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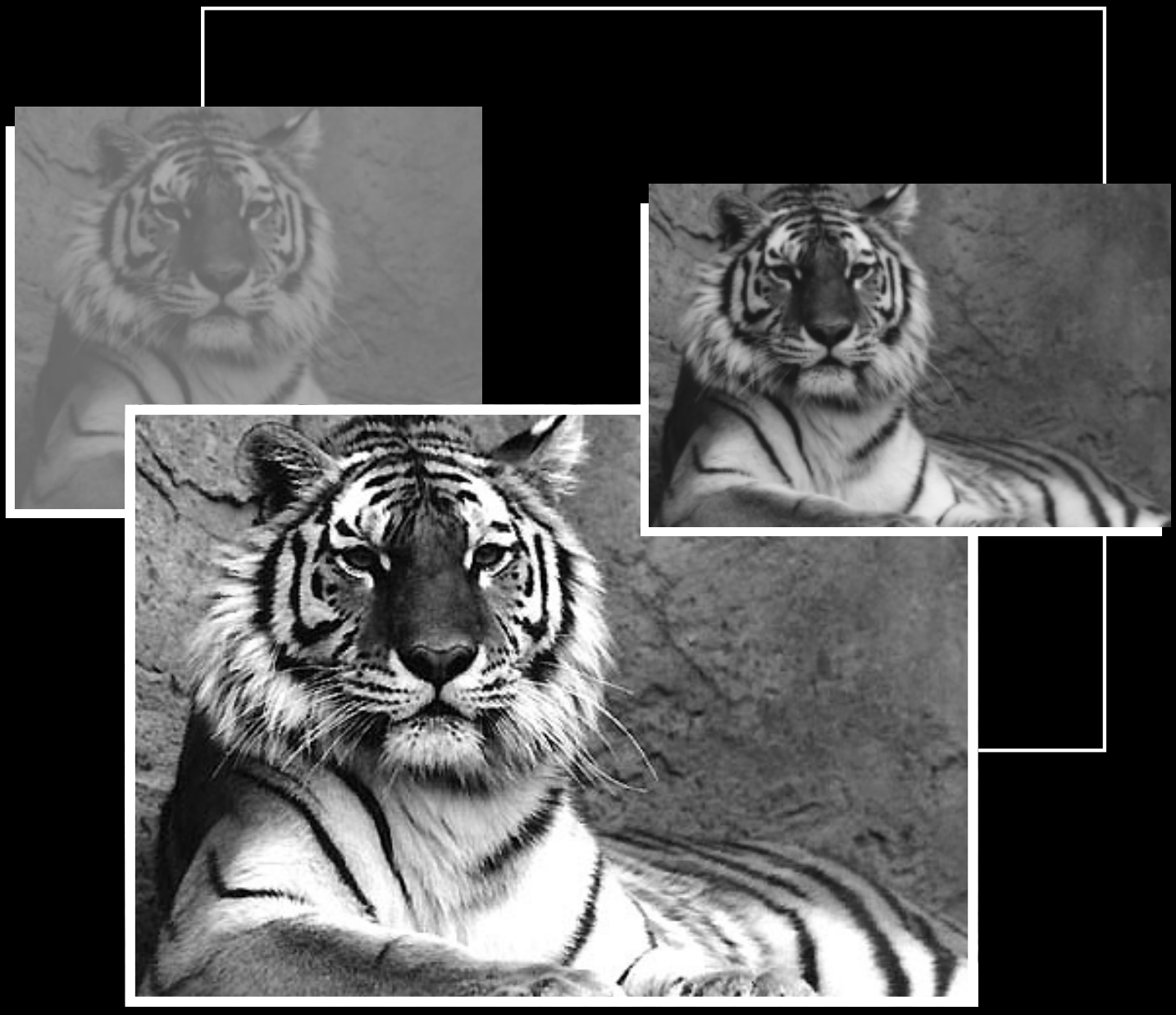
A Manual of Standard Operating Procedures



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A Manual of Standard Operating Procedures

S.D. Crissey, K.A. Slifka,
P. Shumway, and S.B. Spencer

Susan D. Crissey is the director, Kerri A. Slifka is a staff nutritionist, and Pam Shumway is an assistant nutritionist, Nutrition Services, Daniel F. and Ada A. Rice Center, Chicago Zoological Society, Brookfield Zoo, Brookfield, IL.

Susan Bunn Spencer resides in Grand Rapids, MI.

Abstract

Crissey, S.D., K.A. Slifka, P. Shumway, and S.B. Spencer. 2001. Handling Frozen/Thawed Meat and Prey Items Fed to Captive Exotic Animals: A Manual of Standard Operating Procedures. U.S. Department of Agriculture, Agricultural Research Service, National Agricultural Library.

Many captive carnivorous and omnivorous exotic animals are routinely fed frozen/thawed meat, meat-based raw products, and prey items. These meat items often are received in bulk and may be stored for a period of time before being prepared by thawing, cutting, chopping, and grinding for feeding to the animals. Since it is important that nutrient loss and bacterial load in these food sources be controlled, proper handling is essential. This publication provides background and guidance for handling this food. All points of handling are discussed, from ordering, purchasing, and receiving through storage, thawing, and feeding—including cleaning and sanitation—to validating procedures and quality assurance sampling. Following these guidelines should allow institutions to meet or exceed Federal animal welfare regulations, including the Animal Welfare Act.

Keywords: carnivores, food storage, meat, meat handling, prey, sanitation.

While supplies last, single copies of this publication can be obtained at no cost from S. Crissey, Brookfield Zoo, Brookfield, IL 60513 or USDA–ARS, NAL, Animal Welfare Information Center, 10301 Baltimore Avenue, Beltsville, MD 20705–2351; phone (301) 504–6212.

Copies of this publication may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; phone (703) 605–6000 or 1–800–553–6847.

