MICROBIOLOGICAL AND TEMPERATURE EVALUATION AS PART OF A COMPREHENSIVE RAW MEAT QUALITY CONTROL PROGRAM

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Abstract

Raw meat and raw meat-based diets are potentially hazardous food items used to maintain zoo carnivores. It is important to monitor handling temperature of meat throughout the preparation process to insure it is maintained below the appropriate threshold temperature (4°C or 40°F). Handling raw meat below this temperature threshold minimizes growth of harmful microorganisms. Three frozen raw meat samples were tested for microbiological parameters at the Fort Worth Zoo. In addition, temperature was measured throughout the entire handling process for a single meat mix, and those data were paired with microbiological data from those samples to determine the influence of temperature. All initial samples tested were within specifications established for raw meat based diets. Even though temperatures went out of the range considered safe for raw meat handling, microbiological parameters tested remained within the acceptable range specified. However, due to potential lot to lot variation (not captured within this study), it is imperative to maintain temperatures within the goal range. It is important to not only monitor temperatures through meat handling processes, but also to monitor initial microbiological parameters as well as those throughout the entire handling process.

Introduction

Meat is included in the definition of potentially hazardous foods because it can support microbial populations.[3] Maintaining appropriate freezer, thaw, and holding temperatures is critical in order to maintain meat quality. Sources cite optimal freezer temperatures as –30 to –18°C (-22 to 0°F), and a refrigerator temperature requirement for storage as 0 to 10°C (32 to 50°F).[2,4] USDA cites a refrigerator temperature of less than 4 to 6°C (40 to 43°F) as optimal.[4] Hazard Analysis and Critical Control Points (HACCP) evaluation allows for assessment of potential times or areas during diet preparation when temperatures are outside of the appropriate range and there is increased risk of microbiological growth. Microbiological guidelines for raw meat-based diets have been established in order to provide manufacturers with specifications for products used in zoos.[1] Several sources outline appropriate ways of handling raw meat products in zoo settings.[2] This paper examines handling raw meat mixes in the operation at the Fort Worth Zoo, specifically focusing on handling temperatures and microbial growth during the process.

Materials and Methods

Frozen samples of three different commercially available meat mixes (manufacture date within 12 months of sampling) were used to establish base microbiological data. Pre-sawed pieces (250 g) of one meat mix were randomly selected from several cases to provide microbiological data through the entire handling period from thawing through consumption by the animal. Temperatures were tracked during two different meat preparation periods and recorded every 5

minutes through the handling process (freezer to consumption by the target animal) using "I Buttons"™ (Dallas Semiconductor, Maxim Integrated Products, Dallas TX), which allowed temperature logging over the entire 50+ hour period of observation.

Initial frozen (i.e. never thawed) samples for microbiological testing were collected directly from the freezer (-26°C, -15°F). Samples were placed at -26°C (–15°F) on the day of collection, and stored at –62°C (–80°F) prior to culturing. All samples were screened for presence of *Salmonella* spp and *Listeria* spp (Analytical Food Lab, Grand Prairie, TX). Samples also were tested for *Escherichia coli* and *Staphylococcus aureus*. Total plate count and total coliforms were measured.

During the preparation process, meat was held in a freezer at the Fort Worth Zoo (-26°C, -15°F). Meat was pulled directly into an adjacent thaw room (3°C, 37°F) and allowed to thaw for 24 hours. Meat was removed from the thaw room to the main facility work space (20°C, 68°F), weighed into appropriate diet amounts, placed in sealed containers, and returned to the thaw room between 28-32 hours from the initiation of the thaw. Meat was pulled from the thaw room, loaded onto delivery vehicles, and dropped at animal areas close to 48 hours from the initiation of the thaw. Meat was offered to the individual animals based on husbandry routines of each area, between 50 – 58 hours from the initiation of the thaw.

Results and Discussion

During the period of thaw, the meat remained at or below the safe threshold temperature of 4°C (40°F). In all cases, removing the meat from the thaw room to the main floor (increasing the ambient temperature from 3 to 20°C, 37 to 68°F) for between 6 and 22 minutes (mean ± SD, 17.5 ± 7.9 min) resulted in an increase of the meat temperature above 4°C (40°F; Figure 1, spike 1). Once returned to the thaw room after preparation, most meat samples returned to below the 4°C (40°F) threshold, however some samples remained at or slightly above the threshold until removed from the thaw room for delivery.

