Some factors affecting temperature of packaged overwrapped trays of meat in retailers' display cabinets

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Introduction

Temperature is the most important factor determining the keeping quality of meat. Therefore the temperatures maintained in meat during handling and distribution under industrial conditions are of great interest.

Whilst investigating the performance under experimental conditions of types of refrigerated display cabinets used commercially for retailing meat, unexpectedly high temperatures were registered in pre-packaged meat. Shortly afterwards an instance of spoilage in pre-packaged meat was reported by a firm apparently practising exemplary temperature control and hygiene. In preliminary field observations, specimens withdrawn from a shop display because of strong spoilage odours and undesirable colour were found to be between 6.7° and 8.9°C instead of below 4.4°C as anticipated. This effect can presumably be attributed to absorption by the meat and package of radiation passing through transparent film, and has been compared with a "glass-house". However, no satisfactory published data have been traced. This paper presents the results of some measurements made in the laboratory and in a large shop.

Materials and methods

In laboratory experiments a standard, new display cabinet was used. This was 6 ft (1.8m) long, and cooled by natural convection and conduction through polyethylene trays on a wire grid resting on plates housing the cooling pipes.

The experimental room was heated to about 21°C, without forced air movement, and illuminated naturally by a north window. Cabinet lights were switched off and additional illumination was provided by a 500 watt Philips 318 E/43 lamp placed 1.5 metres above displayed meat and providing 2000 to 2800 lux at meat pack surfaces. Temperatures registered by thermocouple between the lamp and the display were as follows:-

Height above display (cm)	60	30	15	5	2	0.5
Temperature (°C)	26.2	24.0	13.2	8.4	5.4	6.7

Without this light, air temperature in the cabinet was 4.5° to 5.0°C thus showing that the lamp had no undue direct heating effect. Air temperature varied between 2° and 8°C, but was mostly between 3° and 5°C. Air velocity measured by a hot wire anemometer (± 0.1 m/s) was < 0.1 m/s.

Boned-out fore-rib of beef from a commercial abattoir was hand sliced to about ¾ in (1.9 cm) thickness. A layer of 350-400 g pieces was placed in the cabinet either exposed to the air or in expanded foam polystyrene or fibre trays, 4¾ x 4¾ x ¾ in (12 x 12 x 1.9 cm) and overwrapped with "shrink-wrap" vinyl film leaving the meat loosely packed. Experimental packs were sited side by side in comparable positions.

In the shop a long, self-service cabinet was studied, with forced air circulation over three shelves and a well. The shop was artifically lit continuously. Air temperature was 19°-21°C in the shop and 3°-5°C over the meat in the cabinet. Air speed in the shop near the cabinet was up to 1 m/s and in the cabinet 0.5-1 m/s.

Thin beef steak slices and pork chops were packaged and overwrapped in expanded polystyrene trays 8 x 4¾ x 7/8 in (21 x 12 x 2.2 cm) and beef steak pieces and mince in polystyrene 6½ x 4¾ x 1¼ in (16.5 x 12 x 3.3 cm), whilst sausages were tightly wrapped in polyethylene film. Again, sites in the cabinet were representative.

Centre and surface temperatures of packs were sampled, using a copper-constantan thermocouple needle and indicator (± 0.1°C). Meat temperatures over periods of about 18 h were recorded by 6 in x 1/8 in diam thermistor probes inserted through the shorter sides of packs and attached to miniature chart recorders (± 0.5°C).

Results

Tables 1 and 2 present the results of sample measurements and Figure 1 of continuous records of meat temperature in the laboratory experiments. Tables 3 to 6 and Figure 2 give the corresponding results in the shop.

Table 1. Meat temperature differences (°C) between film overwrapped expanded polystyrene (P) and fibre (F) trays and unwrapped (U) after 17 hours display

Lighting	P - U			F - U		
	Bottom surface	Centre	Top surface	Bottom surface	Centre	Top surface
Natural	3.0	3.2	3.4	1.0	2.0	1.3
Natural + artificial	5.1	5.7	5.0	4.5	5.1	4.6

Table 1 and Figure 1 show that the meat in trays was considerably warmer than unwrapped meat. Even without artificial lighting, the difference was still appreciable presumably owing largely to radiation from the room. Figure 1 shows that in this type of cabinet unwrapped meat is usually 1° to 2°C lower in temperature than the surrounding air, due to the effect of conduction. Meat in expanded polystyrene trays retains more heat than in fibre trays presumably owing to the greater insulating property of the former.