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Contents

Introduction

This publication provides background and guidance for handling meat, meat-based raw products, and prey items fed to captive exotic animals. Wherever possible, official U.S. Department of Agriculture (USDA 1998), state sanitation, or meat-handling documents were used to provide these guidelines. The guidelines were designed to meet, or in some cases exceed, official regulations. Additionally, Hazard Analysis and Critical Control Points principles have been used to identify potential processing hazards and prevent them from occurring (HACCP USDA 1998b). Therefore, the use of these guidelines, along with the appropriate documentation as presented in the text and sample forms, should allow an institution that feeds meat, meat-based raw products, and prey items (rodents, poultry, etc.) to captive exotic animals to meet or exceed current regulations.[1]

Local sanitation regulations may vary from state to state. Therefore, care should be taken to review any relevant state or local regulations when instituting or modifying the guidelines presented in this publication. As more information on meat contamination, diseases, and sanitation becomes available, it should be used to update and augment these guidelines.

Many captive carnivorous and omnivorous exotic animals (including felids, canids, mustelids, insectivores, and a variety of bird and reptile species) are fed frozen/thawed meat, meat-based raw products, and prey items. While there are regulations for meat and meat products in pet food, these pet foods undergo considerable processing, such as heating and sterilization, during their production. Consequently, a variety of regulations must be considered when using frozen/thawed or raw meat-based products, including regulations for pet food, for raw fish fed to marine animals, and for the processing of meat for human consumption. Since daily food availability is crucial to any captive program, most purchases are made in bulk, requiring that the items are frozen and stored until used. Given the perishable nature of meat, appropriate food-handling procedures are crucial to the nutritional quality of the food, and consequently, to the successful management and welfare of captive animals.

The term "meat" is used throughout this publication to mean all meat, meat-based raw products, and dead prey items (rodents, whole poultry, etc.) that may be fed to captive exotic animals. Types of meat products selected for use by an institution are chosen for specific nutrient content, quality, availability, price, and animal preference. The nutrient value of meat varies considerably due to several factors, such as source species, cut of meat, and additives or supplements mixed into raw-meat products.

Nutrition and quality must be considered as major factors in meat selection. Care must be taken to ensure that the food for captive animals is of the highest quality. The Code of Federal Regulations states that "food shall be wholesome, palatable, and free from contamination, and shall be of sufficient quality and nutritive value to maintain all animals in good health" (9 CFR 3.129). Also, consumption of meat that is contaminated with harmful bacteria or bacteria-related toxins may cause serious health problems for an animal and food handlers as well.

In order to avoid ultimate dependence on one particular food item, it is prudent to offer a variety of food items to an animal. It is possible for an animal to become dependent on a specific food item and

[1]Guidelines for handling fish can be found in the publication, *Handling Fish Fed to Fish-Eating Animals: A Manual of Standard Operating Procedures* (Crissey 1998).

if it becomes unobtainable, it may be difficult to coax the animal to eat a new item. In addition, offering a variety of food items will help assure a complimentary nutrient profile in the diet. For example, when feeding marine mammals, Geraci (1978) emphasizes the need to feed more than one food type, including a high- and low-fat fish, in order to help ensure a balanced diet. The same can be stated regarding meat products. The objective is to provide a balanced diet utilizing the freshest meat possible. USDA's Animal and Plant Health Inspection Service has developed and implemented a policy (USDA 1999) to provide guidance to licensees and registrants on the issues of nutrition and feeding requirements for larger felids.

This manual is not a guide to actually feeding animals and does not cover live prey or behavioral enrichment.

Ordering and Purchasing

To determine the freshness and wholesomeness of meat, the source of the prey item and the history of processing should be ascertained. Since dead, dying, disabled, or diseased livestock can be used as meat sources for pet foods, the applicability of USDA regulations (9 CFR 3.355) for certified products for dogs, cats, and other carnivora are limited in this respect. However, other USDA regulations (9 CFR 3.309), which necessitate the disposal of this type of meat source, would be more applicable to animals fed raw meat products. Basically, this section of the *Code of Federal Regulations* requires dead, dying, disabled or diseased meat sources to be identified, condemned, and disposed of. This suggestion is not unlike Animal Welfare Act standards and Animal Care Policy No. 25, where all food fed to carnivores must be wholesome and palatable and not contain disease or contaminated meats or meat products (9 CFR 3.129; USDA 1999). Therefore, meat fed to animals should be supplied from packers who have processed and stored it as if it were intended for human use and followed HACCP principles (USDA 1998). These principles also should apply to any animals (like whole prey) that have been drugged prior to slaughter; they should not be used.

Any supplier selected should have an effective quality assurance program. The appropriate quality assurance program includes having agreed specifications, auditing of suppliers, and Certificate of Analysis (Motrimore and Wallace 1994). According to HACCP (Motrimore and Wallace 1994), raw material or finished product specifications include—

- Details of supplier and manufacturing/supply site
- A description of the raw material and its function
- An ingredients breakdown
- Details of all intrinsic factors with tolerance limits, for example, pH, salt, and so forth
- Microbiological acceptance criteria, for example, absence of identified hazard organisms
- Analytical and microbial sampling plans
- Labeling requirements
- Storage and distribution conditions

- Safe handling and use instructions

- Description of pack type, size, and quantity.

Once the meat source is determined to be adequate (by ensuring the processor follows the guidelines as mentioned above), a lot number, a manufacture date for meats, and a kill date for prey recorded on the containers provide an indication of freshness. The packaging of meat by a processor can play a significant role in meat quality. Meat must be packaged in food-grade, plastic-lined boxes, with the date of manufacture or processing and the lot number printed on the box. Meat may be block frozen or frozen in smaller packages, and prey may be individually frozen. The optimal size for packages should average 2.2 to 5 kg (5 to 11 lbs.) to allow for proper thawing. Package size, determined by type and usage of meat, should provide 1 day's supply without leftovers. Those meat products used in smaller quantities should be purchased in smaller packages and be prepared in a manner to allow for easy access. Size of the individual prey items in packages may be important to avoid cutting, which can result in nutrient loss and increased preparation time. Also, if the entire prey item is not fed, the nutrient content is altered. For example, there may be a substantial decrease in an item's calcium content if the head is removed, as is done with some fish.

