Rate of Frozen Meat When Freezer Becomes Inoperative.

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Introduction

Freezing has become one of the more common methods of food preservation for retailed packaged foods which are ultimately sold to the consumer and frozen food preservation has in many cases replaced traditional canning and curing of foods for the home (Jul, 1984). Today many consumers purchase fresh retail cuts of meat from a grocery store, place the meat in a freezer for freezing and later thaw before cookery. There is an increasing trend toward the number of consumers utilizing home freezers. This is reflected by the fact that the consumption of frozen foods has been steadily increasing in well developed countries over the past few decades e.g. in 1981 the USA had a 40 kg. increase per capita consumption of frozen foods compared to the ten year period prior to 1981 (Jul, 1984) and this trend seems to be continuing. Additionally the number of home freezers in households in recent years has also dramatically increased. This is seen by the high percentage of households in developed nations with home freezers i.e. United Kingdom, 68% (1978), Denmark, 70% (1980), and the USA, approximately 75% (1979) (Jul, 1984). The temperatures observed in home freezers in the USA as quoted by Olsson and Bengtsson (1972) were as follows; Below $-18^{0}C$, 30% of the households; between -18^{0} to $-12^{0}C$, 37% of the households; between -12^{0} to $-7^{0}C$, 22% of the households; and above $-7^{0}C$, 11% of the households.

The numerous consumers that do have home freezers seldom ever experience a spoilage-related problem with frozen meat which has been properly packaged and stored. It is not until they encounter an extended electrical power outage or freezer malfunction that the consumer becomes alarmed about the fate of their frozen meat products in their home freezers. The university meat extension specialist receives periodic calls from consumers or home economists seeking advice on how long frozen meat products are safe to keep when electrical power has been interrupted for a delayed time interval. Current advice is usually as long as the meat remains frozen it is safe to keep but once the meat has thawed, the fate of the meat for safe consumption and possible refreezing becomes questionable.

The bacterial condition of frozen meat has always been of special interest to the food industry and consumer as well. It has been known for a long time that microorganisms are responsible for deleterious effects to meat tissue if the meat product has been temperature abused in any manner. Freezing of muscle tissue extends the lag phase of microbial proliferation (Marriott et al.,1980). However if there is an instance when electrical power is disconnected from a home freezer, the temperature will begin to rise over time resulting with bacterial proliferation. As noted in previous studies the bacterial general present is more critical to spoilage than is **total** microbial load (Marriott et al.,1980). The genera responsible for meat spoilage in beef is Micrococcus and Psuedomonas and in pork it's, Staphylococcus and Psuedomonas (Rey et al.,1972). These genera at elevated temperatures and increased thaw time create additional proliferation and subsequent meat spoilage becomes evident i.e. discoloration, putrid-odors, proteolysis, etc..

Numerous studies have well documented the freezing and thawing rates for retail cuts of meat but no publications could be located that have studied the problem so frequently encountered by consumers i.e. electrical power is interrupted

for long periods of time or the freezer becomes inoperative. No matter what the circumstance, the freezer owner is concerned about the fate of their frozen meat products. Therefore it was decided to investigate this unique problem area in order to give more accurate and reliable information to the consumer based on scientific data results.

Materials and Methods

This investigation was carried out in 14 consecutive trials, 11 trials utilizing pork and 3 with beef. Each trial consisted of storing fresh retail cuts of meat samples with varying trial total load weights (Range = 43-128 kg.) in an upright White Westinghouse Model FU211C (0.6 cubic meter capacity) freezer adjusted to -29°C. The meat packages (0.5 to 2.0 kg. each) were wrapped in Copco Polyfreeze (polyethylene-coated) freezer paper. Once the meat samples were completely frozen, the electrical power was disconnected and packages within each lot per trial were analyzed periodically for 9 days for temperature, pH, and total viable plate count.

Temperature was monitored using thermocouples attached to an Omega Model 555 temperature recorder. The thermocouple was positioned in such a fashion as to monitor the meat core (smallest package) temperature.

The pH measurements of the meat samples were determined by using an immersion probe attached to a Corning Model 7 pH meter (Ockerman,1985). The pH meter was standardized using a two point pH calibration method with pH 7.0 buffer and pH 5.0 buffer. A 10 gram meat sample was placed into a sterile stomacher bag with 100 ml of distilled water. The bag was stomached for one minute in the Stomacher Lab Blender 400 and the subsequent pH measurement recorded.

The microbiological examinations of the meat samples were determined by using the Standard Plate Count procedure (Jay,1986). Three portions were taken from the meat sample for analysis, one slice from the center and two from approximately one-third the distance of each end. From each sliced portion a 20 gram sample was added to 180 ml of sterile 0.1% peptone water in a sterile stomacher bag. The samples were macerated for two minutes using the Stomacher Lab Blender 400. Serial dilutions were prepared according to standard procedures (Jay,1986). Bacterial counts were enumerated for total colony forming units. Difco standard plate count agar was used to determine total plate counts (25°C, 106 hr).

