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SOME FACTORS AFFECTING THE HEATING AND COOLING LAGS OF PROCESSED CHEESE IN THERMAL DEATH TIME CANS[1, 2]

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SUMMARY

The lag correction factor, the time that must be subtracted from the gross heating time to give the net time at heating medium temperature, varies with the fill-weight and the position of the can for conduction heating of cheese spreads. Results of this study indicate that: (a) The lag correction factor increases with increases in the fill weight. (b) The lag correction factor was larger when the can was heated in the flat position as compared to the edge position.

Thermal death time (TDT) cans 2.5 in. in diameter and 0.375 in. deep, designated as 208 × 006 in canning industry nomenclature, are used as containers for food products for evaluating the effect of heat on microorganisms suspended in a food product. The experiment is usually designed so that the majority of the heating effect takes place at the temperature of the heating medium. However, since the TDT cans can not be instantly heated or cooled, it is necessary to correct the total heating time for lags in heating and cooling.

Several factors are known to affect the heating and cooling lags. Townsend *et al.* (4, 5) determined that the heating characteristics of TDT cans were affected by the quantity of product in the container and the physical characteristics of the product. Sognefest and Benjamin (3) reported that the position of the can during heating affected the rate of heat penetration when heating took place primarily by convection.

The studies reported herein were performed to determine the specific effect of fill-weight and can position on: (a) the heating characteristics of TDT cans of processed cheese spread, and (b) the subsequent lag correction factors.

EXPERIMENTAL METHODS

The usual practice when making heat effect studies at high temperatures using TDT cans is to start measuring heating time when steam is turned on and stop the moment the steam is turned off and the cooling water turned on; this total heating time is designated as B. The net heating time (U) in minutes at the heating medium temperature is the total heating time (B) minus the lag correction factor (t_c). The factor t_c includes the correction for the lag in heating and the lag in cooling.

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[2] This manuscript describes a portion of the research contained in a thesis prepared by the senior author in partial fulfillment of the requirements for the degree Doctor of Philosophy at Michigan State University.

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Copper-constantan thermocouples were mounted in 12 TDT cans at the point of slowest heating (Figure 1). Sognefest and Benjamin (3) found that the dimple in the bottom of the TDT cans displaced the slowest heating point from the geometrical center to a point located between the side and center midway between the top and bottom. The thermocouples were made from No. 30 B & S gauge wire and were held in position by passing the wire through a hole drilled in a section of a No. 00 rubber stopper. The lead wire was brought out through a hole punched in the lower side of the TDT can. An electrical insulating resin [4] was used to secure the stopper in place and seal the hole where the lead wire was brought out of the can.

