Temperayures in open display cabinets. L.Bogh-Sorensen. J3

Introduction

Modern sales methods have resulted in the use of great numbers of open self-service type refrigerated cabinets in the retail trade. The great display area in such cabinets makes it very difficult to maintain the required product temperatures all over the cabinets.

The temperature of the packages in the upper layer of open-top cabinets represents an equilibrium between the energy lost by convection to the air curtain, and the energy gained by absorption of the heat radiation from the ceiling.

The load of radiative heat increases with the temperature and the emissivity of the ceiling and with the emissivity of the packages. The emissivity in conjunction with heat radiation (max. wavelength 9-10μ) is approx. 0,1 for reflective materials, e.g. aluminium foil, and approx. 0,9 for most materials.

In freezer cabinets the temperature of the top layer will be about 10°C (18°F) higher than the temperature of the air curtain; if the product is packed in aluminium foil this difference is reduced to 1-2°C (2-4°F), lowering the product temperature by about 8°C (14°F). The same result could be achieved if the ceiling were reflective, for example made of bright metal.

Eskilson (1967) showed the effect of packaging in reflective materials, and also reported that heat radiation amounts to about 40% of the total refrigeration capacity.

Lorenzen (1968, 1969), Bøgh-Sørensen (1968, 1969), Barillon (1969), Gac (1968, 1969), all reported temperature conditions observed in freezer cabinets and discussed the various factors involved.

The present work deals with temperature conditions in open cabinets for chilled foods where product temperatures are intended to be lower than 5°C (41°F).

Materials and methods

Temperatures were measured continously, using thermocouples and a recorder.

Temperature measurements were performed in 3 cabinets. Cabinet 1 and 2 were open-top cabinets with forced air circulation, as shown schematically in fig. 1. The cabinets were in use in self-service stores where the measurements were carried out during weekends. The product temperatures were measured in the center of packages with sliced luncheon meats in three different commercially used plastic pouches.

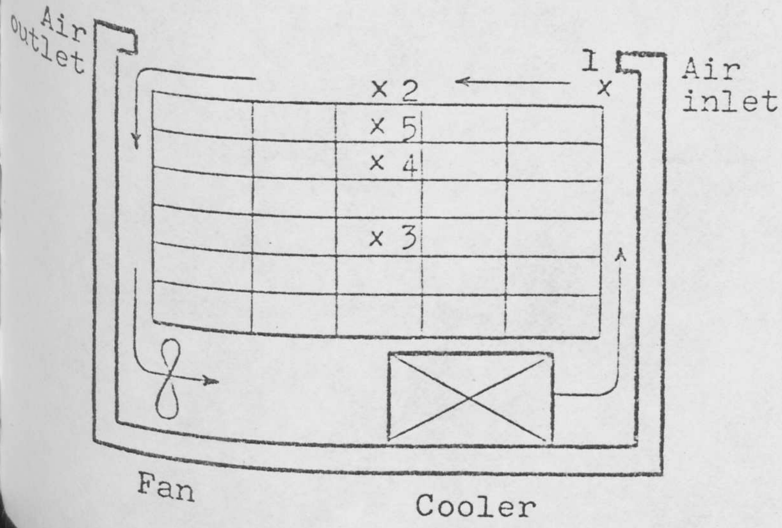

Fig. 1. Schematic cross-section of open display cabinet with forced air circulation (cabinet 1 and 2).
x marks the position of the thermocouples.

Cabinet 3 was an open-front upright cabinet, shown schematically in fig. 2. The test was performed in a special room with temperature and humidity control. The test packages were ground beef in plastic wrappers. These packages were also used for an examination of the bacteriological quality as influenced by the different temperatures in different parts of the cabinet. Fig. 2. shows the position of the thermocouples, and the three different positions of test packages.

