



Number: 10

Date Published: 12/28/2021

Issue	Frozen Meat Safety and Quality
Background	<p>To have the nutrients that the body needs, the Food and Nutrition Research Institute (FNRI) Nutritional Guidelines for Filipinos advocate consuming a variety of foods from all food groups in the right amount and balance. A better nutrient intake includes a balanced intake of proteins, carbohydrates, fats, micronutrients, water, and electrolytes [1]. For proteins, Filipinos' major sources are fish, meat, and poultry [2].</p> <p>Meat is a good source of high-quality protein, iron, vitamin B12, and other B-complex vitamins, as well as zinc, selenium, and phosphorus. [3]. Although cereal and cereal products are the most consumed food group, meat and meat products have an 8% contribution to the total household food intake [4]. In terms of the type of meat, the Philippine Statistics Authority (PSA) reported that pork and chicken are considered as the major meat products being consumed, with about 62% to 63% of household consumption. Filipino households prefer less beef with only 9.66% consumption. Other meats being consumed are carabeef, chevon (goat), and duck meat with only 1% consumption each [5].</p> <p>Meat when sold in market outlets is usually either fresh or frozen. In order to guide producers, retailers, and consumers in proper handling of frozen meat and in making informed decisions, this Technical Bulletin aims to discuss food safety and quality concerns on frozen meat.</p>



General Description

Freezing, a preservation method, prevents the growth of microorganisms that cause food spoilage and foodborne illnesses. Food stored at -18°C will always be safe since it slows down the movement of molecules, causing microbes to enter a dormant stage. At -18°C , bacteria, yeast, and molds present in food are inactivated. Trichinae and other parasites can also be destroyed at sub-zero freezing temperatures. However, once thawed, the microbes will become active again, multiplying under favorable conditions that will lead to foodborne illnesses [6].

In terms of quality, frozen meat quality is mostly determined by the size of the ice crystals formed. During freezing, most of the water content of meat, roughly 80%, forms into pure ice crystals, along with the separation of dissolved particles. Thus, freezing speed is an important consideration when it comes to the quality of frozen meat [7].

There are two methods of freezing - slow freezing and rapid freezing. Rapid freezing prevents undesirable large ice crystals from forming and produces a large number of small ice crystals, mostly within the muscle cells, which decreases water migration and solution separation. Slow freezing, on the other hand, allows the solution to separate and the water to migrate out of the muscle cells, where it then freezes, forming huge crystals [8]. During thawing, large ice crystals damage the cells and disrupt emulsions causing the meat to drip and lose its juiciness [9]. Hence, rapid freezing will keep the meat closer to its original quality and reduce moisture loss, especially while thawing [8]. In a study conducted in 2014, it is interesting to note that the average temperature of home freezers is -20.1°C (with a high of -11.1°C and a minimum of -41.1°C) [10].

Frozen raw meat and poultry maintain their quality longer than cooked counterparts because moisture is lost during cooking. However, food quality will suffer from long freezer storage [6]. Fresh meat and poultry can be stored at freezing temperature for four (4) to 12 months depending on meat type, while cooked meat and poultry



may be stored for about one (1) to six (6) months for quality purposes [11].

Microbiological Hazards Presence in Frozen Meat

The ability of microorganisms to tolerate freezing and frozen storage varies and the type and age of the microorganism have an impact on survival. Gram-negative bacteria (pathogens like *Escherichia coli* and *Salmonella* spp.) are more sensitive to freezing and frozen storage than Gram-positive bacteria, with bacilli being more susceptible than cocci. Due to the ability to tolerate low water activity, yeasts and molds are more resistant than bacteria.

Salmonella, although sensitive to freezing, and other potential pathogens can survive frozen storage [12]. In addition, *E.coli* O157:H7 can survive freezing temperatures [13].

Concerns on the growth of pathogenic microorganisms are more relevant to handling before freezing or during thawing rather than during the frozen state of meat. On this basis, frozen foods behave like their unfrozen counterparts. Rapid consumption reduction in surface temperature during freezing allows less time for microorganisms to grow; however, the growth rate will be faster and will increase after thawing.

Quality Issues in Frozen Meat

Although freezing prolongs the shelf life of meat during storage, the exudation of fluid or the “drip” is evident during thawing. The “drip” primarily contains proteins, peptides, amino acids, lactic acid, purines, Vitamin B complex, and various salts. Protein denaturation, lipid and protein oxidation, and discoloration are the other adverse effects on quality [14].

