E-ISSN: 2582-9467
Popular Article
Patel et al. (2025)

Distribution and Cold Spot Analysis in Canned Seafood Products

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OPEN ACCESS

Keywords

Cold spot, Seafood, Canning, Spoilage

How to cite this article:

Patel, N. D., Kalaria, K. K., Parmar, A. M. and Tandel, B. 2025. Distribution and Cold Spot Analysis in Canned Seafood Products. *Vigyan Varta* 6 (11): 108-112.

ABSTRACT

Heating canned foods for commercial sterilization is a complex process shaped by the properties of the food, container design, and the physics of heat transfer. Since heat does not reach all parts of the can at the same time, identifying the 'cold spot' the slowest heating point within the container is essential to ensure safety. By focusing on the cold spot during process validation, manufacturers guarantee that even the most resistant pockets within the product are thoroughly sterilized, protecting consumers from foodborne risks. Both the composition of the food and characteristics of its container influence heat flow, with the cold spot's location varying between solid and liquid foods. Careful monitoring, usually using thermocouples, tracks heat penetration and confirms that the product receives effective treatment at all stages from initial heating to final cooling. Innovations in sterilization equipment and technology continue to evolve, helping maintain food texture and flavor while prioritizing safety.

INTRODUCTION

During thermal processing of canned foods, the contents do not heat or cool uniformly at any given moment. The area within the container that shows the greatest delay in reaching higher temperatures known as the slowest heating point (SHP) is referred to as the *cold point* (Mohamed, 2015). To ensure commercial sterility throughout the product, process evaluation focuses on the temperature at this cold point and the cumulative lethal effect of heat exposure.

The principle behind this is that if the cold point achieves a sufficient thermal treatment to ensure sterility, the rest of the product will have received an equal or greater heat dose, confirming uniform sterility. In a retort system, temperature distribution within a can varies spatially outer regions near the walls heat more rapidly than the inner portions, creating a temperature gradient. Studies show that in conduction-heated foods, the cold spot lies at the can's geometric center, while in convection-heated products, it is located along the central axis approximately ½ inch to 2 inches above the bottom, depending on the container height.

The time required to vent the retort and bring it to the processing temperature is called 'come-up-time' (CUT). An important processing-related factor is the 'come-up' time. 'It has now more or less been established that 42% of the 'come-up' time should be added to the processing time at the retort temperature. The 'come-uptime' will be different for different sizes and types of retorts and different can loads.

What exactly is a cold spot in food containers?

The cold spot, or slowest heating point, refers to the area inside a food container that reaches the lowest temperature during thermal processing. When a can of food is heated, the regions near the container walls warm up rapidly because they are in direct contact with the hot medium, while the central portions heat much more slowly. This temperature variation is not merely a technical issue it plays a crucial role in ensuring food safety.

In evaluating the heat process applied to foods, the contributions made during the periods in which the contents are heating up and cooling down also should be taken into account since temperatures above 60°C have some killing effect on the bacteria. Data during the heating and cooling phases of the process are required as both these contribute to the total lethality of the process. This is done by measuring the heat penetration into the product during thermal processing. Therefore, for arriving at the thermal process requirements, determination of the cold point and knowledge on the pattern of heat penetration in the food inside the can are very essential.

Determination of cold point:

Heat penetration within a can is measured using a thermocouple, a device that operates on the principle that when two dissimilar metal wires are joined at both ends and subjected to different temperatures at these junctions, an electric current is generated whose magnitude depends on the temperature difference. One junction is placed at the coldest point inside the can, while the other is kept at a stable reference temperature, typically 0°C using an ice bath. The resulting voltage difference is measured with a calibrated potentiometer that directly correlates to temperature. Common metal combinations for thermocouples include copper and constantan or chromel and alumel (ZOTTOLA*, et al.,* 1978).

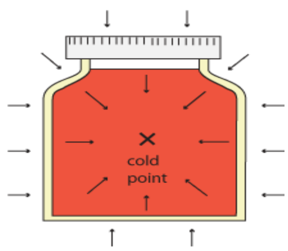
Mechanism of heat transfer in food cans:

The mechanism of heat transfer is dependent on the nature of the foods, whether fluid, solid, or, solids and liquid, or others. Therefore the positioning of the thermocouple junction to determine the cold point becomes very significant.

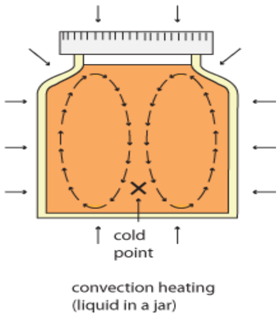
i) **Conduction heating packs**: Solid foods heat by conduction, which is a relatively slow process. In this process, heat is transferred by molecular activity from one substance to another. The rate of heat transfer will decrease as the difference between the temperatures of the retort and that at the centre of the can becomes smaller. All food is composed of molecules that are continuously vibrating. When heat is applied to food, these molecules begin to vibrate more rapidly, causing adjacent molecules to collide with each other. Molecules with higher energy transfer some of that energy to molecules with lower energy through these collisions. This energy transfer continues until the molecules located farthest from the heat source receive some of the transferred energy via conduction. In the case of a glass jar, the food in direct contact with the jar's sides heats up first. The heat then moves inward to the cooler parts of the food. The time needed to heat the entire jar depends on factors such as the food's density, volume, and water content. Solidly packed foods like meats and fish, as well as highly matted are heated primarily by conduction. This mode of heat transfer is relatively slow compared to convection heating, where fluid movement enhances heat distribution. Initially, the temperature of the material at the centre of the can remains constant when that near the can wall increases. In solid packs, the cold point will be generally found at the geometric centre of the can; however, in cans having headspace this will be found just above the geometric centre (GEORGE, 2012).