Table 2. Reduction in centre temperatures (°C) in 4 hours display of film overwrapped trays of meat initially at 13°C to 16°C

Lighting	Expanded polystyrene tray	Fibre tray
Natural	10.9	11.8
Natural + artificial	2.2	2.2

Table 2 shows that the artificial light retards the subsequent co ling of warm pre-packed meat placed in this cabinet.

Table 3. Meat centre temperature differences (°C) between packages, fully exposed to and partly shaded from shop illumination

Product	Average	Range	Number of values
Tray overwrapped pork	2.2	1.6 to 3.4	5
Tray overwrapped beef	2.5	1.9 to 3.0	4
Tightly wrapped sausages	0.3	0.2 to 0.4	2

Table 3 indicates that meat in tray wraps when fully exposed to shop illumination is 2° to 3°C warmer than meat partly shaded by shelves and other produce. The difference is negligible with tightly wrapped meat.

Table 4. Meat centre temperature differences (°C) between top and bottom of stacks of three tray overwrapped pork chops

Illumination	Average	Range	Number of values
Fully exposed	2.2	2.2	1
Partly shaded	0.7	0.5 to 0.9	2

Table 4 suggests that the top pack of a stack is 2°C higher than the bottom one when fully exposed to the shop illumination but less than 1°C when the top of the stack is shaded.

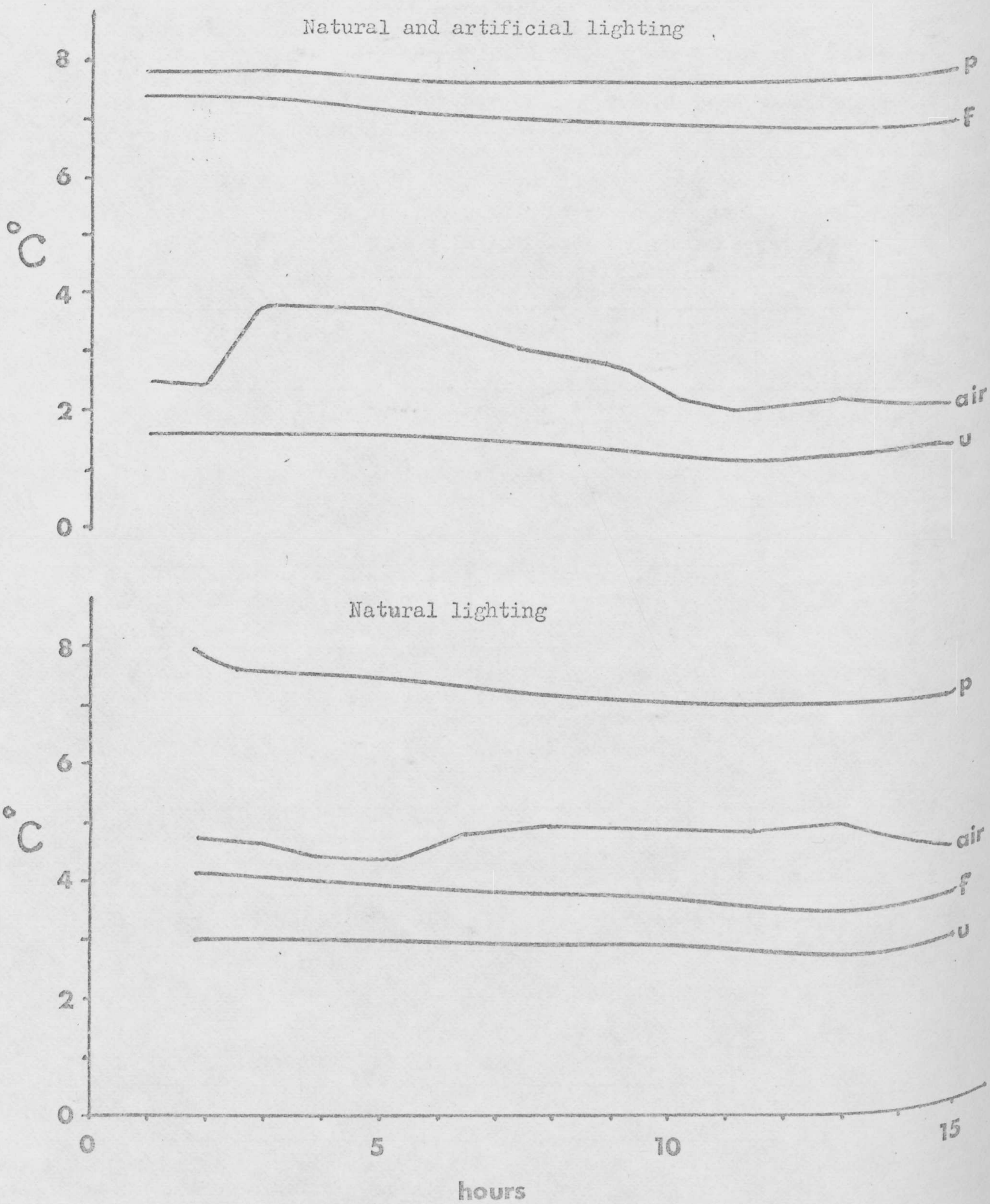
Table 5. Meat centre temperature differences (°C) between top and bottom of fully exposed stacks of two tray overwrapped beef packs

