TEMPERATURE MANAGEMENT TO MINIMIZE GROUND BEEF AEROBIC AND LACTIC ACID BACTERIA GROWTH

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Summary

Increasing storage and display temperature and time of ground beef significantly increased microbial counts but lean level had no effect. Prolonged storage at abusive temperatures (48°F) caused up to 90% unacceptable chubs and aerobic bacteria counts as high as 7.7 $\log_{10}$ CFU/g, which would render chubs unsatisfactory for further processing, packaging and sale. Thus, ground beef chubs should be stored at 32°F. and as briefly as possible to minimize pre- and post-display microbial counts. Maintaining both optimal storage and display temperatures is critical because combining abusive storage and display conditions resulted in the greatest microbial growth. Shelf life and wholesomeness benefits from maintaining cold (32°F) storage and display temperatures are clearly demonstrated.

(Key Words: Ground Beef Microbiology, Cold Chain Management.)

Introduction

Cold temperature is the most critical factor for suppressing microbial growth and maintaining shelf life and wholesomeness. Coarse ground beef is commonly packaged in chubs, which increases shelf life but creates conditions favoring lactic acid bacteria rather than aerobic microflora. Prolonged chub storage can result in a "sour" odor due to production of lactic acid, whereas subsequent regrinding and packaging for display favors growth of aerobic bacteria. When bacterial counts reach 7 to 8 $\log_{10}$ CFU/g, the resulting microbial end products yield offensive odors that cause consumers to declare the meat spoiled and unwholesome. Currently, ground beef chubs delivered to retailers contain approximately 2 to 4 $\log_{10}$ CFU/g. However, suboptimal temperature control may rapidly increase microbial counts. This project assessed the benefits of cold (32°F) storage and display temperatures, and shorter storage times. This project is unique because it simulated "real world" conditions.

Experimental Procedures

Coarse-ground beef chubs (10 lbs each) of three fat/lean blends (7/93, 19/81, and 27/73) were shipped at 32°F to the Kansas State University Meat Lab. Chubs then were stored for six days at 32°F before randomly assigning one chub per lean level per replication to each of 12 possible combinations of storage temperature (32°, 40°, and 48°F) and storage time (0, 4, 8, and 12 days). There were three replications.

After storage (prior to re-grinding), each chub was evaluated for surface discoloration, objectionable odors, excessive purge, and gas pockets. Chubs were considered objectionable if they had either dark green or black spots on the surface, moderately strong off odors, >1 cup purge, or gas pockets of >4 inch^2. The percentage of unacceptable chubs per treatment com-

bination that would be discarded prior to grinding was recorded. However, unacceptable chubs were still re-ground and displayed. Each chub was mixed by hand, re-ground, and approximately one pound of ground beef was placed on a Dri-Loc pad on a tray that was overwrapped with polyvinyl chloride (PVC) film. After packaging, one package per chub per fat level per replication was assigned to each of four display treatments [no-display (initial counts), and display at 32°, 40°, and 48°F]. Ground beef was displayed continuously for 48 hours in open-topped display cases under 150 foot candles of Philips Ultralume 30 fluorescent light. The 32ºF case had two defrost cycles/day, the 40ºF case had 1, and the 48ºF case had no defrost cycles.

Samples were analyzed for aerobic plate counts and lactic acid bacteria prior to and after display at assigned temperatures. Dry-rehydrateable 3M Aerobic Plate Count Petrifilm™ was incubated at 95±1°F for 48 hours and lactic acid bacteria counts were analyzed using MRS agar in a 20% CO_2 incubator for 48 hours at 95±1°F. Microbial analyses were done in triplicate and averaged.

The experimental design consisted of four main effects: lean level (n=3), storage temperature (n=3), storage time (n=4), display treatment (n=4) and their interactions analyzed over three replications. Main effects and all possible interactions were analyzed using the Mixed procedure of the Statistical Analysis System (SAS, 2000). Main effects, interactions, and least square means were considered significant at $P<0.05$.

