	0.75

The tendency seems to be exactly as above, the original gain in weight is offset by corresponding differences in yield during the manufacture of Wiltshire bacon. Shrinkages during transport are the same for the two groups.

Experiment no. 458. Shrinkages during the various stages of processing were as follows (all figures are in per cent and refer to hot dressed carcass weight):

	<u>Quick cooled</u>	<u>Hanging floors</u>
Chilling	2.07%	2.86%
Trimming and offal	18.85%	18.52%
Salting	- 3.26%	- 3.41%
Total	17.66%	17.97%
Transport to U.K.	0.46%	0.42%
Smoking of bacon	2.77%	2.66%
Cooking of green gammons	16.65%	16.95%

Here only about half of the gain was offset during curing. It is particularly noteworthy that no difference seemed to exist between losses during shipment to the U.K. nor between smoking losses nor losses during the preparation of cooked gammons.

Experiment no. 469. Traditional coolers were compared with rooms with unit coolers. The chilling shrinkages were 1.9% and 1.8% respectively, referring to hot dressed carcass weight.

Experiments no. 56-63. Shrinkages in a cooler with overhead finned coil coolers were determined together with other data. Figure 1 gives a diagram for temperature, humidity and weight measurements during one experiment.



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With the rails numbered as indicated in figure 2, the following shrinkages (measured in per cent of hot dressed carcass weight) were found:

Experiment	I	II	III	IV	V
A	1.55	1.50	1.60	1.44	1.29
B	2.08	1.96	2.00	1.85	1.75
C	1.59	1.68	1.57	1.69	1.47
D	1.42	1.67	1.53	1.47	1.42

Air speeds in meter per second are also given in figure 2.

It seems that weight losses are at a minimum for the carcasses most exposed to the flow of air from the cooler unit and high for the carcasses in a neutral zone of air flow. Small improvements in this respect might be expected by improvements in the distribution of the air flow throughout the room.

Experiment no. 5 - S - 1. Weight losses were compared for sides cooled in a cooler like the normal unit type with those obtained in a very dry cooler. Shrinkages were as follows (all figures are gain in per cent of hot dressed carcass weight):

	<u>Normal cooler</u>	<u>Dry cooler</u>
Chilling	1.32%	1.90%
Trimming	14.39%	14.07%
Pumping	- 4.85%	-4.89%
Tank cure	1.10%	0.83%
Mature on	0.73%	0.78%
Total	12.69%	12.69%

Since this represents the average of five experiments, each comprising 18 sides, there seems little doubt that at least where quick coolers are employed, small differences in weight losses during chilling will be eliminated during subsequent curing.

