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Effect of Controlled Climate Thawing upon the Bacterial Flora in Frozen Meat

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Pork and beef are to a great extent frozen and stored in whole carcases or in quarters. Due to quick-freezing in blast tunnels at -40°C and storage at temperatures at or below -30°C losses in weight and quality are small. Carcase meat must, however, be thawed before it reaches the consumer and thawing of whole carcases or parts thereof causes great problems in the handling of frozen meat.

Usually thawing is performed in air in a more or less cooled room. This method of thawing is space and time-consuming - it takes approximately 72 hours to thaw a quarter of beef in a room with a temperature of +5°C (+41°F). Thawing also causes losses in weight due to drip of meat juices and drying of the surface. If the temperature of the air is raised the thawing time may to some extent be shortened but the rise in temperature causes several disadvantages. The microorganisms on the surface of the meat are favoured by the higher temperature and will multiply rapidly and soon make the meat unfit for consumption. The "natural" microflora of the meat consists, however, of different kinds of psycrophilic bacteria, which are able to grow considerably during the relatively long time required for thawing also at lower temperatures. It is also believed that frozen meat becomes more perishable after thawing than fresh meat (Borgström, 1955). Many strains of the psycrophilic bacteria are proteolytic and may cause the surface of the meat to become slimy. It is then necessary to trim off the exterior layer of the meat, causing a considerable loss. The development of the microflora may be reduced by lowering the humidity in the air but the meat surface will then become dried-up with a poor quality and also considerable losses in weight as result.

For economical and technical reasons thawing in air is the only possible method in thawing of whole carcases. In order to shorten the time required and to eliminate as many as possible of the above mentioned undesirable effects, experiments during the last two years have been made in Sweden with controlled climate thawing in special tunnels. *