Inspection of Shipment

Ideally, to ensure the processor is handling fresh meat appropriately, an institutional representative should visit the processor during production and inspect the meat. Since this may be impractical for most institutions, responsible staff should concentrate on a thorough inspection when the product arrives at the storage facility.

The first step in quality control takes place at the delivery stage. Since products should be inspected and stored immediately, deliveries should be scheduled during business hours. An inspection should occur at the place of receipt (storage site) before or during unloading of the shipment so a representative number of boxes can be examined. Inspection must be performed by institutional employees familiar with proper inspection techniques and meat quality. A thorough inspection includes looking for signs of pests around and inside containers, maintenance of proper temperatures during shipment, and signs of thawing and refreezing (Crissey et al. 1987).

Every lot and shipment of meat must be inspected before paperwork is signed to officially receive it from the supplier. Form 1 is designed as a checklist to assist with the inspection of a meat shipment. When inspecting a shipment (U.S. Navy 1965)—

- Check the supplier's documents to assure the meat shipment corresponds to the product ordered—type, size, quantity, and price.

- Observe the overall condition of the shipping vehicle and its contents. Sometimes shippers transport other food and nonfood items in the same truck as the meat order to save freight costs. There should be no nonfood items shipped with the meat. This is to avoid possible contamination with items not intended for consumption.

- Check the temperature gauge in the storage area of the vehicle, since it indicates the temperature of the vehicle's contents. If there is any question concerning appropriate

shipping temperature of the meat, use a portable thermometer to check the temperature inside several of the meat containers.

- Visually inspect the contents of selected representative packages in the shipment to ensure that the entire load is suitable. The number of packages to be checked depends on the size of the shipment. At a minimum, open and examine at least 10 percent or a minimum of three packages from the front, middle, and end of the load. If the shipment is less than three packages, then inspect them all.

- Visually inspect the meat to ensure the product is the correct order and is the proper size and type of meat packaging.

- Look for evidence that the meat may have been frozen, thawed, and refrozen. Indicators can include water or ice buildup on the boxes or floor beneath the boxes; wrappings that are moist, slimy, or discolored; meat that is brown; or prey with soft flabby flesh upon thawing, a sour odor, and/or an off color. If any of these indicators are present, do not accept the order.

When thawed, fresh meat is red and prey has prominent, clear eyes and firm, elastic flesh. Old or thawed/refrozen meat may be discolored and brown. Thawed and refrozen prey items have dull, cloudy eyes and soft flesh; when thawed, finger impressions are easily made and remain (U.S. Navy 1965).

If the quality is questionable, it is wise to thaw a meat package or a few prey items from several packages for a better determination (form 2). Again, try to do this before officially accepting the shipment. Then, take a sample of meat for nutrient and possibly microbial analyses. Analyses for contaminates, such as heavy metals and pesticides, antibiotics, and drugs also can be performed.

If the meat is found to be unsatisfactory for any reason, refuse to take receipt, even if that means reloading the vehicle. The shipper is required to return the load to the supplier. If there is any disagreement as to the quality of the product or what the shipper should do with the product, then the shipper should contact the supplier. Bad meat is unusable because it is unpalatable, a health hazard, and may cause a significant economic loss due to the illness or death of the animals or to those handling the product.

In other words, only sign any documents for official ownership of the meat after the shipment has been inspected and found satisfactory.

Storage

Once a meat shipment has been accepted, it should immediately be placed in the institution's storage facility. This facility should be designed to adequately protect supplies. It is crucial that the length and conditions of storage minimize contamination and ensure the product retains its nutritive value and wholesome quality. Appendix A gives the properties of freezing and some of the product changes that can occur.

Inspect the storage freezer before storing a new shipment to assure it is in good working order. Any older meat stocks remaining in the freezer should be placed so they will be used before the new meat stocks. To help ensure freshness, always use feed items on a first in-first out basis. Optimally, the date received should be stamped or written on the box or pallet of boxes (Crissey et al. 1987).

Because it can support microbial populations, meat is included in the definition of potentially hazardous foods (Illinois Department of Public Health 1993). Richter and al-Sheddy (1990) found that zoo meat kept 24 hours at room temperature had increased bacterial counts and spoiled in a very short time. To decrease or inhibit growth of such microorganisms, proper storage temperatures are required (appendix B).

Several sources cite optimum freezer temperatures ranging from –30 to –18 °C (–22 to 0 °F) (CFR 9 3.105, Crissey et al. 1987, Geraci 1978, IDPH 1993, Shinaburger 1992). Desrosier (1978) reports that in the United States, commercial frozen storage temperature is –18 °C (0 °F), but lower temperatures may be better**.** Desrosier states that temperatures above –9 °C (16 °F) but below the average freezing point for foods of –2 °C (28 °F) causes critical damage to appearance and loss of nutrients and that long-term storage at 6 °C (43 °F) yields unacceptable foods. Nutrients especially susceptible to destruction are included in table 1. It is recommended that meat stored for prolonged periods (that is, up to a year) should be in a freezer with temperatures maintained at –23 °C (–10 °F) or lower.