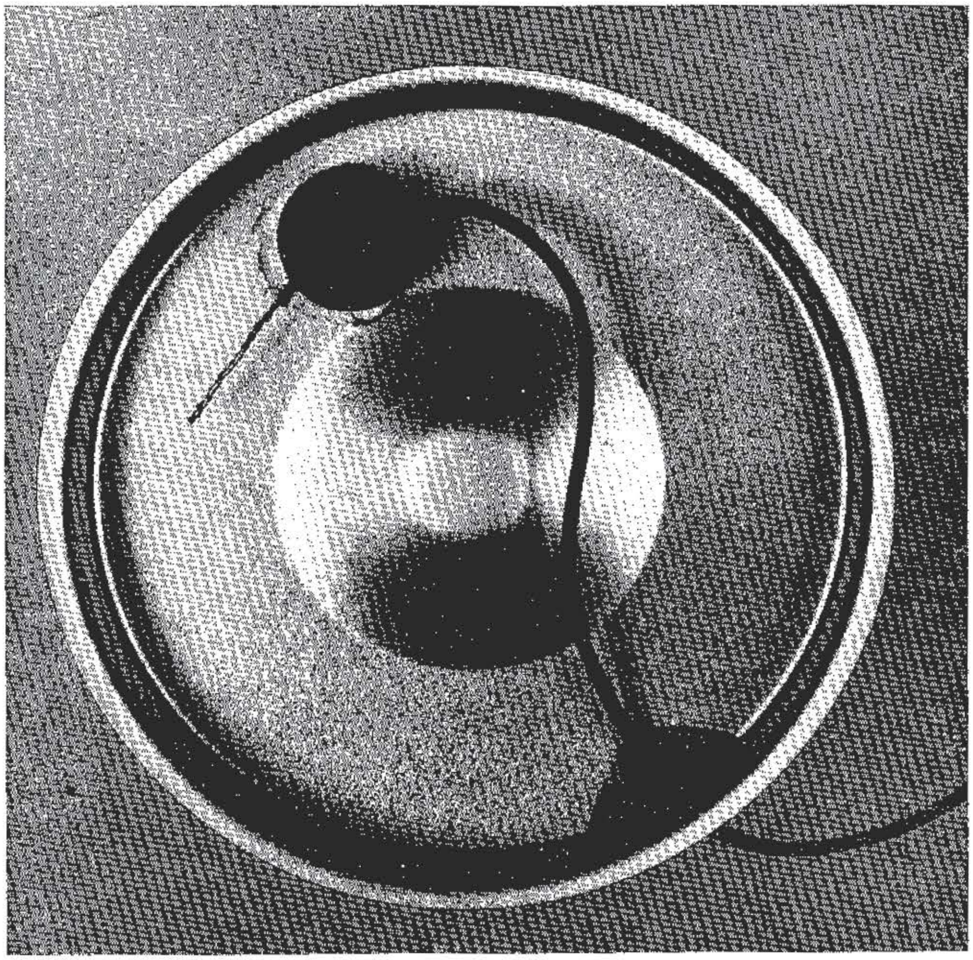

FIG. 1. TDT can and copper-constantan thermocouple.

The jig that supported the TDT can during the can-closing operation was

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[4] Furane Plastics Inc., 4516 Brazil Street, Los Angeles 39, California.

notched so that the thermocouple lead wire did not interfere with the closing machine.

The cans were heated in a miniature retort similar to the one described by Townsend *et al.* (4). Cans were tested with fill-weights of 17, 19, and 21 g. (the maximum capacity of TDT cans is approximately 21 g.) of prepared processed cheese spread. The cans were heated flat and on edge. The heating and cooling curves were plotted and the f_h and j for each curve determined by the method described by Ball (1). An example of these determinations is presented in Figure 2.