Results and Discussion

Table 1 shows the combined effects of each storage temperature, storage time, and display temperature on aerobic and lactic acid bacteria counts and chub loss. In general, storage and display at 32°F resulted in the lowest microbial counts. Following 0 day storage at 32°F with display at 32°F resulted in an increase of only 0.1 $\log_{10}$ CFU/g for aerobic bacteria and a 0.4 $\log_{10}$ CFU/g decrease in lactic acid bacteria. Conversely, combinations involving 48°F consistently resulted in high counts. Prolonged (12 days) storage at 48°F resulted in predisplay chub loss of 90% and aerobic and lactic acid bacteria counts as high as 7.6 and 6.6 $\log_{10}$ CFU/g, respectively. For chubs stored for 12 days at 40°F, 10% were considered unacceptable at grinding.

Storage of ground beef chubs at 32° and 40°F resulted in aerobic bacteria counts that were similar but less than with storage at 48°F, whereas lactic acid bacteria numbers increased with each increase in storage temperature. Storage for 0 and 4 days resulted in similar pre-display counts for lactic acid bacteria, but less than after 8 and 12 days, which were similar.

Following all storage treatments (32°, 40°, and 48°F), display at 32° and 40°F resulted in aerobic bacteria counts that were statistically similar, whereas display at 32°F consistently resulted in less microbial growth than display at 48°F. Following storage and display at 48°F, aerobic bacteria counts reached 8.3 $\log_{10}$ CFU/g and often resulted in putrid off odors.

After 0 and 4 days of storage, display at 32° and 40°F resulted in lactic acid bacteria counts that were similar, but less than at 48ºF. Following eight days of storage, display at 32°F slightly increased growth of lactic acid bacteria, whereas 48 hours of display at 40° and 48°F significantly increased growth.

Considering that the average retail display temperature is 40°F, aerobic bacteria

counts (APC) of ground beef commercially displayed for 48 hours may range from 4.0 to 8.0 $\log_{10}$ CFU/g (Table 1). Storage of ground beef chubs resulted in a 1 $\log_{10}$ increase in APC after 8 days of storage and a 2.8 $\log_{10}$ increase after 12 days. Combining elevated storage and display temperatures (48°F) and prolonged storage periods (12 days) greatly increased bacterial growth. Conversely, insuring that brief but cold storage is followed by cold display will minimize microbial growth, decrease off odors, and increase shelf life.

Storage and display at 48°F results in ground beef that is obviously spoiled, as demonstrated by putrid off odors and gas pockets. However, maintaining cold temperatures throughout storage and display insured low microbial counts, and prevented off odors, gas pockets, product loss, and sales loss. The results clearly demonstrate that 32°F temperatures are essential to suppress microbial growth, maximize shelf life, and should enhance profitability.

Table 1. Combined Effects of Storage and Display on Aerobic, Lactic Acid Bacteria, and Chub Loss of Ground Beef

	Storage Temperature (°F)											
	32				40				48			
	Display Treatment (°F), 48 Hrs											
Storage Time (d)	Pre-display	32	40	48	Pre-display	32	40	48	Pre-display	32	40	48
A. Aerobic bacteria counts ($\log_{10}$ CFU/g)												
0	4.0	4.1	4.2	5.2	4.0	4.1	4.2	5.2	4.0	4.1	4.2	5.2
4	5.0	5.6	5.0	5.7	5.1	5.5	6.1	5.9	6.0	6.0	6.6	6.7
8	4.8	5.5	6.3	6.7	5.0	6.7	6.8	6.9	7.7	7.6	7.4	7.8
12	6.2	6.9	7.3	7.9	6.8	7.7	8.0	8.0	7.6	8.0	8.2	8.3
B. Lactic acid bacteria ($\log_{10}$ CFU/g)												
0	4.0	3.6	3.9	5.4	5.0	3.6	3.9	5.4	4.0	3.6	3.9	5.4
4	4.0	4.5	4.7	5.4	3.7	4.8	5.5	5.9	4.8	5.6	5.9	6.4
8	4.5	4.9	6.0	6.0	5.2	5.8	6.6	6.7	6.6	7.0	7.1	7.2
12	4.4	5.4	5.9	6.5	5.6	6.7	6.7	6.8	6.9	7.2	7.6	7.5

C. Chub loss after storage (%)[a]

Storage Time (d)	Storage Temperature (°F)		
	32	40	48
0	0	0	0
4	0	0	0
8	0	0	30
12	0	10	90

[a]Rejection based on extreme black surface discoloration, objectionable odors, >1 cup purge, and gas pockets >4 inch^2.