Refrigeration is used only for short-term thawing of meat and storage until it is used (CFR 9 3.105). Once removed from the freezer for thawing or thawed under refrigeration, (usually for 24 hours), meat *must* be used within the next 24 hours. Several authors report a refrigerator temperature requirement for storing potentially hazardous foods ranging from 0 to 10 °C (32 to 50 °F) (Geraci 1978, Shinaburger 1978, Crissey et al. 1987). USDA cites a refrigerator temperature of less than 4 to 6 °C (40 to 43 °F) as optimal (Pond 1987).

There are no studies reporting shelf-life recommendations for a particular species of whole prey. However, following the procedures below will help minimize contamination conditions, while retaining the meat's nutritive value and wholesome quality.

- Dedicated refrigerators and freezers must be used only for perishable food to be fed to animals. No substances known to be toxic or harmful to animals should be stored or maintained in the animal food storage areas.

- Adequate and proper cold air circulation is required for maintaining the desired uniform temperature in all areas of the freezers and refrigerators where meat is stored. Check to be sure that cold air ducts are not blocked when items are placed in the storage area. Allowing at least 2 feet between the top of stacks and the opening of air ducts usually provides the circulation needed to maintain the proper range of temperature.

- Proper temperatures in refrigerated and freezer spaces should be—

  Freezer: –30 to –18 °C (–22 to 0 °F) or lower
  Refrigerator: 4 to 6 °C (40 to 43 °F)

- Set up a schedule for routinely checking temperatures in several locations in the refrigerator and freezer. Document the temperatures in writing. Form 3 is provided for recording temperature data.

- Relative humidity should be maintained at 85 to 90 percent in refrigerated spaces. High humidity in the freezer helps to decrease dehydration of the frozen items (Stoskopf 1986).

Transportation

It may be necessary to transport meat from bulk-freezer storage to a location for storing smaller quantities and for subsequent thawing and processing (kitchen preparation area). Such transportation must be done in a way to keep the meat frozen. If a vehicle is required, it should be cooled or insulated. If this is not possible, the load should be covered or insulated while in transit, depending on outside environmental conditions. The length of time necessary to move stock from storage or preparation area should be minimized.

It is recommended that the temperature of meat in transit be monitored by placing a thermometer in one or more of the boxes. This could be a maximum/minimum thermometer or another temperature-sensing or -recording device. If the temperature is monitored, it should be documented. Any boxes thawed or partially thawed during transportation should be used immediately and not refrozen.

Thawing

The thawing process is crucial to the product's final quality. Therefore, it must be carefully controlled (appendix A). Incorrect thawing increases the potential for nutrient loss, lipid peroxidation (rancidity), microbial buildup, and loss of palatability (appendix B). Richter and al-Sheddy (1990) demonstrated that a thawing temperature of 10 °C (50 °F)—the lowest ambient temperature tested—resulted in the least microbial growth, but at 37 °C (98.6 °F), microbial counts were at putrefaction and slime production levels. Freezing tends to break down tissues, making the food much more susceptible to bacterial invasion after thawing. The safest and most preferable way to thaw meat is in a refrigerated space at 4 °C (40 °F) (Stoskopf 1986).

USDA regulations state that food be "free from contamination" and Animal Care Policy No. 25 clarifies this requirement to state "frozen meats must be handled appropriately to prevent contamination, *i.e.*, thawed under refrigeration." Thawing in packages in cold water is not preferable but is allowed by some regulations.

IDPH (1993) outlines three methods for thawing fish or meat products—

1. The preferred method is "in refrigerated units so the temperature of the meat itself does not exceed 7 °C (45 °F)." This is documented by placing a thermometer with the meat.

2. "Under potable running water at a temperature of 21 °C (70 °F) or below, with sufficient water velocity to agitate and float off loose particles into the overflow." However, running water over thawing meat packages will increase nutrient loss, especially of water-soluble nutrients, and is therefore not recommended. Thawing in standing water is not recommended because of loss of nutrients and the possibility of increased microbial buildup.

3. "In a microwave oven set to defrost." This method is to be used only when the food will be immediately transferred for consumption but is not preferred.

Meat should never be thawed at room temperature.

Different regulations and guidelines exist regarding ideal temperatures for meat thawing. Selecting the most stringent conditions will ensure appropriate conditions for meat quality. As above, IDPH (1993) guidelines state that the temperature of the meat should not exceed 7 ºC (45 ºF). Pond (1987) cites USDA recommendations for thawing any meat product at a temperature not to exceed 4 ºC (40 ºF).

Frozen foods should not be thawed by exposure to excessive heat or in standing water. These methods cause increased loss of nutrients (Stoskopf 1986). The use of fans to speed thawing causes loss of fluid through dehydration and is inappropriate.

Ideally, during thawing, meat should be kept in wrapping or in a container that provides insulation and allows the meat to thaw uniformly. The container may be either the original shipping box or a covered plastic container.

As an example, Animal Welfare Act regulations state that all fish shall be fed to the animals within 24 hours following their removal from freezers for thawing (9 CFR 3.105). While this may be ideal, the size of the frozen parcel of meat may preclude thawing within this time frame. To promote uniform thawing, the block of meat may be cut (sawed) or broken up while still frozen and the smaller portions thawed. If a large block of frozen meat is to be thawed, it is advisable to remove the outer, thawed meat as the block defrosts. This will help ensure thawing of the inner meat section, while keeping the outer meat section from thawing for a prolonged period of time. Based on 9 CFR 3.105, USDA recommends, and in some cases requires, that all food be used within 24 hours of thawing. Additionally, Animal Care Policy No. 25 states that uneaten food must be removed from an animal's enclosure within 12 hours of placement, or sooner, depending on spoilage.

Handling Thawed Meat

Some institutions use meat that has not been frozen. Fresh or refrigerated meat that has not been frozen should be handled similarly to thawed meat. The thawed product should be kept iced or refrigerated until a reasonable time before feeding. The term "reasonable" can be interpreted many ways. It is best to frequently document the temperature of the meat before feeding. Frozen foods, once thawed, should *never* be refrozen. If not used, meat must be discarded 24 hours after removal from freezer; if thawed by refrigeration, 24 hours after being thawed. Leftovers must be discarded, at most, 12 hours after the animals have been fed (9 CFR 3.105; USDA 1999).