A: Upper shelf, farthest out
B: Upper shelf, farthest in
C: Bottom, in insulated box

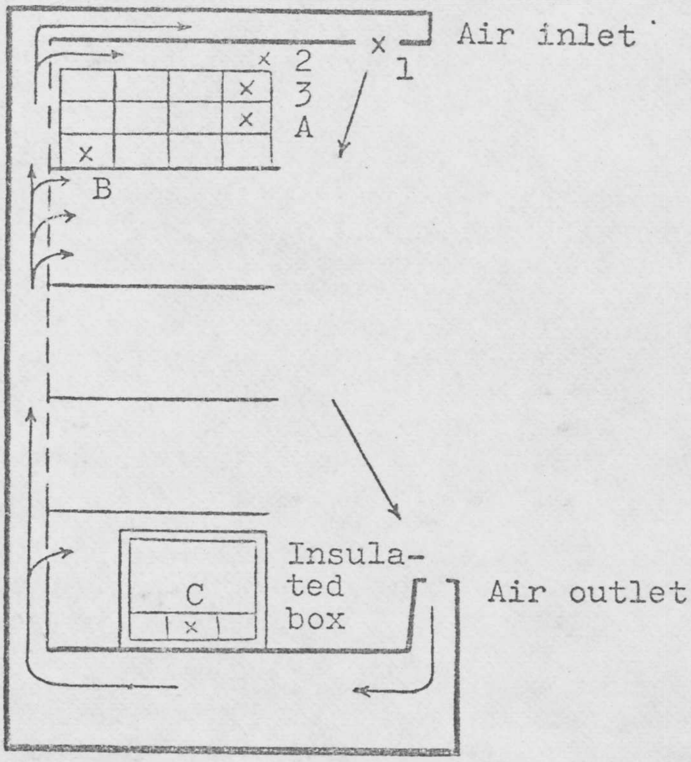

Fig. 2. Schematic cross-section of open-front upright display cabinet (cabinet 3)

x marks the position of the thermocouples

During the test (3 days), samples were taken from the three positions, and immediately frozen. Later, the samples were thawed and total aerobic counts were made by homogenizing 10 g of meat from each package with sterile physiological Saline, and enumerating on plate count agar (Difco). Plates were incubated at 30°C (86°F) for 4 days.

Results

Results of the temperature measurements in cabinet 1 and cabinet 2 are summarized in fig. 3 and fig. 4. The product temperatures in the top layer in the middle of the cabinets were 4-6°C (7-11°F) higher than the temperature of the air flow. In cabinet 1 the inlet air fluctuated between -0,5°C (31°F) and 4°C (39°F), the inlet air velocity was about 0,25 m/sec. and temperature in the top layer was 10-11°C (50-52°F). During defrosting the product temperature rose 2°C (4°F), and it took 4 hours to reach the normal temperatures.

In cabinet 2 the inlet air fluctuated between -4°C (25°F) and 0°C (32°F), the velocity was 0,5 m/sec., and the upper layers were 6-8°C (42-46°F). Defrosting caused the temperatures to rise about 5°C (9°F); here too, it took 4 hours for the temperature to return to its pre-defrosting level.

