The Effects of Time and Temperature on Fingerprint Degradation by Friction Ridge Volume: Practical Implications for Evidence Storage

The 109th IAI Conference
Orlando, FL, USA
August 10-16, 2025

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INTRODUCTION/ABSTRACT

Latent fingerprint (LF) evidence preservation is critical for forensic investigations. Especially in criminal scenarios, the conservation of physical evidence is necessary in case of performing reexaminations, or testing new techniques for further analysis at a later date.[1] By storing the LFs in ideal conditions, the loss of ridge clarity can be mitigated as both temperature and humidity can have have a large impact on the degradation of LFs over time.[2] This study evaluated the impact of temperature and time on natural LF degradation by 2D and 3D imaging[3]. LFs were stored up to 21 days in the dark at -20°C, 4°C, 22°C, and 40°C. Temperature and relative humidity were monitored, but not controlled. The evaluation of LFs with 3D imaging was performed with an Optical Profilometer (OP). In this study, the net volume (Vn) of the LFs was evaluated alongside one traditional 2D method via powdering and photography, the most common for visualization. The FBI's Universal Latent Workstation (ULW) software digitally analyzed ridge clarity of LFs by color coding ridges from best (blue and green) to worst (yellow and red). The Blue/Green (BG) metric was created by adding the percent of the provided blue and green colors. Results showed that 4°C best preserved ridge detail, while those stored at 22°C degraded the most. These findings provide a practical insight into optimal storage conditions for maintaining LF quality in casework.

MATERIALS/METHODS

- Environmental Conditions: -20ºC, 50-95% RH; 4˚C, 12-25% RH; 22˚C, 30-62% RH, 40˚C, 17-38% RH; darkness.
- Deposition surface: glass microscope slides
- Number of donors: 3 biological males
- LF conditions: sebaceous-rich impressions, dominant hand, index finger, triplicates
- Pressure and time of deposition: 400-800g for 5 seconds
- Total number of LFs: 180
- LFs 3D analysis and area: OP (are examined = 5.78 mm²)
- Total number of 3D scans: 540
- LFs 2D analysis: titanium dioxide (TiO_2), photography with Canon DSLR, standardization in Adobe® Photoshop®, ridge clarity examination with ULW :
  - Blue and green colorings indicated good ridge flow with clear minutiae, these were used for the BG% Area metric
  - Yellow and red colorings indicated unclear minutiae and poor ridge flow
- LF aging times: 1, 6, 11, 16, 21 days (5 periods)

Metrics:
- 2D: BG (Blue/Green percent area from ULW)
- 3D: Vn (Net volume of scanned area)

Statistical Analysis:
- Microsoft® Excel® - compilation and clean-up of data, graphs, and tables
- IBM® SPSS® - normality and homoscedasticity tests, boxplots, EMM graphs, univariate, and multivariate analyses

References:
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Qualitative Analysis of 2D and 3D Metrics