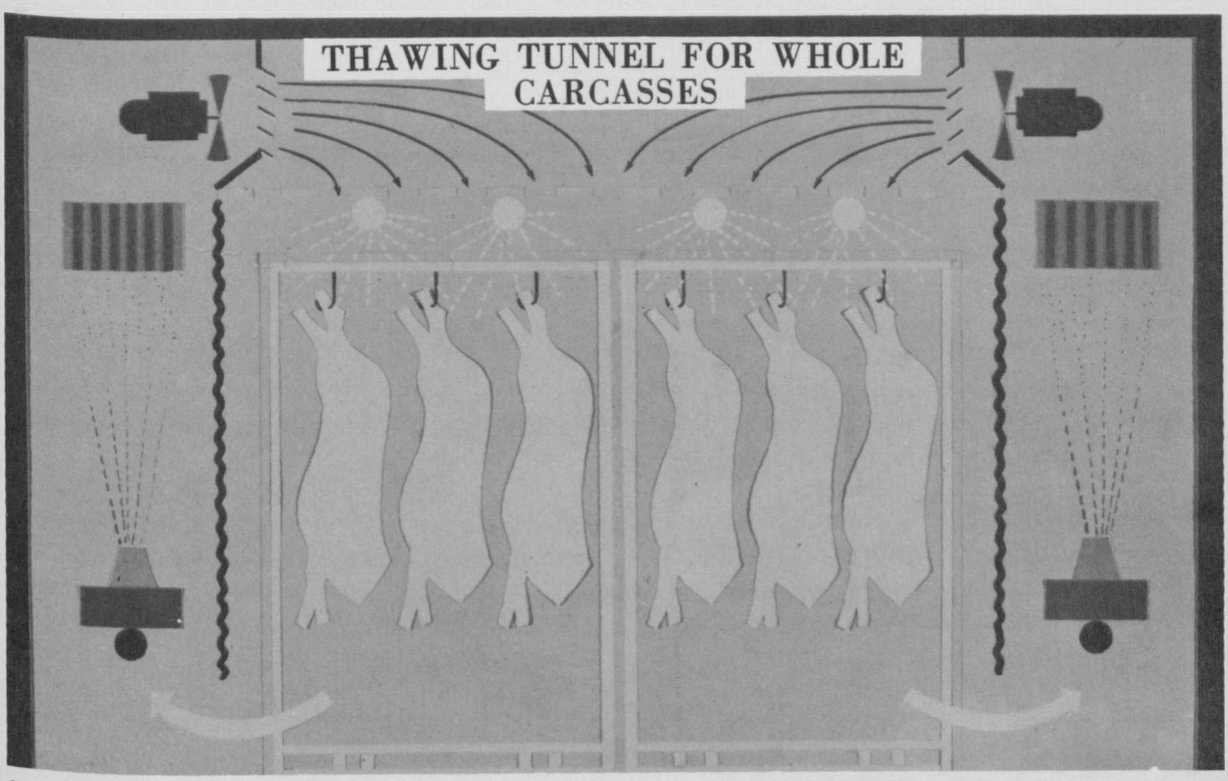

fig. 1.

* The method has been developed by Helsingborgs Fryshus AB, Hälsingborg, Sweden, and is now in use in different freezing-plants i Sweden.

Construction and functioning of the thawing tunnel:

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The method is in principle the following:

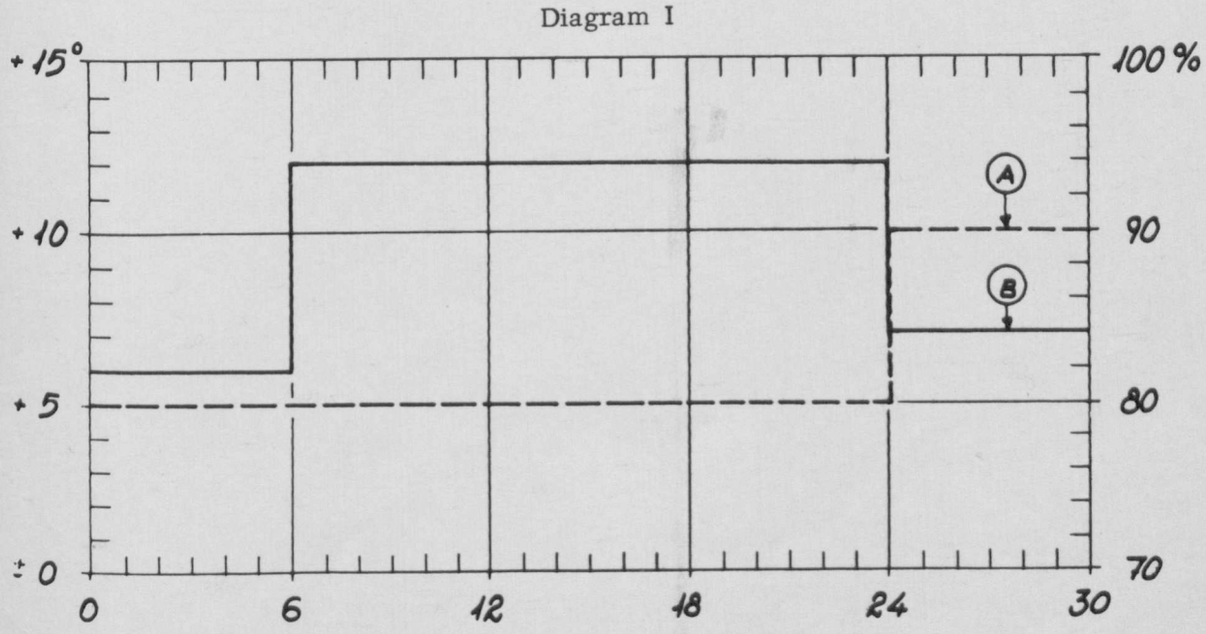
1. Reducing the microorganisms by means of ultra-violet radiation.
2. Maintaining an extremely high humidity by artificial humidification of the air.
3. Accelerated thawing by circulation of warm air at high velocity.

The construction of the tunnel is shown in fig. 1.

The carcases are hung in the tunnel on special racks, allowing the air to circulate between them. By means of fans the air is blown downwards at a velocity af 4 - 5 meters/sec along the carcases. On its return passage the air is damped by water from a spraying unit and is either warmed or cooled in accordance with a predetermined temperature schedule. Cooling units must be used in the end of the thawing because the fan motors produce too much heat. Diagram 1. shows a temperature - humidity programme which has been experimentally worked out for thawing of pig carcases and diagram 2 shows the real figures for temperature and humidity when applying this programme (Nilsson, 1963).

