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StandardPractice for Irradiation of Fresh and Frozen Red Meat and Poultry to Control Pathogens and Other Microorganisms[1]

This standard is issued under the fixed designation F1356; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

The purpose of this practice is to present information on the use of ionizing radiation in treating fresh or frozen red meat and poultry products to eliminate or reduce the numbers of vegetative, pathogenic microorganisms and parasites, and to extend the refrigerated shelf-life of those products by reducing the numbers of vegetative spoilage microorganisms.

This practice is intended to serve as a set of recommendations to be followed when using irradiation technology where approved by an appropriate regulatory control authority. It is not to be construed as setting forth rigid requirements for the use of irradiation. While the use of irradiation involves certain essential requirements to attain the objective of the treatment, some parameters can be varied in optimizing the process.

This practice has been prepared from a Code of Good Irradiation Practice published by the International Consultative Group on Food Irradiation (ICGFI) under the auspices of the Food and Agriculture Organization (FAO), the World Health Organization (WHO), and the International Atomic Energy Agency (IAEA) (**1**).[2]

1. Scope

1.1 This practice outlines procedures for the irradiation of fresh or frozen meat and poultry.

NOTE 1—The Codex Alimentarius Commission defines meat as "the edible part of any mammal" and poultry as "any domesticated bird, including chicken, turkeys, ducks, geese, guinea-fowls, or pigeons" (CAC/MISC 5).

NOTE 2—Current U.S. regulations limit the definition of livestock species to cattle, sheep, swine, goat, horse, mule, or other equine and poultry species to chicken, turkey, duck, goose, and guinea (**2**, **3**).

1.2 This practice covers absorbed doses used for inactivation of parasites and reduction of bacterial load in fresh and frozen red meat and poultry. Such doses are typically less than 10 kGy.

1.3 This practice addresses irradiation of pre-packaged product for retail sale or for use as an ingredient in other products. It also addresses the in-line irradiation of unpackaged product.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E170 Terminology Relating to Radiation Measurements and Dosimetry

E2303 Guide for Absorbed-Dose Mapping in Radiation Processing Facilities

F1416 Guide for Selection of Time-Temperature Indicators

F1640 Guide for Selection and Use of Packaging Materials for Foods to Be Irradiated

2.2 *ISO/ASTM Standards:*[3]

51204 Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing

51261 Guide for the Selection and Calibration of Dosimetry Systems for Radiation Processing

51431 Practice for Dosimetry in Electron and X-ray

[1] This practice is under the jurisdiction of ASTM Committee E61 on Radiation Processing and is the direct responsibility of Subcommittee E61.05 on Food Irradiation.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

(Bremsstrahlung) Irradiation Facilities for Food Processing
51539 Guide for the Use of Radiation-Sensitive Indicators

2.3 *Codex Alimentarius Commission Recommended International Codes and Standards:*[4]

CAC/RCP 1-1969, Rev. 4-2003, A Recommended International Code of Practice—General Principles of Food Hygiene (Including Annex): Hazard Analysis and Critical Control Point (HACCP) System and Guidelines for Application
CAC/RCP 19-1979, Rev-2003, Recommended International Code of Practice for the Radiation Processing of Food
CX STAN 1-1985, Rev. 1991, Amd. 2001, General Standard for the Labeling of Prepackaged Foods
CX STAN 106, Rev. 2003, General Standard for Irradiated Food
CAC/MISC 5-1993, Amd. 2003, Glossary of Terms and Definitions (Veterinary Drug Residues in Food)

3. Terminology

3.1 *Definitions:*

3.1.1 Other terms used in this practice may be defined in Terminology E170.

3.1.2 *absorbed dose*—quantity of ionizing radiation energy imparted per unit mass of a specified material. The SI unit of absorbed dose is the gray (Gy), where 1 gray is equivalent to the absorption of 1 joule per kilogram of the specified material (1 Gy = 1 J/kg).

3.1.2.1 *Discussion*—A standard definition of absorbed dose appears in Terminology E170.

3.1.3 *D_{10}-value*—absorbed dose required to reduce the microbial population in a given food by 90 % (1 $\log_{10}$).

3.1.4 *dose distribution*—variation in absorbed dose within a process load exposed to ionizing radiation.

3.1.5 *process load*—volume of material with a specified loading configuration irradiated as a single entity.

3.1.6 *transport system*—conveyor or other mechanical system used to move the process load through the irradiator.