Moreover, as discussed in the previous section, the size of ice crystals greatly influences the quality of meat. Large ice crystals can potentially damage myofibrillar structures resulting in decreased water holding capacity which has a negative impact on the color and flavor [15].



Because of the significant risk of exposing specific areas of the food to high temperatures and humidity, which favor microbial growth, thawing is a more complex operation to carry out safely than freezing. Process time, microbial growth risks, drip loss, and other quality losses are all reduced with a good thawing or tempering regime. The product should be consistently handled, and high-temperature exposure should be halted as soon as the desired endpoint is reached [16].

**Adverse Health
Effect in
Human:
Microbiological
Hazards**

Since meat stored at frozen temperature is safe almost indefinitely, mishandling during storage and thawing may still cause adverse health effects in humans [17]. The US Center for Disease Control and Prevention has reported *Salmonella* outbreaks linked to frozen chicken and *E. coli* O157 infection linked to beef products in the recent year [18].

Salmonella spp.

Depending on the serotype, *Salmonella* can cause two types of illness: Nontyphoidal salmonellosis and typhoid fever. Although the symptoms of nontyphoidal salmonellosis are unpleasant, the condition is usually self-limiting in healthy people with a strong immune system (although it can cause life-threatening illness even in healthy people). Typhoid fever is more serious than nontyphoidal salmonellosis and has a greater fatality rate.

Enterohemorrhagic *Escherichia coli* (EHEC), Serotype O157:H7 - prototypic EHEC strain

Some people may have a less serious form of the infection, which ranges from having no symptoms to diarrhea that starts out watery, then turns bloody. However, the infection sometimes progresses into the life-threatening form of the illness that causes kidney failure and other problems, with children and people with weak immune systems being at especially high risk [19].



Mitigating Measures

To maintain the safety and quality of frozen meat, the following practices are recommended:

A. For producers/retailers: Storage in Freezer or Cold Storage Facilities [20], [21]

1. When frozen meat is held in a freezer or cold storage facility, the freezer or cold storage facility should be operated and maintained to maintain the safety and suitability of meat.
2. Temperature, humidity and airflow of the facility should be monitored and recorded.
3. Ideally, the cold storage facility should have areas and equipment for cooling, chilling and/or freezing of meat.
4. Freezers or cold storage facilities should have adequate capacity to maintain a temperature of -18°C or lower.
5. Freezers or cold storage facilities shall be kept clean, free from objectionable odor, and in good condition.

B. For Consumers: Buying from Retail Markets [22]

1. Make sure to purchase meat from licensed meat suppliers entities.
2. Observe that meat is kept in a cooler or insulated container to keep it fresh and avoid spoilage.
3. When buying, follow this: Chilled meat is cold to the touch, while frozen meat must be rock solid.
4. In case of imported meat, its frozen state must be maintained at all times, until such time that it will be cooked.
5. Length of travel must not exceed two (2) hours to maintain the freshness of meat.
6. Consider the physical properties of meat when buying:
 - a. no unusual odor;
 - b. no unusual color like greenish or red spots; and
 - c. firm to the touch when thawed.



C. For Consumers: Preparation at Home [23]

1. If storing the meat for a short period of time, home refrigerators should be kept at 4°C (40°F) or below.
2. If the meat will be stored longer, particularly those that were purchased in frozen form, home freezers should be kept at -18°C (0°F) or lower. Home freezers have the capacity to reach a temperature of -11.1°C to -41.1°C.
3. If the meat will be stored in the freezer for more than two months, wrap it in foil, plastic wrap, or freezer paper, or put it in a plastic bag [11]
4. Observe appropriate storage, safe thawing, and proper cooking to maintain meat quality and safety.
5. During thawing, frozen meat, whether raw or cooked, must be kept at a safe temperature.
6. To safely thaw frozen meat, the following methods are recommended:
 - refrigerator thawing
 - cold water thawing
 - microwave thawing
7. If there is not enough time for thawing, frozen meat is safe to cook directly [17].

Researcher

Katrina L. Maminta, Science Research Specialist II

Reference/s

[1] Food and Nutrition Research Institute - Department of Science and Technology. (2015). Nutritional Guidelines for Filipinos Revised 2012. Taguig City: Philippines.

[2] Department of Science and Technology - Food and Nutrition Research Institute (DOST-FNRI). 2016. Philippine Nutrition Facts and Figures 2015: Dietary Survey. FNRI Bldg., DOST Compound, Gen. Santos Avenue, Bicutan, Taguig City, Metro Manila, Philippines.