The relative humidity should be held low during the first stage when the difference in temperature between air and carcase surface is high. A certain condensation, frost, cannot be avoided during this stage but it soon disappears due to the relativly high air velocity. During the second stage the temperature is increased and as third phase the temperature is reduced at the same time as the relative humidity is increased. A certain temperature balance is now obtained in the almost thawed out product. The diagram shows that pig carcases reach a temperature of +5°C after less than 30 hours. This means that the thawing time, as compared to natural thawing, is cut with more than 40 per cent (Nilsson, 1963).

Diagram I



Programme for Humidity (A) and Temperature (B)

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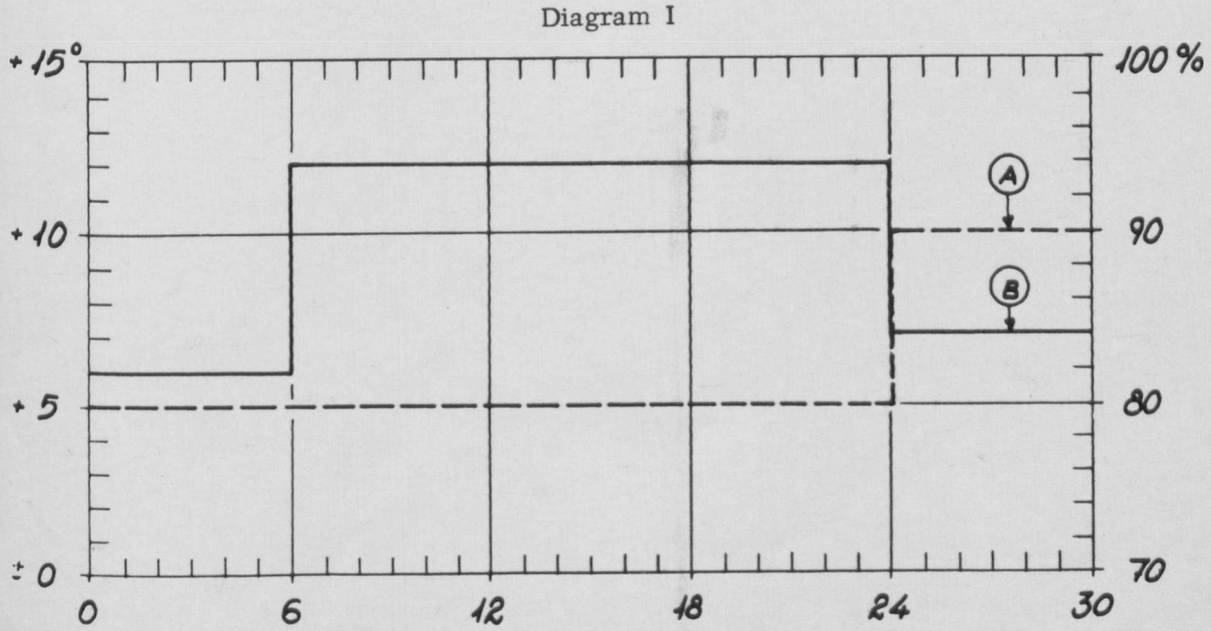