4. Significance and Use

4.1 The principal purpose of irradiation is to control (reduce the number of) pathogenic bacteria in fresh or frozen red meat and poultry to ensure the safety of these foods for human consumption. Irradiation significantly reduces the numbers of vegetative pathogenic bacteria such as *Campylobacter*, *Escherichia coli*, *Listeria*, *Salmonella*, *Staphylococcus aureus*, or *Yersinia enterocolitica*.

4.2 The process also inactivates parasites such as *Trichinella spiralis* and *Toxoplasma gondii*.

4.3 The process may extend the shelf life of fresh red meat and poultry by reducing the numbers of viable, vegetative spoilage bacteria, such as *Pseudomonas* species.

4.4 Radiation processing of fresh and frozen red meat and poultry is a critical control point (CCP) of a Hazard Analysis of Critical Control Points (HACCP) program. It serves as an important measure to control any residual risk from pathogenic microorganisms before the product reaches the consumer.

5. Criteria for Assessing Irradiation Efficacy

5.1 *Irradiation for Control of Pathogenic Bacteria*—The numbers of pathogenic bacteria that can result in an infectious product vary with the specific bacterium and the susceptibility of the consumers involved. The adoption of criteria, such as those used in the U.S. for the pasteurization of milk or in scheduled processes for low-acid canned food, is the most reasonable in the absence of microbiological end product criteria for expected pathogenic bacteria (**4**, **5**).

5.2 *Irradiation for Inactivation of Parasites*—The criterion should be that the parasites in uncooked, irradiated product are noninfectious or noninvasive, as appropriate. (This does not necessarily require the parasite to be killed by the irradiation process.)

5.3 *Irradiation for Shelf-Life Extension*—The criterion should be the bacterial plate count using appropriate time, temperature, and media parameters. Reduction in bacterial counts as final criteria cannot be specified unless local regulations, customer specifications, or both, are known. Therefore, the final product specification regarding bacterial plate count should be established by the customer.

5.4 Failure to meet these criteria should direct attention to the scheduled process (see 8.1) and the reestablishment, if necessary, of Good Manufacturing Practice (GMPs). The hazard analysis and critical control point (HACCP) system or another similar process control system should be applied to the entire processing and distribution chain. With this system, any point in the chain where a hazardous or critical situation could result is monitored and controlled to prevent unsafe and unwholesome product from reaching the consumer. See CAC/RCP 1 and (**6**, **7**).

5.4.1 Implementation of a process control system to assess radiation-processing efficacy should include bacteriological examination of the product before and immediately after irradiation, use of time/temperature indicators throughout the processing chain (see Guide F1416), and testing of package integrity. Bacteriological testing should reveal a significant reduction in relevant bacterial counts compared to those of the non-irradiated product. Temperature monitoring should alert observers of any product abuse that could result in increases in bacterial counts after irradiation.

6. Pre-Irradiation Product Handling

6.1 Product should be handled in an environment that does not increase the risk of contamination from physical, chemical, or biological hazards. Minimize microbial contamination and growth by following relevant standards of GMPs; see for example U.S. Food and Drug Administration (FDA) GMPs (**8**), U.S. Food Safety and Inspection Service (FSIS) Standard Sanitary Operating Procedures (SSOPs) (**9**), CAC Recommended International Codes of Practice, (CAC/RCP1 (see 2.3) and HACCP) (**10**).

[4] Available from the Joint FAO/WHO Food Standards Programme, Joint Office, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

6.2 *Unpackaged Product*—In facilities handling unpackaged product, the irradiation environment and equipment should be designed and constructed to be cleanable and durable to maintain a sanitary condition and, thereby, not increase the risk of contamination.

NOTE 3—An operating environment with high moisture or airflow may contribute to the risk of bacterial contamination. Moisture provides a growth medium for bacteria and airflow provides a means of transport for bacteria. Food contact surfaces may contribute chemical or physical contaminants to products unless such surfaces are fabricated from appropriate materials and properly maintained and cleaned. Also, employee hygiene and pest control should be closely monitored.

6.3 *Pre-Packaged Product*—For pre-packaged product, the package itself provides a barrier that helps to reduce the risk of recontamination. Thus, many of the requirements for the irradiation environment and equipment necessary for handling unpackaged product may not be applicable for facilities handling only pre-packaged product. Information on applicable requirements should be obtained from the appropriate regulatory authorities before starting operations.