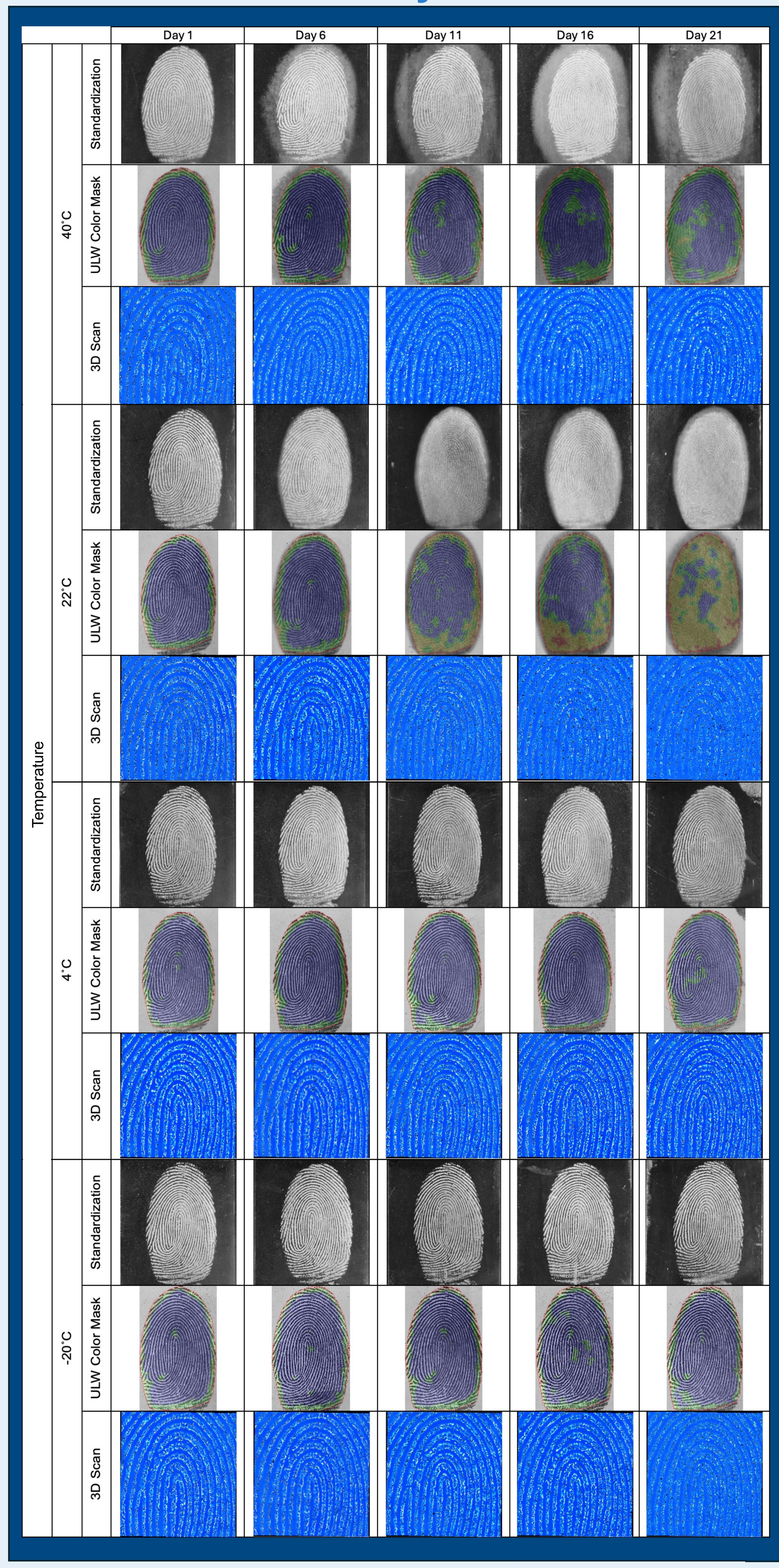

Figure 1. (Left) Standardized images, ULW color-coded masks, and non-destructive 3D scans of one male donor across five time points and four temperatures. In the ULW images the blue and green colored areas represents good quality ridges while the yellow and red colored areas represents poor quality ridges. In the 3D scan, the lighter blue/white represents the ridge flow and the darker blue represents the furrows/background. Note the differences over time in 40˚C and 22˚C, but not as much in 4˚C and -20˚C.

The red box represents area scanned by OP.

