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Irradiation -- The Food Sanitizing Process Suitable for the US Postal Service[1]

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During the 1950s, the terms “'atomic'” and '“nuclear'” suggested progress, futuristic technology, high quality, national pride and power. However, in the 1960s, these terms became associated with the horrors of nuclear war. By the time of the meltdown at Three Mile Island in 1979, “'nuclear'” was full of negative connotations in the public's imagination. Unfortunately, “'radiation'” fell victim to the same fate, through guilt by association. Similarly, some people became suspicious that food irradiation, a productive use of radiation, might taint the food supply rather than protect it.

The Basics of Irradiation

By itself, “'radiation'” or '“irradiation'” can refer to many things; some of which we use or enjoy every day -- sunlight and indoor lighting are examples. Everyone lives in a virtual sea of radio waves, and of course, these radio waves carry all sorts of communications, including radio, television, and cellular telephone traffic. Microwaves safely cook foods or carry phone signals from city to city. Infrared lamps are often found in cafeterias where they keep food warm, or in bathrooms where they take the chill off porcelain surfaces. These forms of radiation are considered to be of relatively low energy. There are also forms of radiation with higher energy, such as x-rays, cosmic rays, gamma rays, as well as particle emissions like alpha, beta and neutron radiation.

Of all these forms of radiation, the food irradiation industry primarily uses two types, gamma (or x- rays) and electron beams. Both of these have specific properties that make them useful, particularly an extraordinary ability to kill microorganisms without “significant collateral damage” to the product itself.

Let's consider the expression “'significant collateral damage.'” First, what exactly is “collateral damage?” Short Answer: Effects that reduce the quality or value of the product. While it is true that either heat or radiation can kill microorganisms, heat also alters the texture, color and flavor of foods. While some foods might ultimately benefit from being “cooked,” consumers do not normally purchase pre-cooked steaks and chicken breasts from supermarkets. Therefore, heating is not practical for fresh meats because it results in too

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much “collateral damage” to the product. Irradiation, on the other hand, efficiently kills dangerous bacteria without changing the fresh character of foods.

One might ask: Who decides when the collateral damage is “significant?” Short answer: The laws of physics, consumers, manufacturers, and governmental regulatory agencies.

First and foremost, the laws of physics define which types of radiation are suitable for food irradiation. On one extreme, one can irradiate a hamburger with a handheld flashlight until the batteries die, but that kind of radiation will not kill one bacterium. On the other extreme, if the hamburger were briefly placed in the neutron field of an reactor in a nuclear power plant, not only would this very specialized radiation kill the bacteria, it would also make the hamburger radioactive! As different as these two types of radiation are, they both are very useful for certain applications, but clearly, neither is suitable for killing bacteria in hamburgers.

Effective Food Irradiation

Between the extremes of radiation are types that are quite safe and suitable for food irradiation. These types are generally referred to as “ionizing radiation.” By definition, they are capable of creating “ions” by stripping electrons off of molecules. It is worth noting that ions are strictly chemical in nature. They are not exclusive to the world of radiation. Heat is also capable of creating ions. Additionally, the types of radiation used to treat foods or sterilize medical supplies, such as band-aids, are “physically incapable” of causing a product to become radioactive; it simply can not happen.

In the process of generating ions, many “ionized” molecules are broken into smaller pieces. This is actually the reason that food irradiation kills bacteria. Special molecules within bacteria are needed to live, grow, and multiply. In particular, functioning DNA molecules are essential to living bacteria (and all living things). Therefore, the goal is to damage bacterial DNA. Fortunately, DNA molecules are very large and relatively easy to hit with ionizing radiation. This helps to make irradiation very effective at killing bacteria. It is the same reason that excessive exposure to x-rays can be harmful to humans. The important distinction is that eating foods that have been exposed to radiation does not result in the consumer being exposed to radiation. The radiation is used to kill the bacteria only. Suffice it to say that a hamburger can be eaten immediately after being irradiated. The radiation does not linger in the hamburger -- there is absolutely no "radiation" residue -- irradiated foods do not "glow in the dark"! When we eat an irradiated hamburger, we are neither being irradiated, nor are we consuming food that has been made radioactive.

It is true that some hamburger DNA is broken down, but rest assured, since the hamburger is no longer living, the DNA does not function anyway. Also, a primary objective of the digestive system is to break down DNA in foods. Hence, unlike heating, food irradiation does not significantly change the overall appearance, function and quality of foods.

Making Mail Safe

Radiation processing technology has been proposed as a means to reduce biological terrorist threats, such as anthrax, in mail. Ionizing radiation is capable of destroying bacterial anthrax spores in mail in the same way that it can kill *Salmonella* bacteria in poultry. The difference lies in how susceptible the genetic material (DNA) is to ionizing radiation.

Certain bacteria are capable of existing in a “dormant” state. When bacteria go dormant, they form a type of bacterial cocoon, called a spore. A bacterial spore is much more resistant to virtually everything than the normal bacterium. A spore is essentially a DNA protection capsule for the bacterium. When favorable conditions return, the spore converts back into a normal bacterium.

Spores are like microscopic BBs. They are dry and protected by a hard shell. They can survive for long periods in dry, hot, salty, or acidic conditions. As might be expected, spores are also less sensitive to radiation than normal bacteria.

Two aspects of bacterial spores in mail make them a bit tougher to destroy, namely (1) dormant spores tend to be more difficult to kill then the active bacteria, and (2) unlike most foods, mail tends to be dry, which offers a degree of protection from radiation. The radiation processing industry faces these same challenges with dry food ingredients such as spices and dry powders.

To understand why bacterial spores are harder to kill than bacteria in moist foods, we need to consider two key factors: the ability of DNA to move freely and the absence of water in dry materials. Regarding the ability of DNA to move freely, when a molecule is broken up in water, the parts can drift away from each other, but in dry conditions, the parts can remain close and may even recombine. Regarding the role of water, the presence of water reduces the chances that the molecule will "heal." Also, water itself is often broken into reactive "free radicals" by the ionizing radiation. These radicals are capable of damaging DNA, and in that way, they increase the effect of the radiation. This is called a "secondary interaction," so if the radiation doesn't hit the DNA directly, one of these free radicals might get the job done.

Mail sanitization will simply require a greater exposure or dose than wet foods. This means that mail will need to spend a little more time being irradiated. Therefore, the same technology used to sanitize foods may prove to be a safe and practical way to ensure the safety of our mail.