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Thermophilic Organisms Involved in Food Spoilage: Introduction

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The thermophilic spoilage organisms will be discussed in this series of papers. As you know, thermophilic means heat-loving. Some of these organisms in the vegetative form can grow at 70 C or 158 F. In fact, Gordon and Smith (*10*) showed that 45 of 87 cultures of *Bacillus stearothermophilus* could grow at 70 C. These thermophilic organisms are all spore-formers, can grow anaerobically, and have some heat resistance, so we would expect them to be of some consequence in the spoilage of canned

Inadvertent under-processing and post-process contamination of canned foods are the leading causes of canned food spoilage today. However, before 1930, the leading cause of spoilage in canned foods was probably thermophilic spoilage.

In 1913, Barlow (*1*) submitted to the University of Illinois his Master of Science thesis, based upon experimental studies on spoilage of canned corn. Almost unnoticed at the time and for some years afterward, this piece of research was eventually recognized as a landmark in the bacteriology of canning. Earlier literature has indicated that the role of thermophilic bacteria in spoilage was suspected, but supporting data were lacking. Barlow's contribution, and an outstanding one, was in demonstrating the fact of spoilage through the activity of thermophilic bacteria.

In more recent years, Barlow's work has been cited by various writers, with fitting tribute to its soundness and originality. The text, however, has not been generally available to workers in the science of food preservation, since it was never published. To make this historic contribution more generally accessible, the National Canners Association reproduced Bronson Barlow's thesis, "A Spoilage of Corn Due to Thermophilic Bacteria."

During the 1926 canning season, bacteriologists from the Research Laboratories of the National Canners Association conducted the first of a long series of bacteriological investigations in canning factories. This work was reported by Cameron (*2*). It was ascertained very early in the investigations that refined sugar, a canning ingredient for a number of products, might contain spores of thermophilic spoilage organisms. This was reported in *The Canner* in 1930 (*3*). The fact that use of sugar containing excessive numbers of these organisms could lead to spoilage difficulties was demonstrated in a practical way by the use of a test pack (*8*). It was quite evident from the data that even extensive heat processing failed to eliminate the spoilage types contributed by the high-count sugar. As a result of the early studies, the National Canners Association, in 1931, set up advisory bacterial standards for sugar (*11*). Reports on microbiological methods for detecting and estimating thermophilic bacteria in sugar were published in the *Journal of the Association of Official Agricultural Chemists* in 1936 (*4*), 1938 (*5*), 1940 (*6*) and 1950 (*7*). These standards are applied to sugar or liquid sugar intended for use in the canning of low-acid foods (pH 4.6 or above). The method is listed as "Thermophilic Bacterial Spores In Sugars - Official First Action (46.062)" in the 12th edition of *Official Methods of Analysis of the Association of Official Analytical Chemists* (*9*).

Similar procedures have been applied to other ingredients such as starch, flour and spices to test for thermophilic spores. Equipment and product material on the canning line, particularly if held hot, can become sources of contamination. These organisms reproduce and form spores much faster than mesophilic organisms, so sanitation plays an important role in keeping their numbers low.

The thermophilic spoilage spores are much more heat resistant than the mesophilic anaerobic spore-formers, such as the putrefactive anaerobes. The thermophilic spoilage organisms produce no toxins and exert no health consequences; some may remain ungerminated in low-acid canned foods. The definition of commercial sterility in the Food and Drug Administration regulations on processing of low-acid canned foods, 21 CFR § 113, allows the presence of some of these spores. Therefore, canned foods are not completely sterile, but may contain dormant spores of thermophilic bacteria. The spores will never germinate if the canned food is cooled properly and held at room temperature. Also, the thermophilic spores will autosterilize eventually when held at temperatures at which they cannot germinate or outgrow. Studies by Pearce and Wheaton (*12*) and by

Schmidt and Nank (*13*) have shown this fact. This information also allows the industry to produce canned food of much better quality than if the thermophilic spores would have to be inactivated.

In addition to the thermophilic spores that affect low-acid canned foods, *Bacillus coagulans*, the aciduric flat sour organism was found in the 1940s, to cause spoilage of tomato juice without swelling the container. Heat resistance of spores of the bacterium does not exceed 0.7 min at 250 F in pH 4.3 tomato juice, and it has been eliminated in commercial practice by presterilization.

The thermophilic anaerobes swell the container. Flat sour organisms do not swell the container but sour the product. There may be other spoilage signs, such as cloudy brine. The sulfide spoilage organisms darken the product and produce the odor of hydrogen sulfide.

Thermophilic spoilage may be eliminated by preventing steam leaks which keep equipment hot; by good sanitation of canning lines, with frequent cleaning; by holding hot product before canning at 165 F or above; by cooling cans to 110 F or lower if possible; by storing cans at temperatures below 86 F and by providing for air circulation among stacked cans.

Thermophilic spoilage is really not a big problem today, but there is still concern about it and interest in the responsible bacteria. The papers in this series will describe these extremely heat resistant sporeformers that reproduce at a rapid rate at very warm temperatures.

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