Boxplots of 2D and 3D Metrics

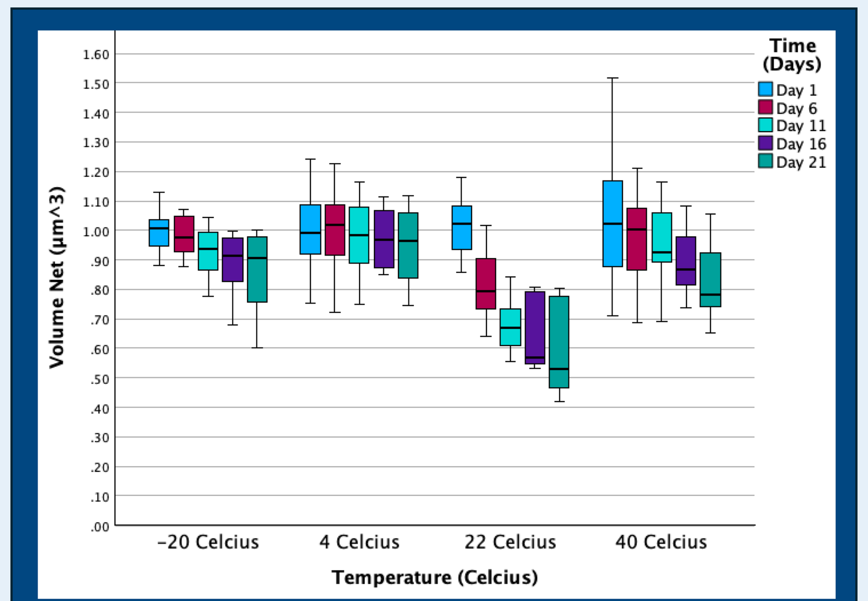

Figure 4. (Above) Boxplot of normalized Vn data over time organized per temperature. The colors represent the different time points. Note the difference in 22˚C.

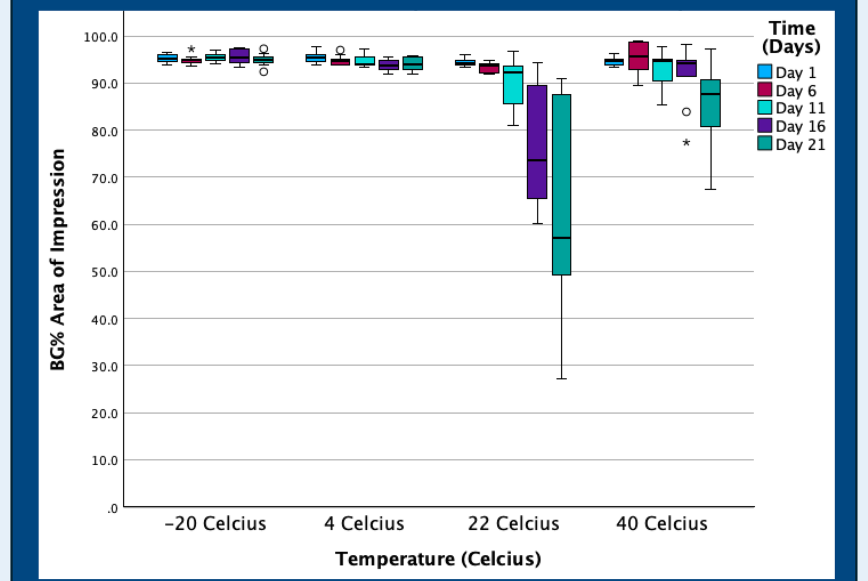

Figure 5. (Above) Boxplot of BG data over time organized per temperature. The colors represent the different time points. The circles and asterisks represent outliers that could not be removed. Note the difference in 22˚C.

Statistical Analysis of 2D and 3D Metrics

Univariate Analysis by Temperature

Factor Combination			Sig.	
1st Factor	2nd Factor		Vn	BG
-20˚C	Day 1	Day 6	0.976	0.954
		Day 11	0.014	0.998
		Day 16	0.001	0.984
		Day 21	<0.001	0.949
	Day 6	Day 11	0.086	0.85
		Day 16	0.008	0.731
		Day 21	<0.001	1
	Day 11	Day 16	0.741	0.999
		Day 21	0.109	0.84
	Day 16	Day 21	0.741	0.719
4˚C	Day 1	Day 6	1	0.884
		Day 11	0.937	0.767
		Day 16	0.977	0.104
		Day 21	0.815	0.122
	Day 6	Day 11	0.97	0.999
		Day 16	0.989	0.487
		Day 21	0.868	0.553
	Day 11	Day 16	1	0.635
		Day 21	0.989	0.704
	Day 16	Day 21	0.99	1
22˚C	Day 1	Day 6	<0.001	1
		Day 11	<0.001	0.951
		Day 16	<0.001	0.029
		Day 21	<0.001	<0.001
	Day 6	Day 11	<0.001	0.98
		Day 16	<0.001	0.044
		Day 21	<0.001	<0.001
	Day 11	Day 16	0.712	0.213
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	Day 16	Day 21	0.707	0.145
40˚C	Day 1	Day 6	0.57	0.999
		Day 11	0.429	0.94
		Day 16	0.077	0.769
		Day 21	0.009	0.012
	Day 6	Day 11	0.996	0.853
		Day 16	0.589	0.633
		Day 21	0.13	0.008
	Day 11	Day 16	0.807	0.994
		Day 21	0.26	0.072
	Day 16	Day 21	0.865	0.164