ii) Convection heating packs: Heating causes a change in the density of fluids and results in setting up convection current. Rapid convection heating takes place in thin liquids; but any dissolved substance that increases the viscosity will cause a decrease in heat transfer (GEORGE, 2012). Convection heating primarily occurs in thin liquids and gases such as air and steam. When these substances are heated, the molecules become less dense and rise to the top of the container, displacing cooler molecules downward. This circulation creates a visible movement, especially notable when heating water in a transparent glass container. Convection heating is particularly effective in liquids such as fruit and vegetable juices, seafood soups or broths. These liquids heat rapidly, which shortens the necessary processing times. However, even small amounts of starch, whether added directly or leached out from vegetables during processing, can slow convection currents and consequently increase the time required for heat to penetrate the product. For instance, jars containing liquid with pieces of green beans or peas will heat more slowly compared to clear apple juice, as the solid pieces obstruct the convection flow within the jar. Additionally, the packing density inside the jar significantly influences heating rates; jars that are tightly packed hinder convection currents more than loosely packed ones, resulting in slower heat penetration. This highlights the importance of avoiding over-packing jars during food processing, as doing so. For instance, the thermal processing duration for soup mixtures is determined by their ability to heat through convection. When filling jars, solid ingredients should be placed first, ensuring that they occupy approximately half of the jar before adding the liquid portion reduces the effectiveness of convection heating and prolongs processing duration (Tope, 1977).

Heat penetration by conduction and convection heating is represented in Figure below



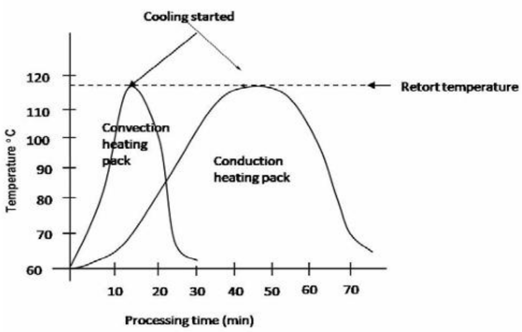
conduction heating
(solid food in a jar)



https://www.meatsandsausages.com/meat-vegetables/canning/thermal-process

Heating and cooling curves of convection and conduction heating foods at the cold spot

Aspect	Conduction Heating	Convection Heating
Heat transfer mechanism	Direct molecular contact	Bulk fluid movement
Speed of heat transfer	Slower, limited by material thermal conductivity	Faster, enhanced by fluid circulation
Temperature-time graph	Gradual temperature rise, gentler slope	Rapid temperature rise, steeper slope



Method of determining heat penetration in the can / Thermocouple mapping technique

First the cold spot in the can is determined by fixing the thermocouple in 5-6 cans at various points along the geometrical axis where the cold spot is likely to occur. Then the cans are filled with required quantity of food (as packed in normal processing) with thermocouple tips at different positions. The cans are seamed and heat processed and the temperature is noted. The slowest heating rate indicates the cold spot. About 6-8 cans of same dimension are then taken, fixed with thermocouple tips at the predetermined cold spot, filled with the product and then the intended process is given by retorting. The retort and can temperature are recorded at the convenient intervals of time ranging from ½ to 1 min for normal products and at 2-5 mins for slow heating products.

Factors influencing cold spot location

Several factors influence the location of cold spots within canned foods, which is vital for food engineers to consider when designing effective heat processing methods.

One major factor is the composition and texture of the food. Liquid foods, such as broths, transfer heat mainly through convection currents, which often causes cold spots to form near the bottom of the container where convection flow is limited. In contrast, solid foods rely on conduction to transfer heat, and so their cold spots usually occur at the geometric center of the container, where heat penetration is slowest. Foods with combinations of solids and liquids, like chunky vegetable soups, present added complexity, as solid pieces can obstruct convection currents while absorbing heat, thereby creating intricate temperature patterns that require careful assessment.

The container itself also plays a significant role in cold spot formation through its shape, size, and material composition. Larger containers usually have more pronounced cold spots because heat must travel greater distances to reach the innermost parts. The geometry of the container affects how heat circulates; tall and narrow containers often exhibit different heating patterns compared to short and wide containers due to differences in convection dynamics. Additionally, the material of the container impacts heat transfer metal cans conduct heat efficiently, promoting quicker and more even heating, whereas glass or plastic containers tend to create varied thermal gradients due to lower thermal conductivity. The thickness of the container walls matters too, as thicker walls can function as thermal barriers, slowing heat transfer and influencing where cold spots develop. Understanding these food and container factors is essential for designing thermal processes that ensure complete and safe sterilization of canned foods.

REFERENCES:

https://agriculture.institute/food-processing-and-engineering-ii/locating-cold-spots-food-containers/

Mohamed, I. O. (2015). Determination of cold spot location for conduction-heated canned foods using an inverse approach. *International Journal*, *2*(2), 11.

Tope, N. F. (1977). Pressure canners, vital for low-acid foods.

ZOTTOLA, E. A., WOLF, I. D., NORDSIDEN, K. C. L., & THOMPSON, D. R. (1978). Home canning of food: Evaluation of current recommended methods. *Journal of Food Science*, *43*(6), 1731-1733.