The objective of handling or preparing the thawed meat before feeding is to inspect its quality and to process the meat for consumption. Again, the goal is to perform these processes while minimizing bacterial contamination and assuring wholesomeness and nutritive value. Meats that are ground or chopped should be refrigerated immediately upon removal from the freezer, as the increase in surface area increases the risk of contamination. This processed meat should be stored in shallow containers of not more than 7.6 cm (3 inches) in depth so that it will thaw quickly (U.S. Navy 1965).

Even with exact care in handling, most uncooked foods will harbor some microorganisms (Frazier and Westhoff 1988; see appendix B). Richter and al-Sheddy (1990) showed that zoo meats can arrive with high levels of microorganisms. The growth of these organisms can be prevented or retarded through proper temperature control, cleaning, and sanitation. Therefore, utensils and processing surfaces must be cleaned and sanitized prior to meat processing (see "Cleaning and Sanitation" below).

Meat must be processed immediately after the thawing stage and as closely as possible to the feeding time. There usually is a span of time between processing meat for feeding and feeding the meat to the animal. Care must be taken to minimize this time while continuing to store the meat under cool conditions. Meat can be cut for feeding while still frozen, just prior to thawing (Stoskopf 1986).

Meat should be fed cold but not frozen. Feeding frozen meat is undesirable because it may lack palatability, is physically rigid, and may decrease the availability of nutrients to the animals. The term "cool conditions" refers to the final temperature of the meat being fed. Meat preparation regulations for the U.S. Navy (1965) state that meat "which is not served immediately after cooking shall be either chilled to temperatures of 4 °C (40 °F) or lower . . . ." They advise that meat held between 4° and 60 °C (40° and 140 °F) and for longer than 3 hours shall be considered unsafe and be discarded because of microbial buildup. This is appropriate for cooked food for human consumption.

The Animal Care Policy gives the licensee 12 hours from the presentation of the food to remove it if unconsumed, or if spoilage does not require earlier removal. Because meat fed to zoo animals is raw and may have a considerably higher microbial count, this time may be extremely important to prevent spoilage or possible illness. Great care should be taken to feed the animals meat when they are likely to consume it in a short period of time. Realistically, many zoo animals do not consume their raw food immediately. While 3 hours should be used as a guideline, care must be taken to ensure the animal consumes the appropriate amount of food.

Environmental conditions affect the final temperature of meat.

> Example A: If the animals are fed outside in hot, humid, sunny weather, it is important to keep the meat cool until feeding time to avoid microbial buildup, nutrient loss, or contact by disease-spreading pests. Meat should be placed in the animal's enclosure as close as possible to the time the animal will consume it.
>
> Example B: If the animals are fed outside in cool or cold conditions, no extra cooling precautions need to be taken. The objective is to ensure the temperature of the meat being fed is cool, not frozen.

Adequacy of the procedure chosen for enclosure feeding should be validated before it becomes a standard procedure (see "Validating Procedures" below). In addition, the temperature of the meat at feeding time should be periodically documented. Once the procedure for feeding has been validated, it should be written and added to this standard operating procedure manual.

Feeding

Food must be wholesome, palatable, free from contamination, and of sufficient quantity and nutritive value to maintain the animal's good health (9 CFR 3.105, 3.129). USDA also requires that animals be fed at least once daily, unless otherwise directed by veterinary treatment or accepted practices.

All food must be served in clean, sanitized receptacles. USDA stipulates that food receptacles, if used, must be accessible to all animals in the same primary enclosure and placed to minimize contamination. All feeding receptacles must be cleaned and sanitized after each use.

For captive marine mammals, USDA requires an employee or attendant responsible for management to perform or directly oversee the feeding. For other animals, this may not be practical or even necessary; however, the amount of food the animal consumes should be recorded to track significant changes in intake. The age, species, condition, and size of each animal should be considered when feeding. The employee must be able to recognize alterations from a normal state of health in order to adjust food intake. The quantity and type of food consumed by each animal should be documented (form 4) and kept on record for at least 1 year.

The diet of animals often includes other items such as a vitamin or mineral supplementation to make up for nutrient losses during food storage and thawing. Table 1 lists some factors affecting loss of selected nutrients. It can be inferred that any nutrient affected by leaching will be affected by thawing and subsequent losses in juices from the meat. While beyond the scope of this publication, use and consumption of diets and supplements should be documented in order to track nutritional status.

Cleaning and Sanitation

Equipment such as utensils, cutting boards, food containers, tables, gloves, and clothing can harbor pathogens and should be properly cleaned and sanitized daily (Stoskopf 1986; appendix B). USDA specifies that "containers such as buckets, tubs, and tanks, as well as utensils, such as knives and cutting boards or any other equipment that have been used for holding, thawing or preparing food for marine animals shall be cleaned and sanitized after each feeding, if the marine mammals are fed once a day, and at least daily if the marine mammals are fed more than once a day." This should also apply to all meat preparation equipment for all animals. However, while regulations say a once a day cleaning is allowable, if the animals are fed more than once a day, one cleaning after each use is preferable. Meat prepared with utensils, stored in containers, or prepared on surfaces that have not been cleaned and sanitized may be contaminated by this unclean equipment, rendering the meat unfit for consumption.

USDA further requires that kitchens and other food-handling areas where animal food is prepared shall be cleaned at least once a day and sanitized at least once a week. This includes surfaces within the preparation areas not directly in contact with meat such as floors, tabletops, freezer doors and handles, and refrigerator doors and handles.