Package	Average	Range	Number of values
Polystyrene	0.9	0.7 to 1.0	4
Expanded polystyrene	1.9	1.8 to 2.0	3

Table 5 confirms that the top pack of a fully exposed stack is 2°C warmer than the bottom pack. It also indicates that the temperature difference between the top and bottom of an exposed stack is less when the therral insulation of the tray is lower.

Figure 2 shows the actual temperature fluctuation during 18 hours display, with

Fig. 1 Steady state temperatures of 500 g, 2.5 cm beef slices in natural convection cooled cabinet

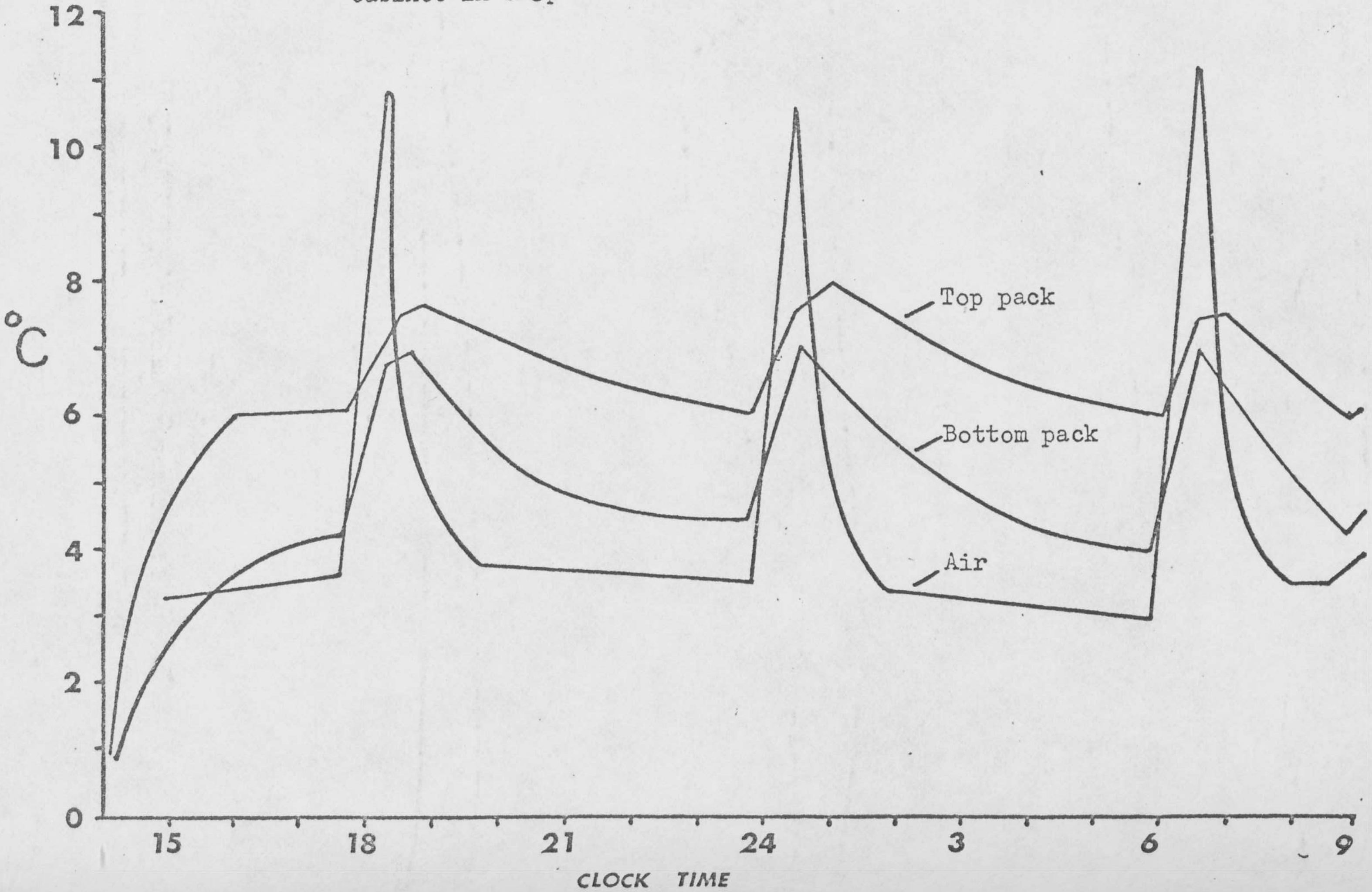


P = film overwrapped, expanded polystyrene tray

F = " " , fibre tray

U = unwrapped

Fig. 2 Temperatures of stacks of two 250 g film-over wrapped expanded polystyrene packs of beef slices in forced convection cooled cabinet in shop



shop lighting on, of top and bottom of stacks of two film overwrapped expanded polystyrene trays of beef slices, in relation to the cabinet air temperature.

Except for periods of about one hour during defrosting, meat temperature is about 3.0° to 3.5°C above air temperature in the top package and 1.0° to 1.5°C in the bottom package. The exposed top pack takes longer to cool down again after defrosts than the bottom pack.

Table 6. Meat centre temperature differences (°C) between fully exposed tray overwrapped meat and tightly wrapped sausages

Product	Average	Range	Number of readings
Pork chops	2.0	1.1 to 2.8	6
Beef steak	3.1	0.1 to 6.9	9

Table 6 indicates that tray overwrapped meat is 2° to 3°C warmer than tightly wrapped products. It may perhaps be significant that beef is slightly warmer than pork.

Discussion and conclusions

Although these few measurements do not justify drawing firm conclusions, they present a warning that meat temperature during refrigerated retail display may be considerably higher than expected from the air temperature setting. It appears that:-