As expected, once removed from the thaw room for delivery, the temperature of the meat quickly rose above the threshold temperature (mean time to rise above 4°C, 40°F was 9.5 ± 4.7 minutes; Figure 1, spike 2). Average time from thaw room removal to drop off at animal areas was 44.7 ± 6.4 minutes. Average time from thaw room removal until the keepers picked up their diets and either fed them out or placed them in a refrigerator was 74.2 ± 11.0 minutes, indicating meat was above the 4°C (40°F) temperature threshold for over an hour prior to being placed into a refrigerator or offered to an animal.

Some animal area refrigerators maintained temperatures below the threshold temperature better than others (3 ± 1°C, 37 ± 2.6°F). In some cases, the 4°C (40°F) threshold was never again attained once the diet left the thaw room at the Nutritional Services Building. In other cases, the temperature returned below the threshold after several hours in the area refrigerators. All diets, unless immediately consumed when offered, quickly rose above the 4°C (40°F) threshold (in some cases, rose to above 27°C (80°F) before consumption).

Initial samples directly from the freezer (not exposed to any thawing event after initial post-manufacture freezing) exhibited a wide range of aerobic plate count and coliform values (Table 1). The specifications for acceptable commercial meat mixes were met for aerobic plate count, coliforms, *E. coli*, and *Staphylococcus aureus* in all meat mixes tested (Table 1).[1]

When samples were collected at different steps through the preparation process, the aerobic plate count increased steadily (although well within acceptable ranges) until the last sample time (Table 2), and most other microbiological parameters remained unremarkable. The differences in the last sample could be attributed to the unrelatedness of all the samples (from different packages or cases). All initial diets and all samples from the time-tested meat mix cultured negative for *Listeria monocytogenes* and *Salmonella.*

The recommended temperature for refrigeration temperature is 4 to 6°C (40 to 43°F) or less in order to keep meat out of the temperature range in which microorganisms experience increased growth.[4] In this case, temperatures remained within or below the recommended range during preparation, but rose outside the range once removed from refrigeration for delivery. Even though an increase in the aerobic plate count was observed, values remained well below the specified upper limit (500,000). This is most likely attributed to appropriate handling and sanitation at both the manufacturing facility and at the Nutritional Services Building at the Zoo.

Based on the temperature data recorded during this experiment, some temperature changes were made in the process (thaw area temperature was reduced, and area refrigerator temperatures were reduced). The influence of these changes can be seen in Figure 1 as the difference between the top line (sample 1) and the bottom line (sample 2). Such simple changes minimized the time that samples were above the 4°C temperature threshold during preparation, and decreased them time needed to return below the threshold once placed back into the thaw room after preparation.

The results were provided directly to the manufacturers as feedback. Beyond this, a series of questions (Appendix 1) was used to verify the quality control measures in place at each production facility.

Conclusions

Monitoring temperatures during meat handling in a zoo setting can help determine critical points when the meat temperature is above the 4° C threshold. The amount of time when meat is handled outside of the threshold, between thaw and offering to the animal, should be eliminated (or minimized). Even though meat temperatures were observed above the threshold, microbiological data indicated that the meat remained safely within the specifications set for raw meat-based diets. Monitoring and maintaining appropriate temperatures is still considered critical in order to maintain the quality of the raw product, given potential variability within lots and production dates. Pairing temperature observations with microbiological testing on a regular basis will allow for (1) initial microbiological contamination to be detected prior to feed out, and (2) delineation of temperature influence on microorganism growth in meat over time. Once results are obtained, it is important to compare them to the guidelines set for raw meat products and to contact the manufacturer immediately. If the results indicate the product is out of specifications, it will allow immediate replacement of product, review of HACCP plans in place at the manufacturer, and development of a plan to avoid the situation in the future. If within

specifications, it also will allow review of procedures as well as continued development of a positive working relationship via shared information.

LITERATURE CITED

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Table 1. Aerobic plate count, coliform count, E. coli, and Staph aureus count for frozen meat samples (never thawed).

Meat Mix[1]	Aerobic Plate Count	Coliform Count / g	*E. coli*, cfu /g[2]	*Staphylococcus aureus* /g
A	100	<10	<10	<10
B	87,000	<10	<10	<10
C	17,000	170	<10	<10
Acceptable*	<500,000	< 500	< 100	<100