Figure 7. (Left) Univariate analysis results of both Vn and BG% Area data for each temperature. α = 0.05. Significant comparisons are highlighted in yellow. Note the differences between Vn significance and BG significance in the different temperatures, mainly -20˚C and 22˚C.

Multivariate Effect of Time Per Temp.

Temperature	Wilks Lambda Sig	Eta^2
-20˚C	0.182	0.165
4˚C	0.119	0.195
22˚C	<0.001	0.666
40˚C	0.005	0.322

Figure 8. (Above) Multivariate analysis results of the effect of time for each temperature. α = 0.05. Significant comparisons are highlighted in yellow. The Wilk's Lambda determined differences between the Vn and BG metrics. Note that only 22˚C and 40˚C were revealed to be significantly different.

Quantitative Analysis of Time and Temperature in 2D and 3D Metrics

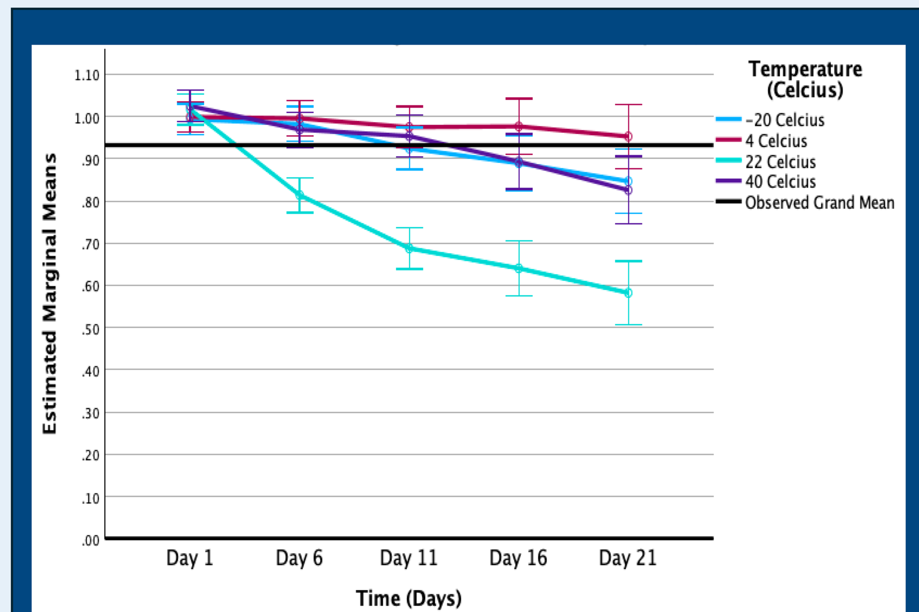
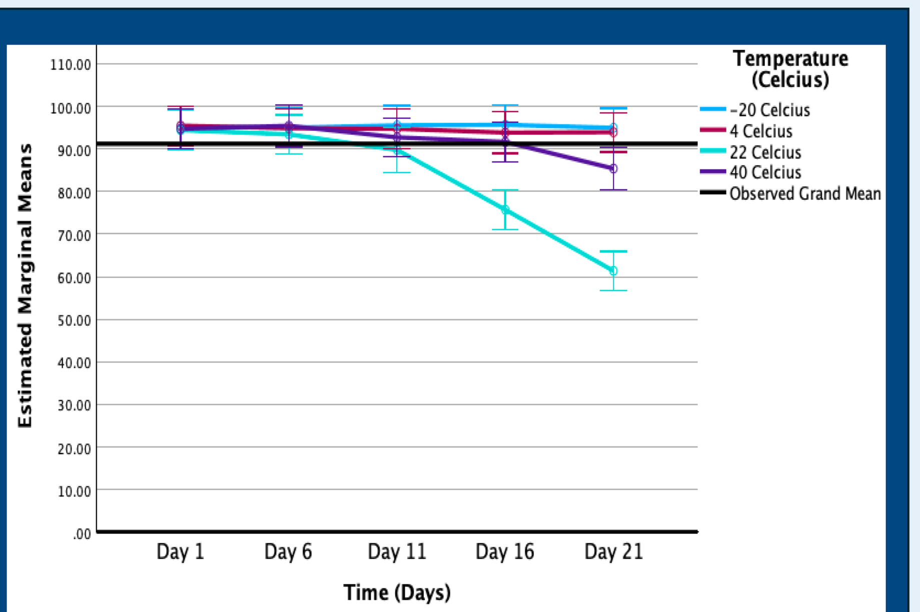