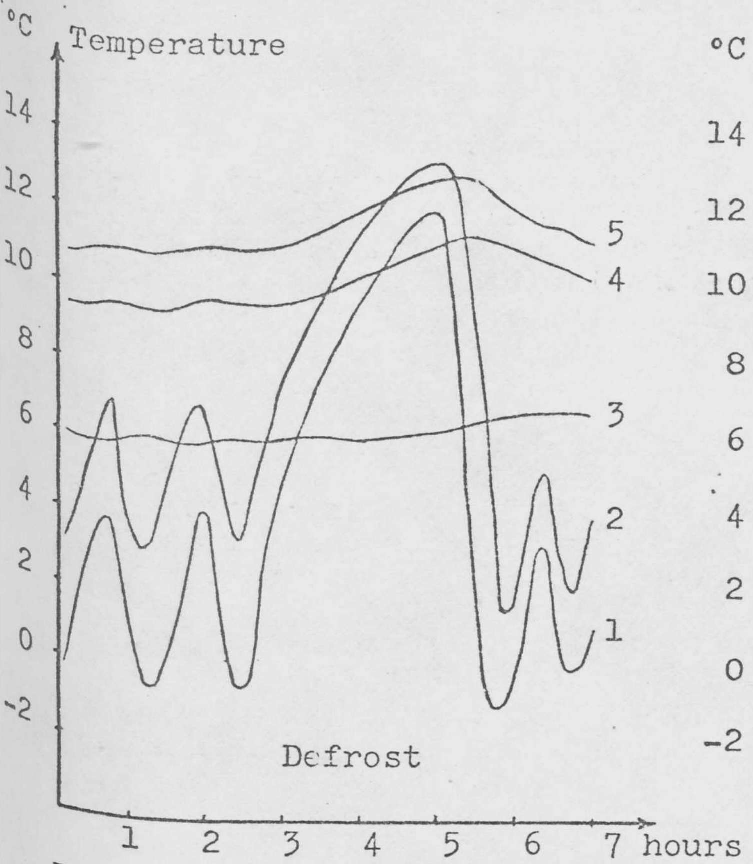

Fig.3. Air and product temperatures in cabinet 1. Numbers refer to fig.1.

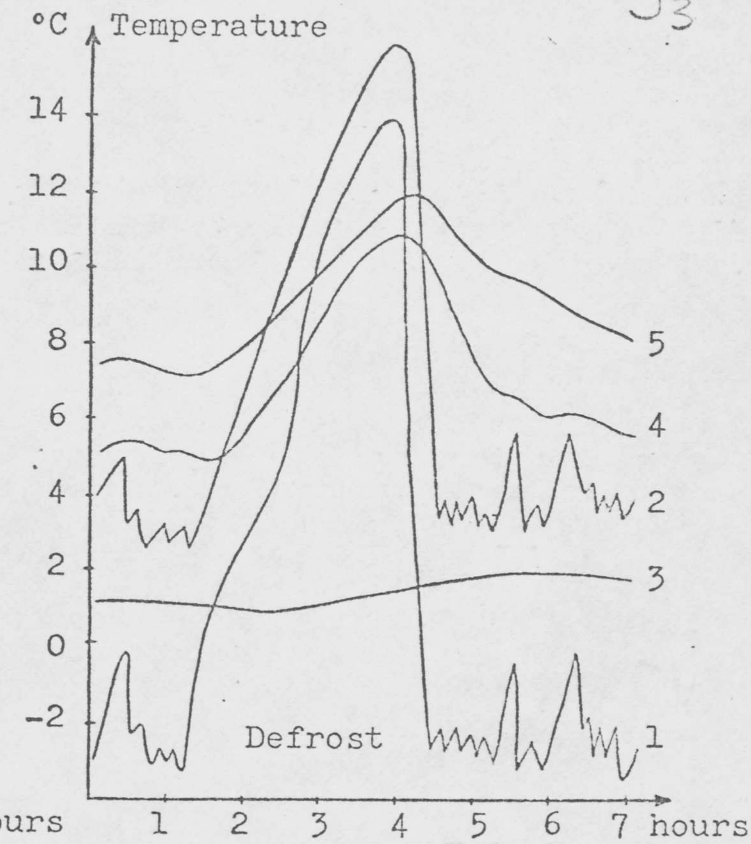

Fig.4. Air and product temperatures in cabinet 2. Numbers refer to fig. 1.

The product temperatures were similar in the three different plastic pouches. One of the pouches was a polyester-aluminium foil-polyolefin laminate; since the surface was a plastic layer, it did not reflect the heat radiation, and therefore, did not result in lower product temperature.

Temperature curves from cabinet 3 are shown in fig.5; product temperatures are about the same as in the two other cabinets, but the defrosting period is only 2 hours.