The plate count data were transformed into logarithms and the pH and the temperature data was entered and the statistical analysis was performed by using the Statistical Analysis System (SAS,1986). The data for Figures 5,6,7, and 8 were accomplished in accordance with the General Linear Models (GLM) procedure of SAS. Figures 5,6,7, and 8 all included a covariant in the linear model. Figures 5 and 6 included temperature as a covariant and Figures 7 and 8 included bacterial count and trial load weights as covariants. Temperature was the dependent variable for Figures 6 and 7 and included the independent variables, specie (beef or pork), trial load weights, days storage time, and their interactions. Figures 5 and 8, bacterial count was the dependent variable and specie, trial load weights, days storage time, temperature and their interactions were the independent variables of the model.

Results

At Day 0 of storage the electrical power was disconnected from the upright freezer, the door remained closed, and thereafter meat packages within each lot were analyzed periodically for temperature, bacterial count, and pH. The results reveal the pH of all samples (Figure

1) increased from an average 5.8 initially to 8.2 final.

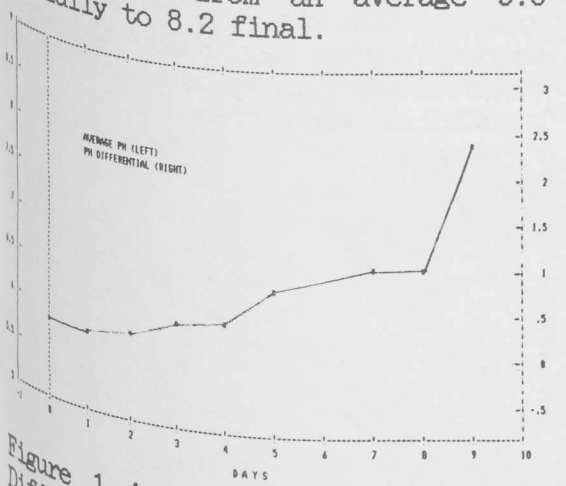

Figure 1 Average pH (left) and pH Differential (right) For All Trials vs. Days of Storage.

In Figure 2 the mean temperature for all the samples increased considerably during the term of the investigation. The rate of sample temperature increase averaged 5.8°C/day for the first 5 days, at which time the rate slowed and leveled off until the final sample temperature of 20°C at Day 9 was reached. The differential change in temperature from Day 0 to Day 9 was a 32.5° temperature increase.

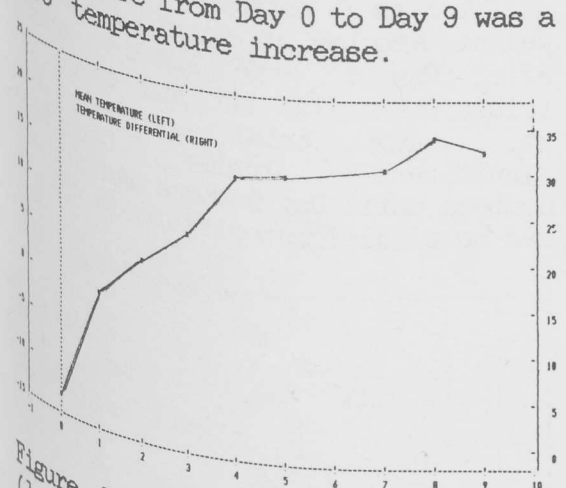

Figure 2 Mean Celsius Temperatures (left) and Rate of Celsius Temperature Change (right) From Day 0 vs. Days of Storage.

As the temperature increased, microbial growth increased at an accelerating pace. Figure 3 illustrates that the log of bacterial counts increased linearly over time up to Day 5 (0.79 log bacteria no./day) after which the stationary phase was reached. There was a 4.5 log increase at Day 9 compared to the mean initial log count of 4.91 at Day 0.

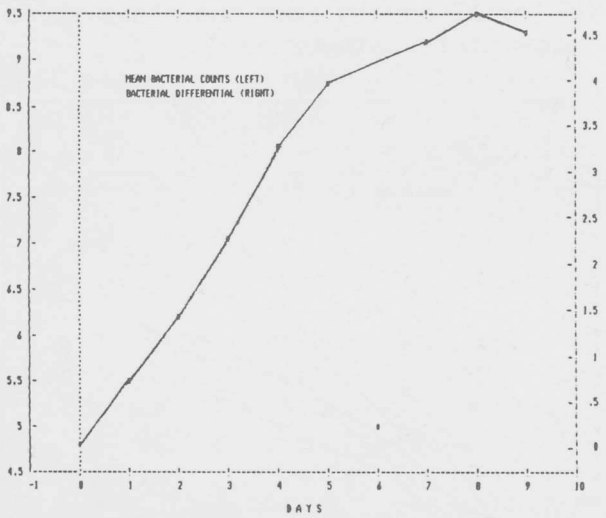

Figure 3 Mean Microbial Log Counts For All Trials (left) and Rate of Log Bacterial Change (right) From Day 0 vs. Days of Storage

Figure 4 indicates that all pork samples had significantly higher bacterial counts than beef during the duration of the study.