Figure 2. Estimated Marginal Means (EMM) of Vn data over time. Each colored line represents a temperature: -20˚C (blue), 4˚C (red), 22˚C (green), and 40˚C (purple). Note the difference in the 22˚C line from all others. Error bars = 95% CI.



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RESULTS/DISCUSSION

- Data showed that levels of ridge degradation were dependent on temperature as detected with both 2D and 3D metrics (Figures 1-5)
- Vn was a more sensitive metric in identifying differences over time than BG (Figures 7 and 8)
- -20˚C: mild preservative effects due to low temperature but high humidity (50-95% RH) – chemical breakdown of LFs slowed by cold temperature
- 4˚C: the least negative effects on degradation due to low temperature and low humidity (12-25% RH) – result of dehydration and slowed chemical breakdown caused by cold temperature
- 22˚C: noticeable degradation in both Vn and BG due to moderate humidity (30-62% RH) and a warmer temperature – moderate humidity and warmer temperature did not protect LF integrity
- 40˚C: mild preservative effects due to lower humidity (17-38% RH) but high temperature – result of dehydration caused by low humidity

CONCLUSION

- The ideal temperature for storing LFs was at 4˚C, in a fridge
- The most damaging temperature to keep LF evidence was 22˚C, at room temperature
- There was a notable difference in the sensitivity of the BG and Vn metrics, with Vn being more efficient than BG
- Limitations: small sample size of three donors and one substrate examined
- Future research: include more donors and substrate types