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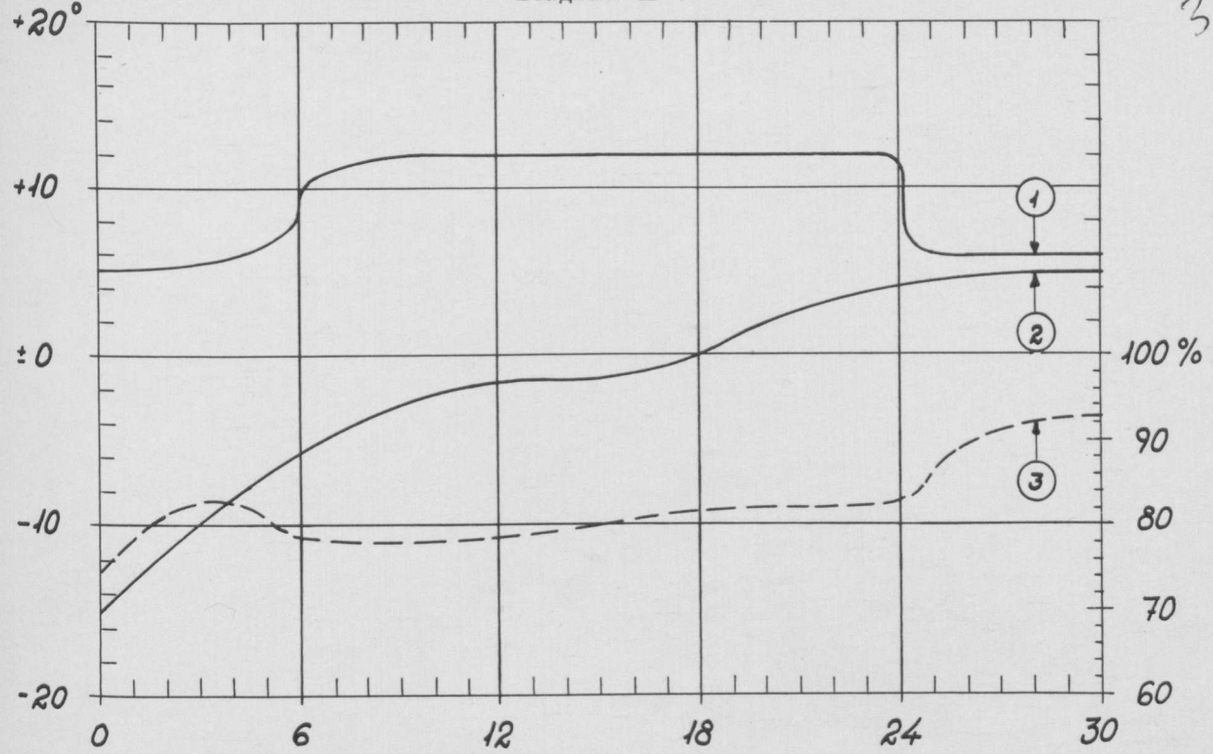
Diagram II



Real figures for Air Temperature (1), Carcase Temperature (2), and Humidity (3)

Bacteriological aspects:

The relatively high temperature during the major part of the thawing time and the high humidity favours growth of microorganisms on the surface of the meat. To eliminate this risk the tunnel has been equipped with lamps emitting ultra-violet rays with a wave-length of 2537 Å. (Philips Germicidal Lamps TUV-15W). The lamps are placed in the ceiling in such a manner that the radiation on to the meat is both direct and - through reflection from the aluminium clad walls of the tunnel - indirect.

To examine how the bacteriological count was influenced by the thawing method the following investigations were performed.

Material and methods:

The bacteriological investigations were performed on horse meat and on beef. All carcases were frozen and stored in quarters. The samples were taken on the frozen meat immediately before the carcases were brought to the thawing tunnel. By means of a steel trocar discs of the meat with an area of 5 square centimeters and a thickness of approximately 2 millimeters were cut from surface muscles. After thawing samples were taken in the same manner close to the spot where the samples on the frozen meat were taken. After removal the samples, weighing approximately 3 grams, were homogenized in 27 ml sterile salin solution with an "Ultra-Turrax" (Janke & Kunkel K G, Staufen) and from the homogenized samples tenfold dilutions were made.

The bacterial numbers were estimated using the plate count method. Total bacterial counts were made on meat pepton agar containing 5 per cent equine serum. The plates were read after 72 hours incubation at 30°C. Hemolytic bacteria were determined on meat extract pepton agar containing 5 per cent defibrinated bovine blood (48 hours incubation at 37°C) and the presence of coli-aerogenes bacteria was determined by use of violet red bile agar (24 hours incubation at 37°C).

Results and discussion:

Due to the technique used in collecting the samples the bacteriological count represents the bacteria on the surface of the meat as well as the bacteria in the meat samples. The ultra-violet radiation has only effect on the surface bacteria since the rays do not penetrate the meat surface. In meat from healthy animals, however, there are very small numbers of bacteria present in the meat and therefore the bacteria found are entirely due to a surface contamination.

Table I.

Mean values of total bacterial count on horse meat thawed in tunnel A. (Numbers of bacteria per 5 square centimeters) Numbers of carcases: 64.