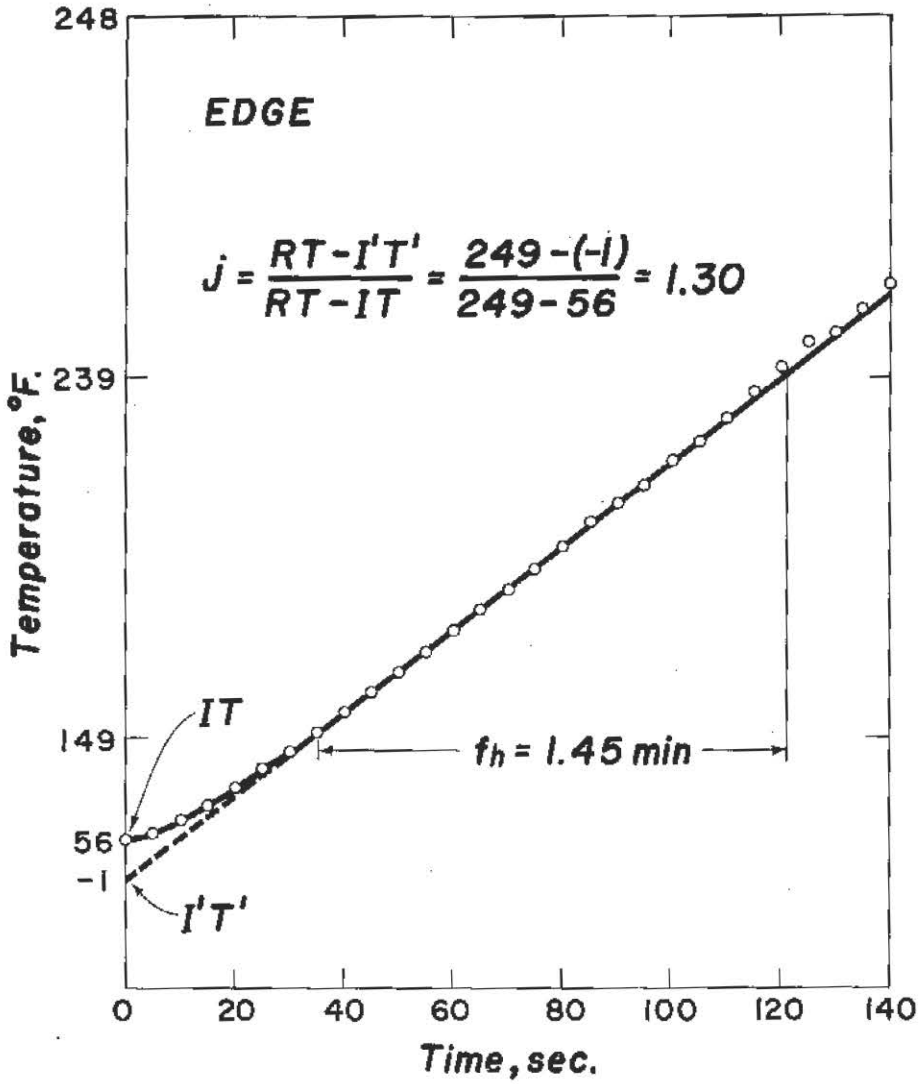

FIG. 2. A typical heat penetration curve, illustrating the method by which the f_h and j values are determined.

When the heating and cooling data may be approximated by straight lines when plotted on semilogarithmic paper (Figure 2), the lag correction factor can be calculated as a simplified thermal process calculation using the method of Ball (1). Using a z-value, which is a measure of the slope of the thermal destruction curve of the microorganism or chemical under study, of 18° F., and calculating the lag correction to 0.1° F. below heating medium temperature, the lag correction factor can be calculated by the following equation developed by Pflug and Esselen (2).

$$t_c = f_h \ (\log j \ \mathrm{I} - 0.725)$$

where f_h = a measure of the slope of the heating curve
j = lag factor
RT = heating medium temperature
IT = initial temperature
$I = RT - IT$.

RESULTS AND DISCUSSION

The calculated lag correction factors for the different fill-weights and the different positions of the TDT cans are shown in Table 1. In the calculations it was assumed that $I = RT - IT = 194°$ F. Since f_h and j do not change with changes in I, the lag correction factor for other values of I can be easily calculated.

TABLE 1

Effect of fill-weight and can position on the lag correction factor of a processed cheese spread in TDT cans

(Average of two trials)

	Position of the cans					
	Edge			Flat		
Fill-wt.	f_h	j	t_c	f_h	j	t_c
(g.)	*(min.)*		*(min.)*	*(min.)*		*(min.)*
17	1.44	1.30	2.41	1.87	0.90	2.83
19	1.74	1.20	2.82	2.00	1.06	3.16
21	1.83	1.20	3.00	2.04	1.12	3.28

Results show that each increase in the fill-weight resulted in an increased lag correction factor; the greater the fill weight, the slower the rate of heating and cooling (larger f_h) and, consequently, the larger the lag correction factor.

The f_h of the heating curve and, therefore, the lag correction factors were greater when the TDT can was in the flat position as contrasted to the edge position. Due to the configuration of the TDT can, less of the product would be in direct contact with the metal of the can when it is in the flat position than when it is on its edge, unless the can was completely full. Since less product is in contact with the heat transfer surface with the TDT can in the flat position, heating will be slower, resulting in a larger f_h and, therefore, a greater lag correction factor. The cans tested in the flat position had the closure side up;

because of the shape of the TDT can, tests performed with the closure side down might have given slightly different results.

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