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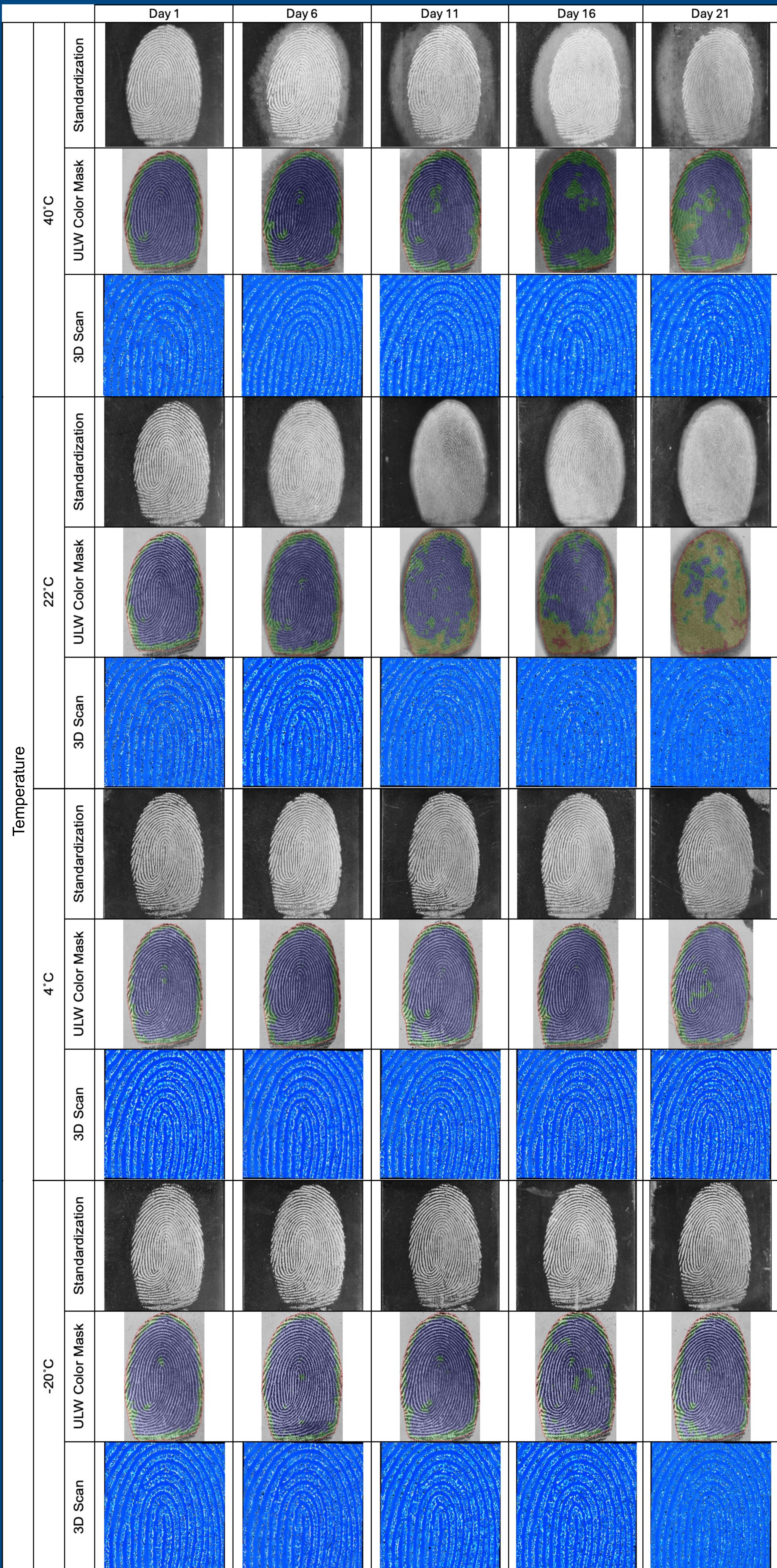

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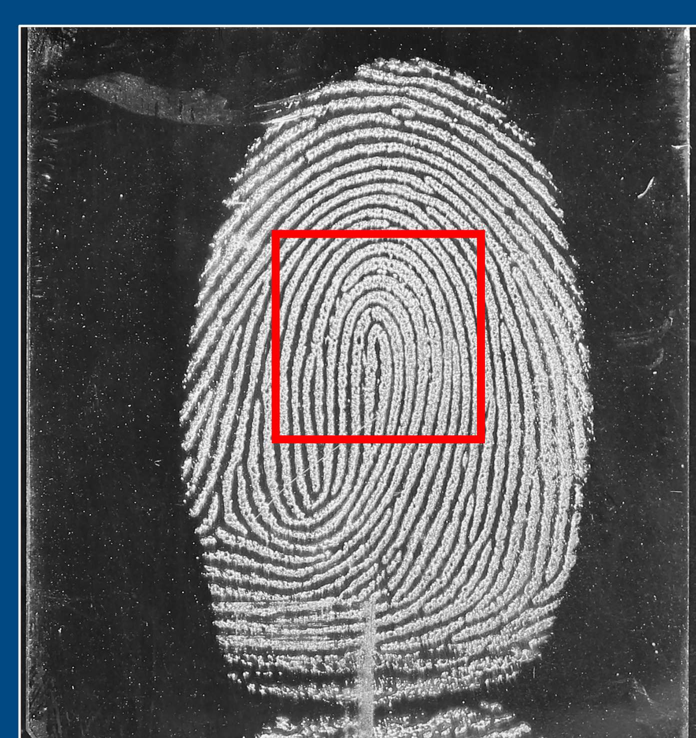