1) Meat film-overwrapped in expanded polystyrene trays can be 6° to 7°C warmer than unwrapped or tightly film-wrapped meat under the same conditions.

2) The temperature of unwrapped and tightly film-wrapped meat approximates to the temperature of the surroundings.

3) Meat temperatures in tray overwrapped packages are higher with increased exposure to illumination.

4) The thermal insulating properties of the packages can influence (a) the rate of cooling of initially warm meat; (b) the increase in the temperature of meat exposed to radiation.

Although shop illumination is a considerable source of heat, that might conceivably be reduced by selecting lamps of suitable spectral composition, background radiation is also important. This could probably be minimised by protective screens over the produce in the cabinet, at least when the shop is shut. Such screens are being recommended as night covers for protection of frozen food, where the effect of background radiation on the top layer of produce has been realised for some time, although this is not literally a "glass-house" effect.

Radiation absorbed by meat and packages from illumination, walls, ceiling etc. can be removed by conduction through the material of the tray or convection across the air space between the meat and the film overwrap and possibly by re-radiation. The better the thermal insulation of the tray, the greater the effect and the existence of an air space above the meat retards heat loss. Where there is neither insulation nor air space, as with tightly wrapped meat products such as sausages in polyethylene film, heat is extracted practically as fast as it is absorbed.