USDA requires sanitizing by washing with hot water of 82 ºC (180 ºF) or higher and soap or detergent in a mechanical dishwasher or by washing all soiled surfaces with a detergent solution followed by a safe and effective disinfectant. Manual sanitation methods can be accomplished by

one of the following methods using a final sanitizing rinse (IDPH 1993, California Department of Health Services 1994; also 9 CFR 3.105):

- Contact with a solution of 100 parts per million (ppm) available chlorine solution for 20 seconds or 50 ppm for at least a minute.
- Contact with a solution of 25 ppm available iodine for 1 minute.
- Contact with 200 ppm quaternary ammonium for 1 minute.
- Contact with water of at least 77 to 82 ^{o}C (170 to 180 ^{o}F).
- Use of a dishwashing machine with approved sanitizing methods (chemical or hot water).
- Washing all surfaces with a detergent solution, followed by washing with a safe and effective disinfectant.

Only those poisonous or toxic materials necessary for cleaning and sanitizing equipment, utensils, and the kitchen area, or for controlling insects and rodents may be present in a food preparation area (IDPH 1993). CDHS (1994) states that any "insecticide, rodenticide or other poisonous substances" should not be stored in any food preparation area, "except in a separate enclosure provided for that purpose." IDPH (1993) states that to prevent possible contamination, such substances shall not be stored above or with any food, food equipment, or preparation utensils. Substances such as cleansing and sanitizing agents, pesticides, and other potentially toxic agents must be stored in properly labeled containers away from food preparation surface areas (IDPH 1993; 9 CFR 3.107). Provisions of the Animal Welfare Act regulations and standards (9 CFR 3.105, 3.129) require food to be free of contamination, including chemical contamination. It is recommended that any potentially hazardous materials be stored in a separate room away from any food preparation or storage area. This greatly limits potential contamination conditions.

Provisions need to be made for the removal and disposal of food wastes, trash, and debris (9 CFR 3.125). Disposal facilities should be provided and operated in a manner that minimizes vermin infestation, odors, and disease hazards (IDPH 1993). IDPH (1993) and CDHS (1994) cite that garbage and refuse in the food preparation area should be in a container that is rodent- and insect-proof, as well as leak-proof.

Validating Procedures

To ensure that conditions are appropriate and that the methods for storage and handling of meat are proper, validation of the conditions and procedures is needed. Validation must occur (1) before procedures become policy and practice, (2) at periodic intervals to ensure compliance, and (3) when the procedure is changed.

The nutritional quality and wholesomeness of meat can be determined by periodic, scheduled sampling of the meat at multiple or all stages in the handling process. Meat should be examined for nutrient content and microbial load. These tests indicate the effectiveness of the handling procedures when compared to the nutrient content and microbial load of the product when it arrived at the facility. Sampling methods for analyses are covered in the following section.

Validating the procedures employed in all of the meat-handling processes is a determining factor in setting or modifying any procedure. Documentation can serve not only as validation that meat is held under specified conditions, but also as a record to help identify and define potential problems.

The validating of procedures can be done by documenting temperatures of the meat and storage compartments at key points in the process. One method of validation is to take samples of meat at key points (for example, at receipt, storage, thawing, preparation, and before feeding) to determine the temperature of the meat itself (form 2). Documentation of freezer and refrigeration temperatures should also be included (form 3). As stated previously, it is best to document cold storage conditions at several locations within the storage area to ensure uniform and compliant temperatures.

Another method of validation is to use a maximum/minimum thermometer placed in a container with the meat throughout the process—from its frozen state to feeding (form 5). A maximum/minimum thermometer should be placed in a sealed plastic bag (in case of breakage) before being placed in the container of meat. A thermometer shows temperatures in the immediate vicinity of the device, so be sure to place it somewhere other than the outside section of the container. For example, if thawing meat in a refrigerator, the thermometer will register the temperature of the refrigerator, not the thawing meat. However, the thermometer will show the maximum and minimum temperatures to which the meat is exposed. Freezer and refrigerator temperatures should be periodically documented.

Validation requires careful documentation. Everything must be recorded in pen. Forms in this manual may be used exactly or modified. Initially, validation of a procedure should be performed more than once. Procedures used for validation, a schedule for validation and temperature monitoring, and documentation of such should be maintained and continually updated. Data can be transcribed on a computer spreadsheet and graphed, if needed.

Sampling

Meat can be sampled for microbial buildup (total plate count and for any number of specific organisms), as well as nutrients (Crissey et al. 1987; Richter and al-Sheddy 1990; appendix B). Microscopic examination of cells can be used to determine whether the meat has been frozen, thawed, and refrozen (Stoskopf 1986). Although not all facilities will have the instrumentation or resources to perform these tests, all should strive to make them part of regular procedures. This information can become very important when investigating animal health or facility problems.

Sampling for microbial buildup can be performed at various stages of meat thawing and handling. If microbes increase substantially (above the counts recognized as safe for humans), procedures need to be reviewed and updated appropriately. Maintenance of acceptable microbial levels is important since many microbes can cause animal illness and increased levels may decrease nutrient content (appendix B).

Meat should be analyzed for protein, fat, and energy content in order to formulate a nutritious diet and determine correct feeding quantities (Stoskopf 1986). Meat also can be analyzed for vitamin and mineral content. Results should be compared to specifications and guaranteed analysis. In addition to using these data to provide a balanced diet, such analyses may help to further quantify meat quality (Stoskopf 1986). Sampling meats periodically during long-term storage to determine nutrient loss is advisable.

Meat also should be sampled and analyzed for common toxins or heavy metal contamination to monitor the food source or determine if there may be a problem. Immediate testing must occur if any problem is suspected. If feasible, testing should be performed with every lot of meat. Once a year is a minimum, although that may not be sufficient to detect potential hazards.