6.4 *Pre-Irradiation Inspection*—Packages and containers of fresh and frozen red meat and poultry should be inspected upon receipt at the irradiation facility to ensure that the product is suitable for irradiation. Written acceptance criteria for product temperature, package integrity and inspection frequency, as applicable, should be established by the product owner and agreed to by management of the irradiation facility prior to accepting product from the owner. Also, criteria for handling of product unsuitable for irradiation should be established.

6.4.1 *Product Temperature*—Upon receipt of product, its temperature should be measured using a calibrated sanitized temperature-sensing device, at a predetermined location and frequency as specified by HACCP and GMPs. Temperature should be between –2 and +4°C for refrigerated fresh red meat and poultry or –18°C or lower for frozen red meat and poultry. For unpackaged product, insert the device directly into the product and sanitize the device between each measurement. For prepackaged product, use a device that can be placed between individual packages without puncturing them.

6.4.2 *Package Integrity*—A visual inspection of the product packaging should be performed to ensure there is no evidence of compromised or damaged product. Also, a sensory inspection should be performed. No leakage of fluids or odor indicative of product spoilage should be evident upon inspection.

6.4.3 *Product Inventory*—The number of containers should be counted and the description/identification of the product to be irradiated should be verified and compared with the documentation from the product owner. A comparison of this pre-irradiation count with a count performed after irradiation provides a check that all products received have been irradiated.

6.4.4 *Product Identification*—A unique identification number for tracking the product throughout the irradiation process should be issued and documented for the incoming product.

6.5 *Pre-Irradiation Storage:*

6.5.1 For fresh red meat and poultry, the principal requirement for pre-irradiation storage is maintenance of the product temperature between –2 and +4°C without freezing.

NOTE 4—U.S. poultry regulations presently require that the temperature of fresh poultry be maintained at or below 4.4°C (**10**).

NOTE 5—Holding product under refrigeration for an unduly long time would violate principles of GMPs because such treatment may result in excessive growth of psychrotrophic bacteria and undesirable changes in products.

6.5.2 A second requirement is that the pre-irradiation storage period at the irradiation facility be minimized, approximately one day or less, whenever possible.

6.5.3 For frozen red meat and poultry, the product temperature should be maintained at or below –18°C at all times. The relatively short duration of frozen storage prior to irradiation is not particularly critical under normal commercial conditions. However, freezing does not provide an unlimited product life without loss of quality, and the pre-irradiation storage period should therefore be minimized.

6.6 *Product Segregation*—Distinguishing irradiated from non-irradiated product by inspection might not be possible. Therefore, the use of appropriate means integral to the facility design, such as physical barriers or special segregation in clearly defined staging areas, to maintain non-irradiated product separate from irradiated product is important.

NOTE 6—Radiation-sensitive indicators undergo a color change when exposed to radiation in the pertinent dose range. These indicators may be useful within the irradiation facility as a visual check for determining whether or not a product has been exposed to the radiation source. They are not dosimeters intended for measuring absorbed dose and must not be used as a substitute for proper dosimetry. Information about dosimetry systems and the proper use of radiation-sensitive indicators is provided in ISO/ASTM Guides 51261 and 51539, respectively.

7. Packaging and Product Loading Configuration

7.1 *Packaging Materials:*

7.1.1 Use packaging materials suitable to the product, taking into account planned processing (including irradiation) and consistent with regulatory requirements (see Guide F1640).

7.1.2 Packaging materials should provide appropriate gas and moisture permeability to maintain product quality.

7.2 *Product Loading Configuration:*

7.2.1 The size, shape, density and loading configuration of a process load to be irradiated should be determined primarily by considering design parameters of the irradiation facility. Critical design parameters include the characteristics of product transport systems and of the radiation source as they relate to the dose distribution obtained within the process load.

7.2.2 The dose distribution within the process load can often be optimized by using product packages that are geometrically well defined and uniformly loaded. With certain irradiation facilities, it may be necessary to limit the use of particular package shapes and sizes depending on the density of the product and facility Operational Qualification (OQ) data (see ISO/ASTM 51204 and 51431).

7.2.3 Prescribed product dose specifications should be taken into account when determining the appropriate product-loading configuration (see 8.4).

8. Irradiation

8.1 *Standard Operating Procedures (SOPs)*—A standard operating procedure, or scheduled process, for food irradiation