Summary of Differences in Carcass Chill Rate using Rinse & Chill® Technology Compared to Conventional Slaughter Practices on Cull Cow Carcasses

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Summary

In this small data set (n=19 carcasses per treatment), we observed that the Rinse & Chill® treated carcasses chilled significantly faster in the deep round than carcasses chilled conventionally ($P<0.05$). The Rinse & Chill® treated carcasses also exhibited less variation in deep round temperature, but the impact of this cannot be estimated from this small study.

Background

MPSC desired to understand whether their proprietary Rinse & Chill® process is capable of chilling the probed area in the “deep round” faster than carcasses chilled using the conventional chill process. For Conventional chilling, carcasses were placed on a single rail in the carcass cooler and held at 35.5°F ± 3°F during the chilling process using a standard spray chill. The Rinse & Chill® (RC) process was conducted on carcasses after they passed the inspection table. These carcasses were subsequently chilled using the same spray chilling cycle as the conventional carcasses. Conventionally chilled carcasses were denoted as “Conventional” while Rinse & Chill® carcasses were denoted as “RC”.

Robert Campbell noted in the companion document (1) (Chill Curves white paper for DS Project) that, “While there was considerable weight variation in both groups, the average of 20 carcasses in each treatment was within 50 lbs. of each other.” He further noted that the average weight was ca. 1000 lbs. with a range of 700 to 2000 lbs. in each treatment group. The population of cattle was ca. 70% dairy cows and 30% other. The variation in weights may be reflected in the results. Cattle weights were not provided for inclusion in the analysis.

Methods

Data was provided by MPSC in the form of an Excel data sheet consisting of 19 columns of time/temperature data for RC and 19 columns of data for Conventional carcasses (2). The time frame covered the time from when the probes were inserted (0.75 hr. from the start of harvest until 25.32 hrs. Note that not all probes were left in the entire time. The shortest time chilling time was 19.37 hrs. while the longest was 25.32 hrs. The data was arranged for analysis using JMP into a large data set of four columns representing time (hr.) postmortem, treatment (Conventional or RC), carcass number, and temperature (°F). The final data set was 117,962 rows.

First order rate

$a \times \exp_{(-bx)}$
a=initial value
b=rate constant
x=hr.

The first operation was to calculate the first order rate constants for the temperature decline for each carcass. First order rate constants were chosen since they have scientific meaning and fit the data well. Other fitting methods are available, but they are sometimes difficult to interpret and provide no association between fitted value functions and scientific mechanisms. JMP calculated the rate constants by fitting the first order non-linear curve to the data. Once these were calculated, the values were placed into a second data sheet to determine whether there was a statistical difference between the rates from the Conventional and the RC chilled carcasses. This data table consisted of three columns (carcass number, treatment (Conventional or RC), and rate. The table was 19 rows representing the 19 different carcasses. The data was analyzed using a one-way analysis of variance (ANOVA). Treatment was analyzed as a fixed effect.

Results

<u>First order rate (temperature change (°F)/hr.)</u>

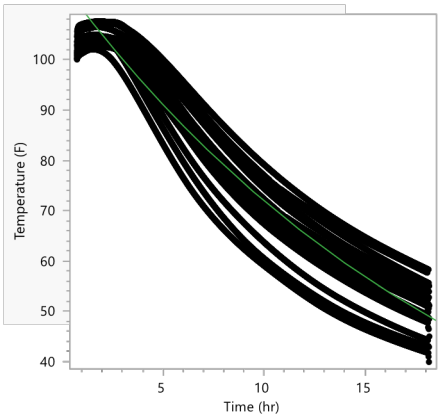
Although the rates were determined for each carcass separately, for the subsequent calculations, it seems better to show the chill curves by treatment with all the carcasses included to show how they vary visually. There are several things to note:

1) The final temperatures for the RC carcasses reached a lower temperature than did those conventionally chilled in the time recorded. This was also noted in the Chill Curve white paper (1) where, “The carcasses processed with Rinse & Chill® technology averaged 51.4°F at 18 h post-mortem, while the conventionally processed carcasses averaged 64.4°F at 18 h post-mortem”.
2) In all cases, there was a slight increase in temperature during the subsequent one to three hours in the deep round post exsanguination. This is typical and represents increased heat build up due to the lack of blood flow throughout the round as rigor progresses. The first order rate seems to be calculated during the peak of this period of increasing temperature rather than from the initial deep round temperature observed at 0.75 hr.
3) Variation between carcasses. This variation can be clearly seen in Figs. 1 & 2. The R^2 values for these, however both exceeded 0.9 (RC = 0.93, Conventional =

0.92). The variation observed could be due to many factors including probe placement, conformation differences in the rounds used, and carcass weight and its influences on round size, etc. (Appendix Figure 2).

4) Temperature of the fluids used in the RC process. If the temperature of the RC fluids is kept constant throughout, then the RC process may result in more consistent temperature decline.