A written protocol for sampling, including procedures for sampling, a sampling schedule, and procedures for reporting results (for example, who is notified about results) should be established. Results of analyses should be recorded and maintained. Protocols should be reviewed yearly and continually updated. This list may be copied and laminated for use when inspecting a shipment or can be filled out and filed for documentation.

Table 1. Stability and factors affecting loss of selected nutrients

Vitamin	Stability	Sensitivities	Factors affecting loss
C (ascorbic acid)	very unstable	oxygen, heat, alkaline pH, water	leaching into water, especially from cut surfaces
B_1 (thiamin)	very unstable	heat, alkaline pH, water	leaching, exposure to light
B_2 (riboflavin)	somewhat unstable	alkaline pH, water	leaching, exposure to light
Niacin	stable	water	leaching
Pantothenic acid	somewhat unstable	heat, alkaline pH, acidic pH, water	leaching, heat destruction
B_6 (pyridoxine)	somewhat unstable	water	leaching
Folic acid	somewhat unstable	heat, alkaline pH, acidic pH, oxygen	heat destruction
B_{12}	somewhat unstable	heat, alkaline pH, oxygen	leaching
Biotin	somewhat stable	oxygen, alkaline pH, acidic pH	leaching
A	somewhat unstable	heat, oxygen, light	exposure to light
E	somewhat unstable	oxygen, light	oxidation
K	stable	oxygen, light	exposure to light, oxidation

Source: Kutsky 1981.

Form 1

Checklist for Inspecting a Meat Shipment

1.	Are the documents in order? A. Type of product B. Size of entire shipment: number of boxes/containers C. Quantity: total quantity by weight of shipment D. Freezing method: block – IQF – shatter pack E. Pricing	YES	NO
2.	Is the packaging size correct?	YES	NO
3.	If required, are the boxes dated?	YES	NO
4.	If required, is there a history of the product included?	YES	NO
5.	Are there any nonfood items in the shipping vehicle?	YES	NO
6.	Does the temperature gauge of the vehicle indicate frozen conditions inside?	YES	NO
7.	Do the contents appear frozen?	YES	NO
8.	Is there any evidence of thawing (and refreezing)? A. Are there areas of ice under the boxes? B. Are any of the boxes stained or distorted?	YES YES YES	NO NO NO
9.	Examine 10% or a minimum of 3 boxes (make appropriate comments). Quality of meat. (Meat needs to be thawed for a thorough inspection.) (See form 2).		

Form 2

Quality Control Standards

Quality control factors are used to determine meat quality during inspection and preparation. Although there is no ultimate test to determine the quality of meat, below is a compilation of descriptions of acceptable, inferior, and unacceptable whole prey and meat, with suggestions for meat inspection.

Factor	Acceptable	Inferior	Unacceptable
General appearance	Meat: cherry red tissue Prey: shine or luster to skin; no breaks in skin; no bloating or protrusion of viscera; no dehydration	Meat: some browning Prey: some loss of sheen	Meat: brown, slimy Prey: luster gone, lumpy
Eyes	Prey: translucent, full; may be slightly sunken	Prey: dull or cloudy, slightly sunken	Prey: dull, sunken; cornea opaque (white); red-bordered eyes
Odor	Meat and prey: fresh odor	Meat and prey: mild sour odor	Meat and prey: medium to strong odor, putrid odor
Feel	Meat: firm and elastic Prey: firm and elastic; meat does not stay indented when touched	Meat: moderate softness to touch if whole meat Prey: moderately soft, slight indentation left when touched	Meat: slimy, soft and mushy Prey: soft, spongy, and flabby; exudes juice and easily indented when handled; may break open or skin may split when handled

Source: U.S. Navy 1965, Frazier and Westhoff 1988, Oftedal and Boness 1983, Stoskopf 1986.

Form 3

Refrigerator/Freezer Temperature Chart

Record temperatures for each refrigerator and freezer for 3 locations. Record relative humidity.

<u>Circle one</u>:   Refrigerator   Freezer

<u>Location</u>:

Date	Initials	Temp #1	Temp #2	Temp #3	Relative humidity

Form 4

Meat Consumption Chart

The employee must be able to recognize deviations from a normal state of health in order to adjust food intake. The quantity and type of food consumed by each animal should be documented and kept on record for at least 1 year.

Record consumption (in kilograms or pounds) for each animal if fed individually, or for each enclosure if group fed.

Animal and enclosure identification:

Date	Time	Initials	Name of meat product	Name of meat product	Name of meat product	Number of of animals in enclosure

Form 5

Temperature Log for Single Box of Meat

Place a minimum/maximum thermometer in a container of meat. Record temperatures at critical control points throughout meat handling.

Date	Initials	Box number	Point in handling	High temp	Low temp

Appendix A
Properties of Freezing

Richter and al-Sheddy (1990) report that high microbial counts in meat may be caused by improper thawing. Delays in freezing, slow rates of freezing, and inadequate freezer temperatures also affect quality. The physical, chemical, and biological changes that occur during freezing are complex and not fully understood (Desrosier 1978).

The freezing point of a substance is "that temperature at which the liquid is in equilibrium with the solid." Many foods, including meat, have a high water content and freeze between temperatures of 0 to 3 ℃ (27 to 32 ℉) (Desrosier 1978).

There are several methods of freezing, including cold air blasts, direct immersion in a cooling medium, contact with refrigerated plates in a freezing chamber, and freezing with liquid air, nitrogen, or carbon dioxide (Desrosier 1978).

Changes in flavor, color, and texture, as well as losses in nutrients occur fairly rapidly at temperatures above 9 ℃ (48 ℉). Because of the physical nature of meat, the method of freezing affects quality and nutrient loss upon thawing. Meat frozen rapidly to 0 ℃ (32 ℉) has less "drip" (nutrient loss due to water loss from cells) when thawed. Length of time for meat to freeze is dependent on temperature of the freezing chamber, temperature of food upon entering the freezing chamber, and type, shape, and size of packaging (Desrosier 1978).

