Inspections, Compliance, Enforcement, and Criminal Investigations

Sterilizing Symbols (D, Z, F)

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DEPT. OF HEALTH, EDUCATION, AND WELFARE PUBLIC HEALTH SERVICE FOOD AND DRUG ADMINISTRATION *ORA/ORO/DEIO/IB*

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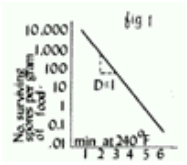
Related Program Areas:
Low Acid Canned Foods

ITG SUBJECT: STERILIZING SYMBOLS (D, z, F)

Napoleon Bonaparte's army lost more soldiers due to spoiled foods than from battle \a\. As a result, Nicolas Appert, a french candy maker in 1810, collected a 12,000 franc prize for inventing a "cook, seal-with- wax, cook again" method for preserving foods. Appert's "cook charts" were forerunners to modern food processing schedules. Today the effectiveness of a canning process is determined from a combination of experimentation and calculation. Processing parameters are expressed in terms of a series of symbols of which D, z, and F are key \b\. We anticipate that the inspector will encounter these symbols frequently during investigations, on process filing forms, and during technical conferences.

When bacterial spores are heated to a lethal temperature as during retorting of canned foods, the death of most species approximates a first order chemical reaction that can be described by a straight line on semi-logarithmic graph paper. Fig 1[4] shows a hypothetical result from heating a species of spore at 240 Fahrenheit (F).

Figure 1 & 2[5]



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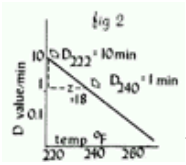

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In the fig. 1[9] example, one minute is required to reduce the survivors from 10,000 to 1,000 or a 90% reduction (one log reduction). Similarly, one minute is required to reduce the survivors from 1,000 to 100 per gram of food and so on until only 0.01 of a spore is present in 1 gram of food-which really means that there remains only one living spore for each 10(grams of food. This time to reduce the survivors by 90% is the Decimal reduction (D) value or in fig. 1, D 240 = 1 min. The subscript after the D indicates temperature at which the D value was determined. Many factors affect the D value, such as the species of spore, and the kind of food the spore is suspended in.

To continue on with the example, additional studies could be made on spore inactivation at temperatures other than 240 F. Let us assume this was done and the D 222 value was 10 min. and also the D 240 value was 1 min. These data could be summarized on a thermal resistance curve as shown in fig. 2[10]. Here we are interested in equivalent D values at other temperatures. From the example in fig. 2[11], a change of one log cycle (1 to 10) is equivalent to an 18 F change in processing temperature. The slope*\ of this curve is called the z value. The z value for spore death time typically range between 16 to 20 F. As shown in fig. 2[12], z = 18 F, and indicates that if a process is raised 18 F, the processing time ca be lowered one log cycle (10 to 1 min. for this example) and still have an equivalent process. Under conditions of industrial practice, however, the process is modified to take into consideration the characteristics of heat penetration into the in-container product, and to integrate this data with the microbial thermal resistance data to determine the actual sterilizing value of the new process.

The F value**\ for a process is the number of minutes required to kill a known population of microorganisms in a given

food under specified conditions. This F value is usually set at 12 D values to give a theoretical 12 log cycle reduction of the most heat-resistant species of mesophilic spores in a can of food. For example, if there were 10,000 spores of a species of spore in a can of food and a 12 D process was given, the initial 10,000 spores (10 4 spores) would be reduced to a theoretical 10 -8 living spores per can, or again in theory, one living spore per 10 8 cans of product (one spore per one hundred million cans). To refer back to the original example where the D 240 was 1 min., the F value for the process would be 12 min. or F 240 = 12 min.

When F is used without a subscript indicating temperature, 250 F is assumed. When the symbol F is used, a z value of 18 F is assumed with an exposure temperature of 250 F. The actual processing time a can of food is given in a retort is always greater than the F value due to heat penetration requirements. Industry makes extensive use of F values in maintaining processes and in developing new schedules. Optimally the old and new processes are equated to acceptable F values. Two different processes are considered equivalent when the processes are equally effective with respect to destruction of a given microorganism.

The serious reader is referred to Desrosier \c\, Ball \d\, American Can \e\, and Stumbo \f\. Additional symbols and definitions are found in Joslyn \g\. \a\ World Book Encyclopedia: Vol. 3; p. 142 Field Enterprises Educational Systems Corp., Chicago (1960)

\b\ Laboratory Manual for Food Canners & Processors: p. 187 & 122; Nat. Can Association

\c\ Desrosier, N. W.: Tech. of Food Preservation; p. 203-240: AVI Pub. Co.: Westport, Conn. (1970)

\d\ Ball, C. Olin: Olson, F. C. W.: Sterilization in Food Tech.: p. 599; McGraw-Hill Co.: New York (1957)

\e\ Tech. Service Dept.: Calculations for Processes for Canned Foods; p. 42; American Can Co.: Barrington, IIL. (1967)

\f\ Stumbo. C.R.: Thermobacteriology in Food Processing; Academic Press; (1965)

\g\ Joslyn, M.A. & Heidt. J. L., p. 411 Food Processing Operations. AVI Pub. Co.: Westport, Conn. (1963)

*\ Note: z is customarily referred to as "slope" although its value is measured along the abscissa and not along the incline of the curve.

**\ The F value should not be mistaken for degrees Fahrenheit or F.

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