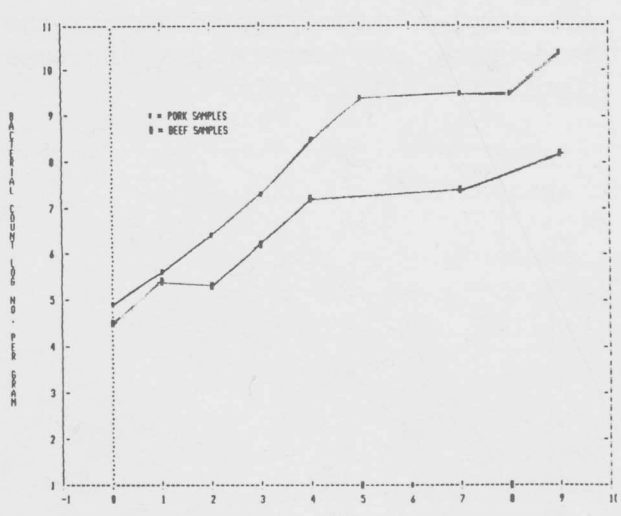

Figure 4 Mean Microbial Log Count For Beef and Pork Samples vs. Days of Storage.

The trials were divided into the following temperature categories (below -18°C, -18° to -12°C, -12° to -7°C, and above -7°C) at Day 0 and then adjusted to a mean bacterial count of 4.91 log at Day 0. In Figure 5 the temperature categories were monitored for the mean microbial

count of each initial temperature category. The data reflects that the bacterial counts for the greater than -7°C samples had significantly higher bacterial counts over the other three temperature categories.

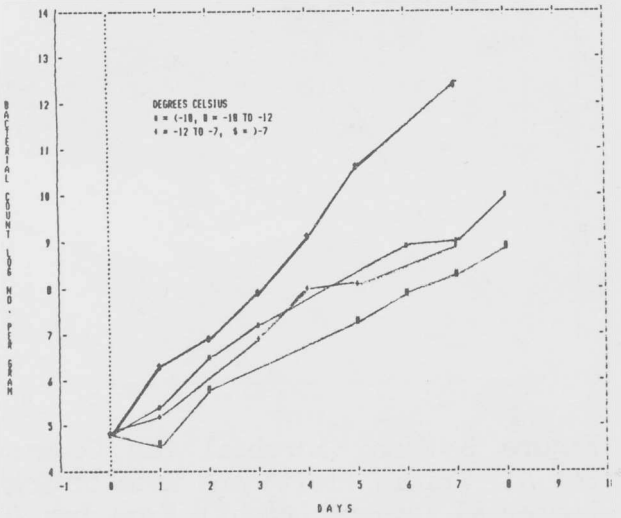

Figure 5 Mean Microbial Log Count For the Initial Temperature Categories vs. Days of Storage.

Figure 6 shows the mean temperatures of the four initial temperature categories versus days of storage. All samples showed approximately the same rate of temperature increase during the trial study.

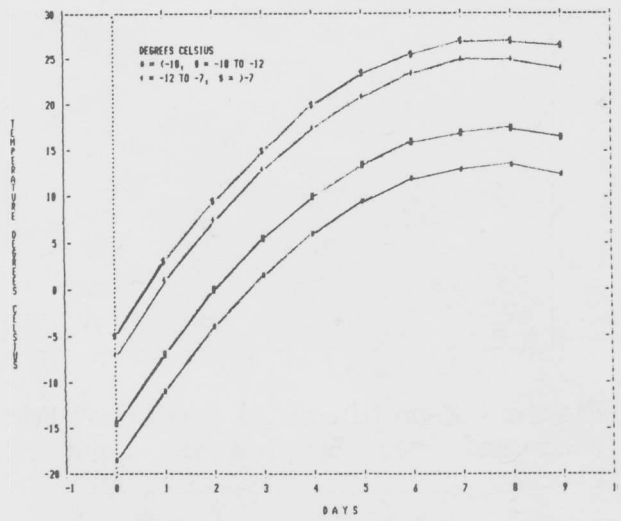

Figure 6 Mean Celsius Temperatures of the Four Initial Temperature Categories vs. Days of Storage.