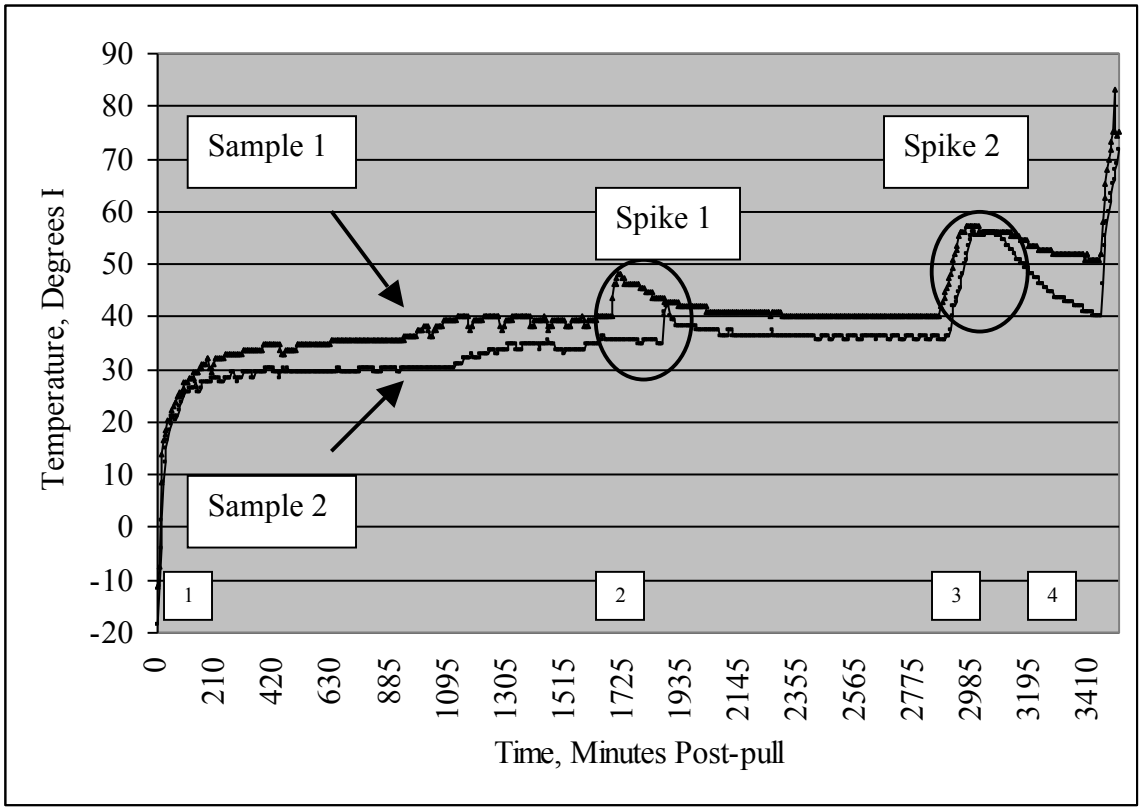
[1] A = Dallas Crown Zoo Carnivore, 95/5 (Dallas Crown, Inc., Kaufman, TX), B = Central Nebraska Brand Canine Diet (Central Nebraska Brand, North Platte, NE), C = Natural Balance Zoo Carnivore 10 (Dick Van Patten's Natural Balance Zoological Formulas, Pacoima, CA).
[2] cfu = colony forming units
* Specifications established in Allen et al.[1]

Table 2. Meat samples[1] taken at different steps from initial frozen state through offering to animal.

Sample Time	Temperature ° C	Aerobic Plate Count	Coliform Count / g	E. Coli cfu /g
Freezer Sample	-23.8	100	<10	<10
Day 2, 07:52 (thaw)	4.0	200	<10	<10
Day 2, 11:31 (prep)	6.5	400	<10	<10
Day 3, 07:50 (delivery)	9.0	500	<10	<10
Day 3, 08:19 (pick up)	13.0	700	<10	<10
Day 3, 16:53 (feed out)	11.0	700	<10	<10
Day 3, 17:31 (consumption)	24.0	60	<10	<10

[1] Dallas Crown Zoo Carnivore 95/5 (Kaufman, TX). 7 independent samples.

Figure 1. Meat temperature through preparation, delivery, offering, and consumption by 1.0 jaguar at the Fort Worth Zoo. Time 1 is initiation of thaw, Time 2 (Spike 1) preparation, Time 3 (spike 2) delivery to animal area, Time 4 offering to animal.



Appendix Table 1. Basic questions for manufacturers regarding raw meat diets, temperatures, and microbiological testing.

1. Do you use a HACCP program?
2. Do you monitor temperatures throughout your process? Where?
3. What is your freezing method initially (temps?) and your storage method (temps?)?
4. What tests do you use to check/monitor microbial content? - What is the source of your meat and is it cultured prior to entering the manufacturing process? - What lab do you use? Where during the production process are samples taken for analysis?
5. During your monitoring, what process occurs once a problem has been detected?
6. Have problems been detected in the past year?
7. How do you handle customer complaints?