[3] Pereira, P. M. de C. C., & Vicente, A. F. dos R. B. (2013). Meat nutritional composition and nutritive role in the human diet. Meat



Science, 93(3). Retrieved from https://core.ac.uk/reader/62691625?utm_source=linkout

[4] Department of Science and Technology - Food and Nutrition Research Institute (DOST-FNRI). 2020. Dissemination Forum - Presentation of the Household Food Consumption Survey. FNRI Bldg., DOST Compound, Gen. Santos Avenue, Bicutan, Taguig City, Metro Manila, Philippines.

[5] Philippine Statistics Authority. (2017). Consumption of Selected Agricultural Commodities in the Philippines: Volume 1 - National and Regional. Retrieved from <https://psa.gov.ph/sites/default/files/2015-2016%20CSAC%20Vol1.pdf>

[6] United States Department of Agriculture Food Safety and Inspection Service. (2013). Freezing and Food Safety. Retrieved from <https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety-basics/freezing-and-food-safety>

[7] Food and Agriculture Organization of the United Nations. (1992). Meat and meat products in human nutrition in developing countries. Retrieved from <https://www.fao.org/3/t0562e/T0562E00.htm#Contents>

[8] Food and Agriculture Organization of the United Nations. (1991). Manual on Meat Cold Store Operation and Management. Retrieved from: <https://www.fao.org/3/t0098e/T0098E00.htm#TOC>

[9] United States Department of Agriculture. (2019). How does fast freezing improve the quality of frozen food. Retrieved from: <https://ask.usda.gov/s/article/How-does-fast-freezing-improve-the-quality-of-frozen-foods>

[10] Evans, J. A., Foster, A.M., and T. Brown. (2014). Temperature Control in Domestic Refrigerators and Freezers. London Southbank University, Langford, Bristol, UK. Retrieved



from:https://www.researchgate.net/publication/282116578_EVANS_J_A_FOSTER_A_M_AND_BROWN_T_Temperature_control_in_domestic_refrigerators_and_freezers_3rd_IIR_International_Conference_on_Sustainability_and_the_Cold_Chain_London_2014

[11] United States Food and Drug Administration. (2018). Refrigerator and Freezer Storage Chart. Retrieved from <https://www.fda.gov/media/74435/download>

[12] James, S. J., & James, C. (2014). Food Technologies: Freezing. Encyclopedia of Food Safety, 187–195. doi:10.1016/b978-0-12-378612-8.00266-3

[13] United States Department of Agriculture. (2019). Will E. coli be killed by freezing? Retrieved from: <https://ask.usda.gov/s/article/Will-E-coli-be-killed-by-freezing>

[14] Xiong, Y. L. (2017). The Storage and Preservation of Meat. Lawrie's Meat Science, 205–230. doi:10.1016/b978-0-08-100694-8.00007-8

[15] Dang, D.S.; Bastarrachea, L.J.; Martini, S.; Matarneh, S.K. Crystallization Behavior and Quality of Frozen Meat. Multidisciplinary Digital Publishing Institute.

[16] Pham, Q. T., (2014). Refrigeration and Freezing Technology - Thawing. Encyclopedia of Meat Sciences, 202–208. doi:10.1016/b978-0-12-384731-7.00124-0

[17] United States Department of Agriculture Food Safety and Inspection Service. (2013). The Big Thaw - Safe Defrosting Methods. Retrieved from <https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety-basics/freezing-and-food-safety>



[18] United States Centers for Disease Prevention and Control. List of Selected Outbreak Investigation, by Year. Retrieved from: <https://www.cdc.gov/foodsafety/outbreaks/multistate-outbreaks/outbreaks-list.htm>

[19] Food and Drug Administration. Bad Bug Book. Retrieved from <https://www.fda.gov/media/83271/download>

[20] Bureau of Agriculture and Fisheries Standards. (2015). Philippine National Standard Code of Hygienic Practice for Meat (PNS/BAFS 168:2015)

[21] Bureau of Agriculture and Fisheries Standards. (2020). Philippine National Standard Code of Hygienic Practice for the Sale of Fresh Agriculture and Fishery Products in Markets and Authorized Outlets (PNS/BAFS 46:2020)

[22] National Meat Inspection Service. Public Advisory. Retrieved from <https://www.nmis.gov.ph/9-category-latest/188-notice-to-the-public>

[23] University of Nebraska-Lincoln. Refrigerator and Freezer Storage. Retrieved from: <https://food.unl.edu/article/refrigerator-and-freezer-storage>