Samples from:	Frozen meat	Thawed meat
Surfaces, radiated directly from UV-lamps	25.700	4.300
" " by reflection	51.600	21.000

Table II.

Mean values of total bacterial count on beef thawed in tunnel B. (Numbers of bacteria per 5 square centimeters) Numbers of carcases: 32.

Samples from:	Frozen meat	Thawed meat
Surfaces, radiated directly from UV-lamps	11.300	65
" " by reflection	30.800	29.300

Table III.

Mean values of total bacterial count on horse meat thawed in tunnel B. Glasses of UV-lamps unclean (See text). (Numbers of bacteria per 5 square centimeters) Numbers of carcases: 32.

Samples from:	Frozen meat	Thawed meat
Surfaces, radiated directly from UV-lamps	378.000	620.000
" " by reflection	252.000	934.000

In table I the results of tests of the total bacteriological count on horse meat in one thawing tunnel (Tunnel A) has been summarized. The result showed that the bactericidal effect was considerable on areas where the ultra-violet radiation was direct. On areas where the radiation was indirect from reflection from the walls there was a smaller but noticable reduction in the bacterial numbers. In this tunnel the lamps were placed in a manner to give a maximum of reflection from the walls.

In the table the total number of bacteria is reported. The bacterial flora consisted mainly of genera usually found on meat, e.g. Micrococci, Achromobacter and Pseudomonas. Also hemolytic bacteria were regularly found in the samples. The hemolytic flora consisted mainly of alfa-hemolytic bacteria (mostly Streptococci) and in some cases of hemolytic strains of Bacillaceae. The reduction of the hemolytic flora on the thawed meat was of the same magnitude as of the total numbers of bacteria.

Only in few samples were bacteria belonging to the coli-aerogenes group found. The effect, if any at all, on these bacteria was insignificant. The samples in which coli-aerogenes bacteria were found were, however, too few to allow any definite conclusions.

Pathogenic bacteria were not found in any cases in the material investigated.

In table II the results are summarized of bacteriological examination on beef in a thawing tunnel (Tunnel B) where the ultra-violet lamps were placed nearer the meat, allowing a more direct radiation on to the meat. This tunnel was narrower and the reflection from the walls was in part shadowed. The result showed that the reduction in bacterial numbers on the parts of the carcases which were subject to direct radiation from the lamps was obvious while the effect from reflection was less effective than in tunnel A.

It is important that the lamp glasses are kept clean. Table III shows the results of tests on horse meat (quarters) when the lamps in tunnel B had got a film of moisture and dust. The bactericidal effect is much lower then when the glasses are clean.

Ozon formation:

The ultra-violet lamps have been selected with special consideration to the range of wave-length as it is necessary to use a range where ozon is not formed. Formation of ozon is undesirable owing to the effect it has in accelerating the oxidation of fat. To ascertain that no ozon was formed tests were run both immediately after the lamps were lighted and after 40 hours burning time. Samples of air were collected in two wash flasks (connected in series) each containing 10 ml 1 per cent potassium iodide in neutral phosphate buffer solution (Byers and Saltzman, 1958). The samples were collected by means of a Reciprotor pump and the air was pumped at a speed of two liters per minute through the bottles and the test time was 30 minutes. In no instance free iodine was found in the solution, which proves that no ozon was formed.

The effect on the bacterial flora then cannot be due to ozon but is caused by the action of ultra-violet radiation.

Summary.

Meat thawed under controlled climate conditions in special tunnels equipped with ultra-violet lamps has been bacteriologically examined. The results show that the surface infection is reduced in spite of a relatively high temperature and humidity during thawing. The bactericidal effect was due to action of the ultra-violet radiation. The direct radiation was most effective but also radiation reflected from the walls had a marked effect. No ozon was formed by the lamps used.

References:

1. Borgström, G. 1955. Microbiological problems of frozen food products. Advances in Food Research, 6, 163-230. Academic Press Inc., New York.
2. Byers, D.H. and Saltzman, B.E. 1958, Am. Ind. Hyg. J., 19, 251.
3. Nilsson, T. 1963. Controlled-climate Thawing of Meat, Report T25, Frigoscandia, Helsingborg, Sweden.