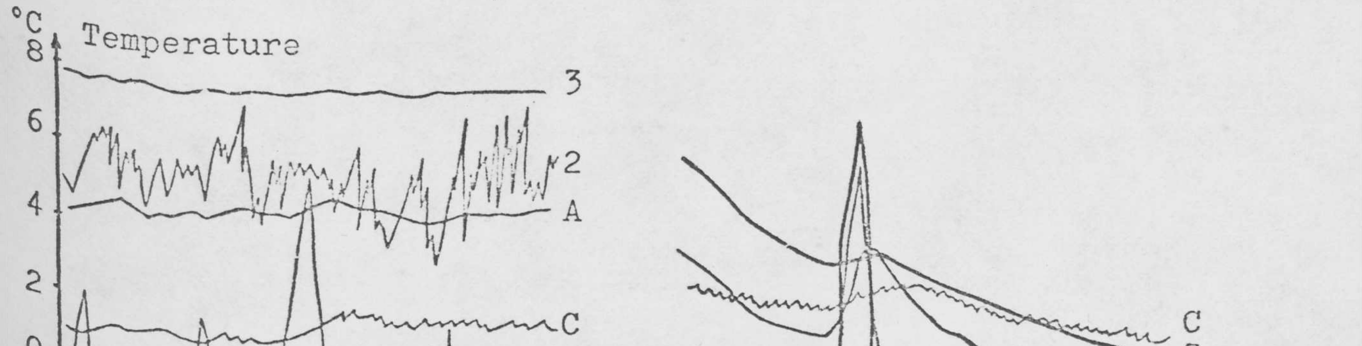

Fig.5. Air and product temperatures in cabinet 3.
0-7 hours: Normal air flow; 8-15 hours: adjusted air flow
Numbers and letters refer to fig. 2.

At the end of the test period, minor adjustments in the air circulation system of cabinet 3 were made. By means of a smoke generator it could be seen that this caused a great reduction in the air infiltration into the cabinet, resulting in a reduction of product temperatures by 1-6°C (2-11°F), as shown in fig. 5.

Bacteriology

As shown in table 1, the bacteriological quality may be greatly influenced by the position of the food in the cabinets. The initial bacterial number was only 30.000 per gram, and a higher initial number might have resulted in 10 or 100 times as high bacterial counts after 2 days, especially in position A.

Table 1. Storage temperatures and bacterial numbers in packages of ground beef, in three different positions in cabinet 3.
Positions A, B and C are shown in fig. 2.

Position in cabinet 3	Product temperatures		Bacterial number per g	
	1st day	2nd day	Initial	After 2 days
A	6-8°C	4°C		8.000.000
B	1-2°C	-0,5°C	30.000	100.000
C	0-1°C	1-2°C		900.000

Discussion

Temperatures in the top layers in open display cabinets are generally too high. In freezer cabinets this may lead to a deterioration in food quality, but in most cases it is only of minor significance as the turn-over of the top layers often will be very high.

In cabinets for chilled foods the temperature conditions will lead to a substantial deterioration in quality, and thus, to a reduction in shelf life. Many products will have a shorter shelf life than found in storage tests, simply because storage tests often are carried out at a constant temperature of 5°C (41°F). This, of course, is not relevant when temperatures in cabinets often are about 8°C (46°F), and even higher during defrosting.

As food poisoning bacteria do not multiply below 5°C (41°F), display cabinets should safeguard against these bacteria. Consequently the required temperature in the cabinets is 5°C (41°F) or below. But at the temperature conditions found, most open display cabinets may represent a public health danger, especially in the case of faulty stacking and slow turn-over.

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Possibilities for improving the temperature conditions in open-top cabinets exist. Mentioned above is the possibility of using reflective packaging materials or reflective ceilings, and the necessity of keeping the defrosting period as short as possible. Cabinet manufacturers should provide for adequate temperature and velocity of the circulating air all over the cabinet. It is not always advisable to lower the temperature of the inlet air as this would result in freezing of some of the products. In the food store, the siting of the cabinets is very important; direct sunlight must be avoided, and great care should be taken to minimize the room air movement around the open cabinets. Products should never be stacked outside the load line, and stock rotation (first in - first out) should be systematised.

The use of "night covers" reduces the average product temperatures and also cuts running costs. In fact, the use of night covers might be made mandatory.

These measures would help to some extent, but it is most probable that only the use of more appropriate types of cabinets will completely solve the problems.

Conclusion

The temperature of the top layers in open refrigerated cabinets is considerably higher than the temperature of the circulating air passing over the packages.

These temperature conditions may lead to a deterioration in the food quality, in freezer cabinets often insignificant, but in chilled cabinets sometimes substantial.

In horizontal open-top cabinets with forced air circulation air infiltration and, especially, heat radiation make it exceedingly difficult to maintain the required product temperatures. In vertical multi-deck cabinets heat radiation is reduced, and the results here attained seem to indicate that satisfactory temperature conditions may be attained by perfecting the air circulation system, causing a lowering of the infiltration of room air into the cabinet.

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