The trials were also divided into three weight categories (less than 45 kg., 45-91 kg., greater than 91 kg.) and was then adjusted to the average temperature at Day 0. Figure 7 exhibits that the rate of temperature increase after Day 1 for the three weight categories to be approximately parallel to each other.

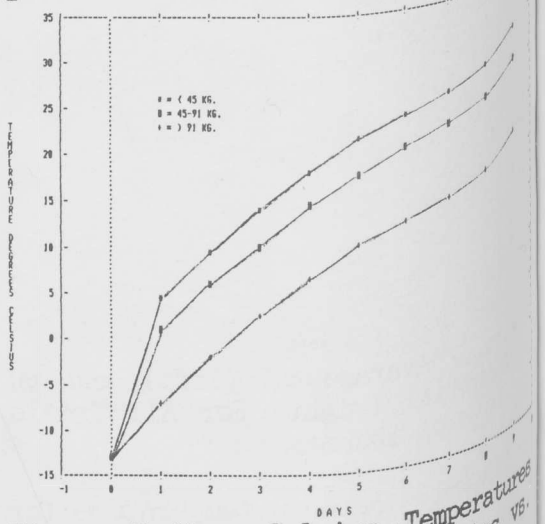

Figure 7 Mean Celsius Temperatures For the Three Weight Categories vs. Days of Storage.

In Figure 8 mean bacterial counts for the three weight categories were monitored after adjusted to an average bacterial count at Day 0. Up to Day 5 there was no significant differences between categorical weight samples in microbial count. After Day 5 the lighter weight trials (i.e. <45 kg. and 45-91 kg. wt. range trial groups) had significantly higher bacterial numbers until Day 9 where again there was no significant difference.

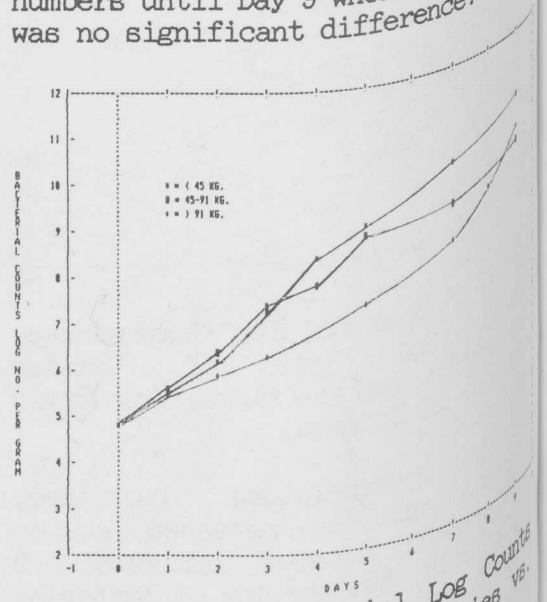

Figure 8 Mean Bacterial Log Counts For the Three Weight Categories vs. Days of Storage.

Both in Figure 7 and 8 the mean temperatures or bacterial counts were adjusted to the same mean at Day 0.

Conclusion

The results of this study have clearly shown that once electrical power is disconnected from a home freezer the temperature will start to rapidly increase (5.8°C/day for the 1st 5 days) along with accelerated bacterial proliferation for the first 5 days. After Day 5 of storage the rate of increase in temperature and bacterial number begin to moderate. It has also been shown that the pork samples have faster bacterial proliferation than beef samples.

This study has illustrated that the meat packages with the highest internal core temperature will have the highest bacterial count (Figure 5) and the highest temperature (Figure 6) over time. It should also be noted that regardless of initial internal temperature, the rate of temperature increase was relatively parallel for all the temperature categories. The data also suggests (Figure 7) that the lighter weight trials will have the highest mean temperature over the heavier trial weights but again the rate of temperature increase was relatively constant after Day 1 irregardless of trial load weight.

The results from this study indicate that at approximately 36 hours, bacterial counts will reach log 6 if initial count has an average log of 4.8. Log 6 is usually considered to be the bacterial count at which meat products can be safely consumed so long as the meat is sufficiently cooked to destroy pathogenic types of organisms (Banwart,1979). The USDA suggests a minimum end-point temperature of 63°C. This temperature destroys some pathogenic microorganisms but will not affect bacterial spores, the enterotoxin of S. aureus or the neurotoxin of C. botulinum (Banwart,1980). Therefore it would seem that a good quality product with a low microbial load was 2frozen, and electrical power was interrupted, that the products would have approximately log 6 microbial count at 36 hours. After 36 hours power disconnect, the fate of the frozen meat products for consumption or possible refreeze is questionable and is left to the discretion or risk of the consumer whether to salvage the meat products.

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