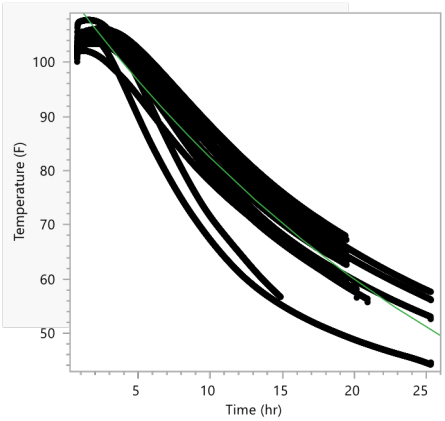
Figure 1. Plot Temperature data for Rinse & Chill to calculate first order rate



The blue line represents the best fit line

R-Square
0.930733

Figure 2. Plot Temperature data for Conventional chill to calculate first order rate



The blue line represents the best fit line

R-Square
0.9168053

Rate differences by treatment

The analysis of variance showed that there is a difference between the first order chill rates by treatment (P<0.05). The ANOVA table (Table 1) and the LSMeans difference test used (Table 2) show that the carcasses treated with RC had a higher chilling rate than did the conventional carcasses. This was also illustrated in the box and whisker plot in Figure 3 and the LSMeans plot in Figure 4.

Table 1. Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00215253	0.002153	62.0241
Error	36	0.00124937	0.000035	**Prob > F**
C. Total	37	0.00340189		<.0001*

Table 2. LSMeans difference test (Student's t test)

Level		Least Sq Mean
Rinsed	A	0.04747368
Unrinsed	B	0.03242105

Levels not connected by same letter are significantly different.

Figure 3. Box and whisker plot of first order rates by treatment

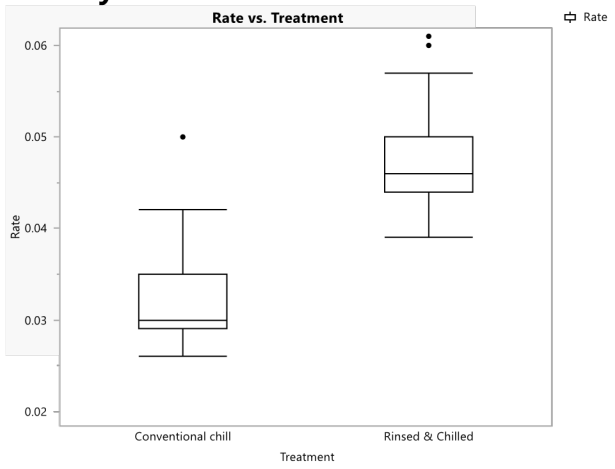
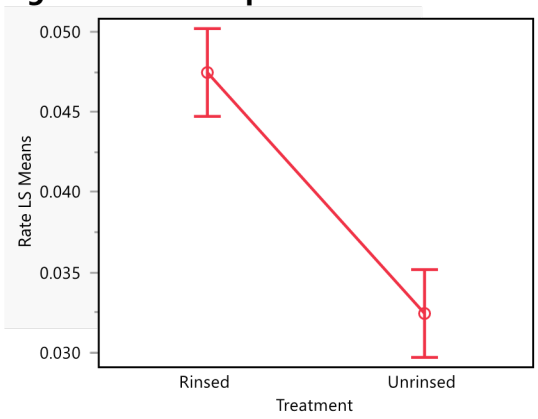


Figure 4. Least Squares Means Plot



Brackets indicate 95% confidence intervals

Discussion

Using the first order rate of temperature decline in cow carcasses did pick up the faster temperature decline observed in RC carcasses compared to Conventionally chilled carcasses. The figures do seem to show a slightly more uniform chill using RC, slightly less variability and a slightly larger R^2 value in these 19 carcasses. This may be of value in the future. In addition, it is difficult to know whether some of the variation between the chill rates of the various carcasses could be decreased knowing the carcass weights. This is because the total mass of round muscle in aged dairy cows may not be closely related to carcass weight. This could be tested if the carcass weights are provided.

References

1 Campbell, Robert (2020). Chill curves: Rinse & Chill® vs. conventional chill on cull cow carcasses – an explanation. Chill Curves white paper for DS project.docx.

2 Campbell, Robert (2023). Rinsed and Unrinsed all data DS b.xlxs.

Appendix

Appendix Table 1. Table of first order rate constants by carcass and treatment used in the data analysis.

	First order rate	
carcass	Rinsed	Unrinsed
1	0.060	0.035
2	0.045	0.030

3	0.061	0.033
4	0.057	0.042
5	0.046	0.035
6	0.040	0.028
7	0.047	0.026
8	0.050	0.034
9	0.049	0.032
10	0.039	0.026
11	0.050	0.030
12	0.044	0.050
13	0.044	0.029
14	0.048	0.030
15	0.044	0.029
16	0.047	0.030
17	0.046	0.035
18	0.043	0.030
19	0.042	0.032

Appendix Figure 2. Plot of Carcass Deep Round Temperatures by Treatment