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National Advisory Committee on Microbiological Criteria for Foods Work Group Assignment: Supplemental Information

Potential Scientific Parameters that Must be Considered to Establish Global Dates for Refrigerated Ready-To-Eat Foods

Background

The development and subsequent analysis of the draft FDA/FSIS microbial risk assessment on "The Relative Risk to Public Health from Fooborne *Listeria monocytogenes* Among Selected Categories of Ready-to-Eat (RTE) Foods," reinforced the relationship between the temperature and time of refrigerated storage and the microbiological safety of refrigerated ready-to-eat (RTE) foods. Foods that had relatively low levels of initial contamination at manufacturing but which supported the growth of *L. monocytogenes,* were in many instances found to pose a sufficient risk if the duration and temperature of storage permitted significant growth. Inversely, despite often having significant frequencies of contamination, foods that did not allow growth of the pathogen typically did not have elevated levels of the pathogen at the time of consumption and generally were not associated with an increased risk of disease. Further, the risk assessment predicted that refrigerators operating at high temperatures (> 50 F) led to a disproportionate fraction of illnesses. While information on the distribution of storage times associated with refrigerated RTE foods is limited, the analysis suggested that preventing storage for excessive times would also have a marked effect in reducing the number of illnesses.

While the temperature and duration of refrigerated storage on RTE foods is particularly important for psychrotrophic pathogens such as *L. monocytogenes*, these factors can also impact the risks associated with mesophilic pathogenic bacteria. Typically, gram-negative enteric pathogens such as *Salmonella* or enterohemorrhagic *Escherichia coli* do not grow below temperatures of 8 to 10 C. However, at marginal abuse temperatures in the range of 10 to 12 C, growth of *E. coli* O157:H7 and other enteric pathogens can be relatively rapid. It is generally assumed that the more extended the shelf-life of a refrigerated RTE food, the more likely it is that the product will be exposed to one or more periods of marginal temperature abuse prior to consumption.

It has been suggested that the various storage time recommendations that currently appear on food labels seem to be based on quality attributes. The goal of the current request to the National Advisory Committee on Microbiological Criteria for

Foods (NACMCF) is to have the Committee consider the scientific parameters and data that would be needed to develop "safety –based" "use-by" date labels for RTE foods. This document is intended to provide some of the related issues that may need to be considered in responding to the charge that has been presented to the Committee. The issues presented are for illustrative purposes only and should not be considered all inclusive.

Selection of Target Organisms and "Safety-Based" End Points

Two parameters that are prerequisites for the development of "safety-based" "use-by" date labels are the microorganism of concern and the biological end point that will serve as the basis for the shelf-life value. To date, it has generally been assumed that the target organism for RTE foods should be *L. monocytogenes*. However, it could be argued that it would be beneficial to use a surrogate microorganism that has a higher rate of growth at refrigeration temperatures. Once the target microorganism is selected, the end point that should be the basis for decision-making must be agreed upon in order to set the "use-by" date. Typically, the end point that has been considered has been that of the food having been subjected to conditions that lead to some degree of growth (e.g., < 1 log cycle). Ideally, the end-point selected is one that correlates with an agreed upon increase in the risk of adverse health effects.

In developing shelf-life criteria based on quality attributes, it is generally assumed that a portion of the consumers will use the product after the recommend shelf life. This is taken into account in setting the shelf-life dates. One referenced value seen is that consumers will generally consume or discard a product within a period that is 1.3 times the stated shelf-life.

Some of the related issues that have arisen about the selection of the target organism and shelf-life end point are:

- **Target microorganism for the development of "safety based" "use-by" date labels for RTE foods**
- **Need for more than one target microorganism given the range of RTE foods**
- **Criteria for using one microorganism instead of another**
- **Criteria based on the genus Listeria versus *L. monocytogenes* specifically**
- **Biological endpoint and rationale for "safety-based" "use-by" dates given that a pathogen such as *L. monocytogenes* is not supposed to be present in a RTE food**

Built in safety margins for "safety-based" "use-by" date labels that take into account the propensity of the consumer to consume products that are marginally past shelf-life dates

Sufficiency of current data on industry, marketing, and consumer practices to develop "safety-based" "use by" date labels and the significance of the data gaps

Need for "safety-based" "use-by" date labels on those products that will acquire obvious spoilage characteristics prior to consumption thereby offering some assurances that the product will not be consumed

Storage conditions pertinent to reliance on sensory characteristics instead of "safety-based" "use-by" date labels?

Modeling the Growth of Pathogenic Bacteria

Considering the wide range of products, product formulations, and production facilities, as well as the wide diversity of practices associated with the distribution, marketing, and consumption of RTE foods, it does not seem feasible to conduct inoculated pack studies on more that a limited number of product classes. Accordingly, it is assumed that the modeling of microbial growth will play an important role in the development of "safety-based" "use-by" date labels. During the past decade there has been extensive research directed toward the development of mathematical models that describe the growth characteristics of *L. monocytogenes* and other foodborne pathogenic bacteria.

Modeling techniques are being used extensively in the development of both the FDA/FSIS and FAO/WHO *L. monocytogenes* risk assessments. In applying growth models, several assumptions were made by the FDA/FSIS and FAO/WHO risk assessment teams in order to achieve realistic representations of the "real world." Several of these assumptions are outlined below as examples of potential parameters that may have to be considered in the development of "use-by" dates.