Freezer burn due to dehydration can be reduced by method of packaging. Unprotected items are subject to a constant moisture loss as water is removed through circulating air. Damage caused by freezer burn is irreversible and results in changes in color, texture, flavor, and nutritive values (Desrosier 1978).

Freezing kills some microbes. Those not killed will grow upon thawing (Frazier and Westhoff 1988). Although most microorganisms do not grow well at temperatures below 0 ℃ (32 ℉), some yeasts and molds can grow in unfrozen foods with temperatures as low as 9 ℃ (48 ℉). Growth of microorganisms can be greatly influenced by the temperatures at which the food is thawed (Desrosier 1978).

Some nutrients can be affected by freezing. Although there is little change in the nutritive value of proteins, they can be denatured by freezing, altering the appearance and quality of the product. Proteolysis can occur while animal tissue is frozen if the enzymes are not inactivated. Freezing only slows enzyme activity, which is usually optimum at higher temperatures (Desrosier 1978).

At a temperature of about 2 ℃ (36 ℉) there is a reduction in rancidity of fatty tissue (Desrosier 1978). Rancid fats cause a lower nutritive value. Antioxidants, such as vitamin E, are utilized during fat breakdown and are therefore deficient in rancid fats (Oftedal and Boness 1983). Also, processing of foods, including the exposure of tissue to air and heat, allows oxidation and destruction of vitamins and the buildup of microbes (Desrosier 1978).

Freezing temperatures may destroy parasites (Desrosier 1978). Molds and yeasts may grow at freezing or slightly below freezing temperatures (Frazier and Westhoff 1988). Some bacteria in meat (*Salmonella* spp., *Escherichia coli*, and *Staphylococcus acromonas*) can survive freezing temperatures and will resume growth when thawed (Frazier and Westhoff 1988, Richter and al-Sheddy 1990). At temperatures of 3 ℃ (37 ℉) or above, spores of *E. clostridium botulinum* can survive, grow, and produce toxins (Frazier and Westhoff 1988).

Appendix B
Infections and Toxins of Foods

Stewart (1987) states that food infections and intoxications, often referred to as food poisonings, have largely gone undetected in zoo animals because investigations have been limited. Such infections can be caused by natural toxins found on the meat, improper handling of foods, and exposure to microbes (Stewart 1987, Richter and al-Sheddy 1990).

Meat is categorized as a perishable food item and must be handled carefully to prevent spoilage (Frazier and Westhoff 1988). The IDPH (1993) includes meat in "potentially hazardous food, . . . in a form capable of supporting rapid and progressive growth of infectious or toxigenic microorganisms."

There are a variety of causes for spoilage of foods, including one or more of the following:

- growth and activity of microorganisms (or occasionally higher forms) present; often a succession of organisms are involved
- insects or parasites
- action of the enzymes naturally found in meat
- purely chemical reactions, that is, those not catalyzed by enzymes of the tissues or microorganisms
- physical changes, such as those caused by freezing, burning, drying, pressure, etc. (Frazier and Westhoff 1988).

The type and number of microorganisms on the meat, in the storage area, in the preparation area, on the utensils, or transferred by the handler will determine the type and extent of spoilage (Frazier and Westhoff 1988). Several types of bacteria can be found on or transferred by human carriers, including *Salmonella* spp., *Staphylococcus aureus*, *Clostridium perfringens*, *Campylobacter jejuni*, *Clostridium botulinum*, *Listeria monocytogenes*, *E. coli*, and *Yersinia enterocolitica* (Rehe 1990). Competition occurs among bacteria, yeasts, fungi, and molds—one organism outgrowing another due to the environmental conditions. Not all microorganisms are antagonistic. Some may be symbiotic or synergistic. Microorganisms can also be metabiotic, with one organism making conditions favorable for growth of the second (Frazier and Westhoff 1986).

Stewart (1987) describes the difference between food infections and intoxications. Infections are caused by the ingestion of the organism. In healthy adult humans, infections usually are not fatal, but they can be in weakened individuals. Food intoxications are caused by the ingestion of toxins produced by bacteria, molds, plants, and insects. Intoxications occur less frequently, but reactions may be more severe and result in gastroenteritis, paralysis, and possibly death.

Exposure to live insects and rodents may increase the microorganism load or introduce new microorganisms to the meat. Live insects and other pests also can carry microorganisms to utensils, buckets, tables, and so forth, which can then contaminate the meat. Environmental conditions will govern the fungus, yeast, and bacteria that will flourish (Frazier and Westhoff 1988).

All foods and possibly utensils should be kept covered in containers that are rodent- and insect-proof to prevent contamination (Stewart 1987). Good hygiene by the staff preparing the meat is equally as important (Pond 1987, Stewart 1987).

Chemical properties of the meat also may affect spoilage (Frazier and Westhoff 1986). Properties of food that will influence spoilage include pH (hydrogen-ion concentrations), nutrient content, moisture availability, oxidation potential, and presence of inhibitory substances.

The physical state of the food—frozen, heated, moistened, or dried—can influence whether it will spoil and the type of spoilage. Organisms need water to grow. Salt dissolved in water draws water from the cells, and freezing it may damage tissue, causing a release of juices when thawed (Frazier and Westhoff 1986). The emulsions of fat and water caused by the breakdown of tissue and denatured protein are readily available to support the growth of microorganisms.

Prevention of foodborne illnesses begins at slaughter with appropriate killing techniques used on good-quality specimens. Proper and sanitary processing at the manufacturer is also essential. Zoos can help prevent food-related illnesses with proper handling when storing and processing meat and prey. Meat should be kept frozen until 24 hours before preparation and use. Proper procedures and validation processes will help ensure contamination does not occur and growth of those contaminants is kept to a minimum.

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