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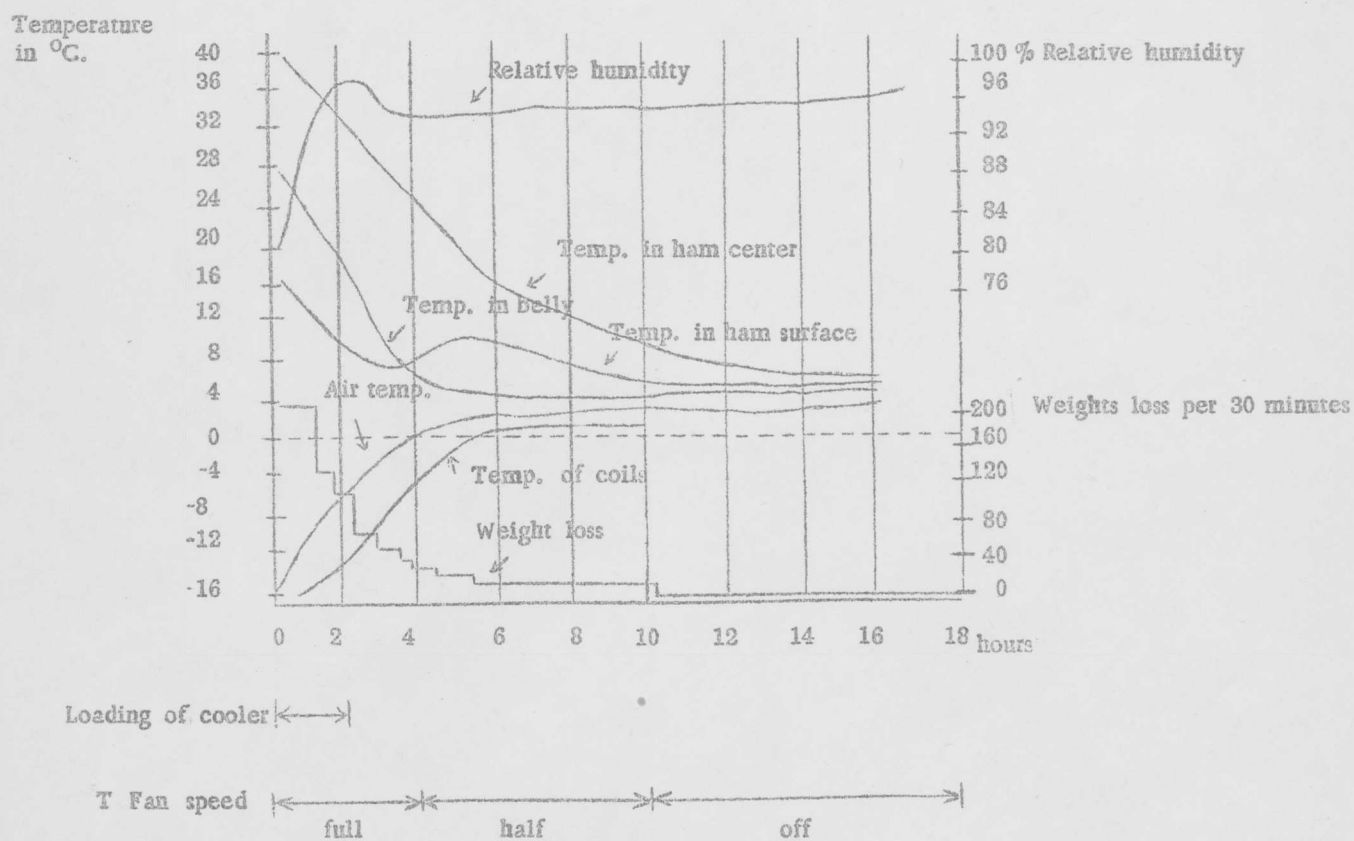


Fig. 1. Diagram of a quick cooling process for hog carcasses.

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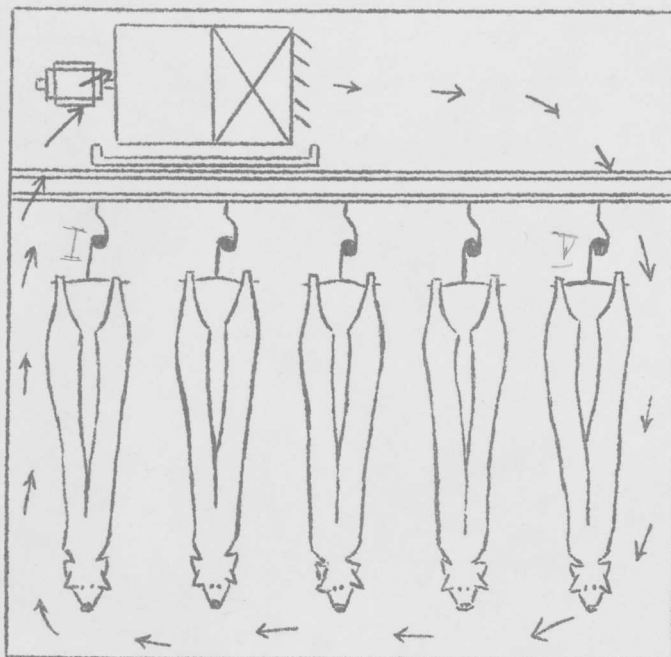


Fig. 2. Dry coil cooling room for pigs. Figures indicate air speeds in meter per second.