1. **Storage temperatures and times are not independent. When refrigerator temperatures are high, the storage times are relatively short. When temperatures are low, storage times may extend from immediate use to months for foods such as smoked fish, cheeses, and some deli meats. In the FDA/FSIS risk assessment, a negative correlation was used for the uncertainty ranges for the most likely and maximum storage times. This means, for example, if the most likely storage times for a food ranged from 6 to 10 days, the 6 days was more frequent at the higher temperatures. The**

FAO/WHO risk assessment used r = -0.5 for dairy products. However for smoked seafood, a time-temperature model for spoilage was available. The resulting good/spoiled criteria was used to eliminate the excessive high time-high temperature storage combinations. The precise relationship between storage times-temperatures combinations and consumer acceptance for most RTE foods is poorly documented for most foods.

2. **Inoculated pack studies have demonstrated that *L. monocytogenes* can grow to high numbers on foods in the presence of a product's normal microflora. The maximum levels of *L. monocytogenes* reached in a food appear to depend upon storage temperatures; i.e., lower temperatures have lower maximum levels. The two *L. monocytogenes* risk assessments assumed a correlation between storage temperature and maximum levels. However, there are several limitations associated with much of the available information. The *L. monocytogenes* inoculum levels used in most experimental trials are typically 10^3 cfu/g, which is higher than the typical contamination levels of < 100 cfu/g. Whether 10 cfu/g would grow to as high a level at the higher levels used in the inoculated pack studies, given the same spoilage flora, is unclear. When both spoilage flora and pathogen levels are low, competition probably does not affect growth of either. However, when the spoilage flora reaches high levels (ca. > 10^6), growth of all microorganisms including *L. monocytogenes* reach a plateua. This phenomenon, which is known as the Jamieson Effect, suggests that in RTE foods, *L. monocytogenes* growth may not routinely reach the levels indicated by the inoculated pack studies.**

Very few inoculated pack studies have been conducted to determine when spoilage and rejection of the food by the consumer would occur. The current modeling approaches may project storage periods and growth beyond a reasonable time. However, *L. monocytogenes* does not produce as obvious an organoleptic change in the food as do many other microorganisms. The chocolate milk outbreak where many people consumed 10^9 cfu/ml illustrates this phenomenon.

Some of the related issues that have arisen in regard to possible modeling approaches are:

Depth of knowledge about pathogen growth in foods

Adequacy of currently available models to develop "safety-based" "use-by" date labels

Applying a general model (e.g., based on microbial behavior in a model system) versus employing models developed for specific classes of RTE foods

Log phase calculations in available models and their impact on the

development of "use-by" date labels

Differentiating Foods that Do or Do Not Support Growth

As indicated above, a key parameter that influences the risk of RTE foods being associated with human cases of listeriosis is their ability to support the 5rowth of *L. monocytogenes*.

Some of the related issues that may need to be considered are:

Distinction between foods that do and do not support growth of *L. monocytogenes* in relation to the need to establish "safety-based" "use-by" date labels

Scientific criteria needed to demonstrate that a food does not support the growth of *L. monocytogenes* under both normal and moderate abuse conditions and recommended validation testing methodology versus criteria for foods that do not support the growth of *L. monocytogenes* under abuse conditions

Criteria to be applied when a product may or may not support the growth of *L. monocytogenes* depending on the specific formulation or storage parameters used by the manufacturer

Determining "use by" date labels for products that do not support the growth of *L. monocytogenes* in an intact package (e.g., modified atmosphere package) but do support the growth of the pathogen once opened and subsequently stored in the home or in a food service environment

Biological Diversity

The biological systems that make up the disease triangle (pathogen, host, and food) for foodborne diseases are noted for their diversity. Traditionally, food safety experts have dealt with this diversity by seeking the "worst case scenario." However, this typically leads to highly conservative food control systems. With the advent of microbial risk assessment techniques, it is increasingly possible to directly consider diversity in the analysis of food safety data and the subsequent development of microbiologically-based criteria such as "safety-based" "use-by" date labels.

Related issues that may need to be considered are:

Current knowledge base on the extent of differences among strains and strain

differentiation in developing “safety-based” “use-by” date labels

Specific serotype, genotype, lineage, or pathogenicity group that should be used for the development of “safety-based” “use-by” date labels

Validation and Verification

It is assumed that validation and verification will be integral parts of the establishment and use of “safety-based” “use-by” date labels.

Some of the related issues that may need to be considered are:

Critical factors needed to design a validation protocol and a verification protocol

Strain(s) reference standard(s) and recovery methods

Storage conditions for validating a “safety-based” "use-by" date label (temperature, temperature fluctuations, atmosphere changes, degree of abuse).

“Time-temperature integrators” (TTI) on boxes or consumer packages or other technology-based alternatives as indicators of “safety-based” "use by" date labels.

Use of natural competitive flora or the deliberate addition of microflora to a food as a reliable control measure for either preventing excessive growth of *L. monocytogenes* or preventing consumption of the food that has been held beyond its “use by” date and validating and verifying such a process

Types of microbiological testing or related analyses to verify the effectiveness of a “safety-based” “use by” date label and their application during a product’s “life cycle” (e.g., manufacture, warehouse, retail, consumer) to provide the most useful information

Sufficiency and availability of scientific data to establish "default" use by date labels.