Impact of Frozen Storage Temperatures on Ground Beef Microbial Quality

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I. INTRODUCTION

In response to escalating energy costs and growing pressure from society to be more energy-efficient and climate-smart, along with the ambitious goal set out by the United Nations Net Zero Coalition to achieving net zero emissions by 2050 [1], this study was conducted to examine how different frozen storage temperatures affect the microbial shelf life of ground beef. By improving our precision of temperature controls during frozen storage, we can address the sustainability goals of society while also preserving meat safety and quality. In 2022, the Transparency Market Research valued the global frozen meat market at 23.2 billion USD [2], thus highlighting the importance to further understand freezing impacts. The objective of this study was to evaluate the impact of frozen storage temperatures on the microbiological quality utilizing ground beef during 30 days of storage as a model to represent frozen beef in commerce in highly controlled frozen storage environments.

II. MATERIALS AND METHODS

Beef strip loins (IMPS #180; vacuum-packaged product held at 2°C for 12 days post-fabrication) were divided dorsally into smaller portions and were submerged in boiling water for 2 min, to reduce the natural microbial contamination level on the surface of the loins. The heat-exposed surface was then trimmed off and lean was separated from the fat tissue. The separated lean and fat were cubed to simulate beef trimmings. Batches of lean (90%) and fat (10%) tissue were inoculated with a mixture of six common meat spoilage bacteria [3] previously isolated from spoiled beef steaks. The 6-isolate mixture was comprised of three *Pseudomonas* spp. (*P. fragi*, *P. fluorescens*, *P. lundensis*) and three lactic acid bacteria (*Carnobacterium divergens*, *Leuconostoc gelidum*, *Lactobacillus sakei*). The inoculated trimmings (ca. 4 log CFU/g) were coarse ground twice through a 12.7 mm grinder plate. Ground beef was portioned into 100 g samples and vacuum packaged. The samples were then randomly assigned to and stored in temperature test chambers (Tenney T2C-A-F4T Temperature Test Chambers, Thermal Product Solutions, New Columbia, PA, USA) at experimental temperatures of -20.6°C, -15.0°C, and -9.4°C (-5°F, 5°F, and 15°F, respectively). On days 1, 15, and 30 of storage, samples were removed from frozen storage, thawed (4°C, 24 h), and analyzed for aerobic plate counts (APC; tryptic soy agar; 25°C, 72 h). Non-frozen samples were also analyzed for APC on day 0 to determine the ground beef inoculation level. Two trials were performed per storage temperature with five replicates per trial (n = 10). Due to the availability of only two temperature test chambers (A and B; Table 1), three experimental setups were performed, and treatments (i.e., storage temperatures) were randomized between the two units as shown in Table 1. Statistical analysis was performed using R version 4.1.2 and included block (replication) and storage temperature. Significance level was set at $\alpha = 0.05$.

Table 1 – Experimental setup with two temperature test chambers and randomization of treatments (i.e., storage temperature) for ground beef.

Temperature test chamber	Experimental setup		
	1	2	3
A	-9.4°C	-20.6°C	-15.0°C
B	-20.6°C	-15.0°C	-9.4°C

III. RESULTS AND DISCUSSION

Our preliminary findings suggest that, under the highly controlled (i.e., minimal variation of ±0.01°C) frozen conditions of our study, storage of ground beef at -20.6°C, -15.0°C, or -9.4°C did not ($P \geq 0.05$) have an impact on microbial quality (Table 2). It remains to be seen if temperatures in commercial facilities can be controlled to likewise maintain microbial quality of beef, while simultaneously increasing storage temperatures and reducing environmental impact.

Table 2 – Mean (n = 10) aerobic plate counts (log CFU/g ± standard deviation) of inoculated (4.35±0.07 log CFU/g) ground beef stored at -9.4°C, -15.0°C, or -20.6°C for up to 30 days.

Storage day	Storage temperature[1]		
	-9.4°C	-15.0°C	-20.6°C
1	4.34±0.05	4.32±0.09	4.33±0.05
15	4.33±0.05	4.27±0.08	4.28±0.07
30	4.30±0.03	4.28±0.05	4.28±0.06

[1]The interaction between storage temperature and storage day was not significant ($P \geq 0.05$); storage temperature and storage day main effects were also not significant ($P \geq 0.05$)

IV. CONCLUSION

No effects of storage temperature were observed on the microbiological quality of ground beef stored for 30 days. This pilot study offers valuable insights into the influence of storage temperature on microbial survival and the quality of beef products and provides a basis for adjusting, using modern cold storage technologies, frozen storage temperatures to reduce scope-3 environmental impacts of meat distribution. As cold storage facilities and meat packers strive to achieve sustainability goals, such as reaching net-zero emissions by 2050, adjusting frozen storage temperatures could potentially reduce energy consumption within facilities without compromising food safety or quality, provided that temperatures are maintained at very consistent levels. Further research is needed to validate these findings on other products.

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