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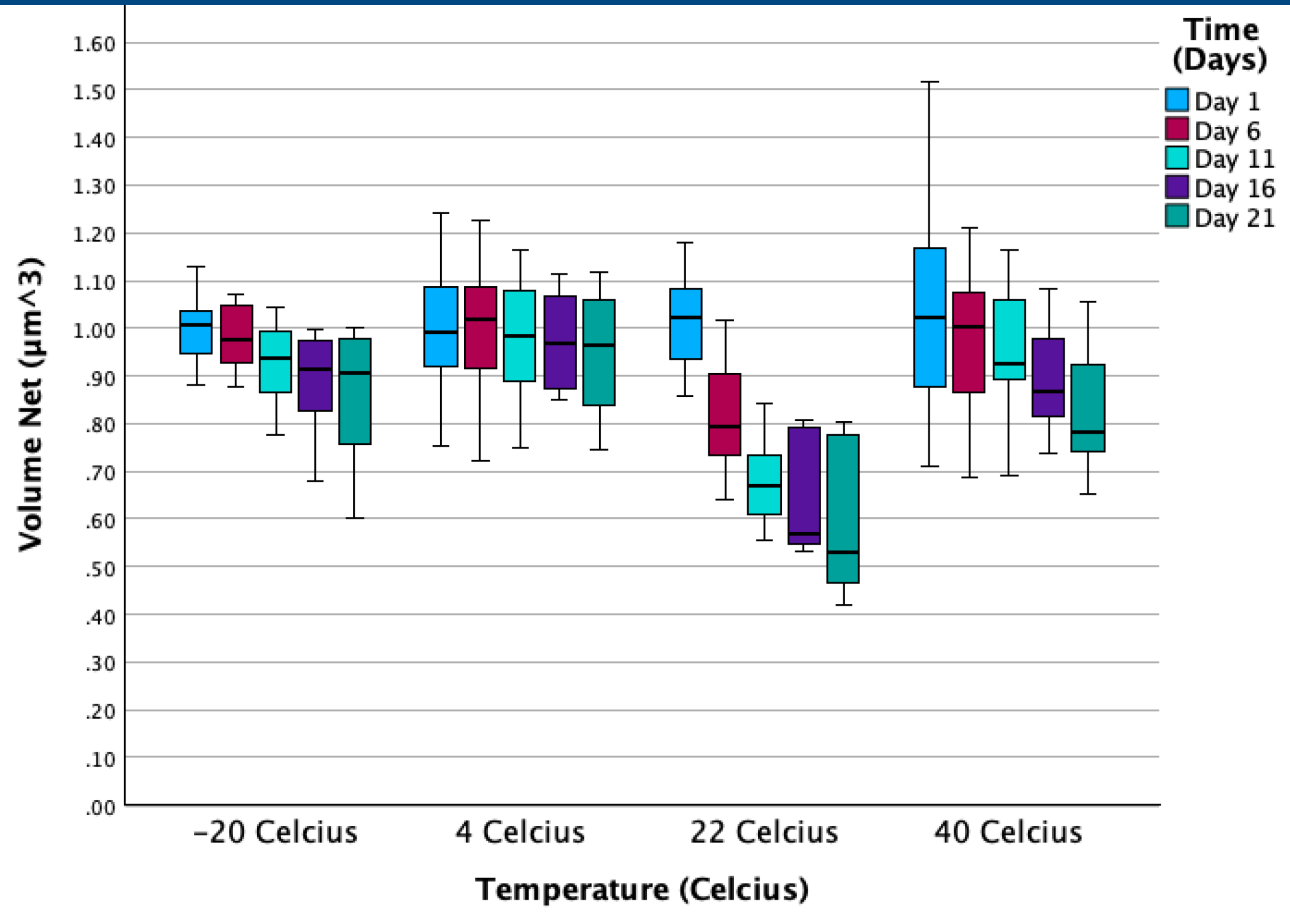

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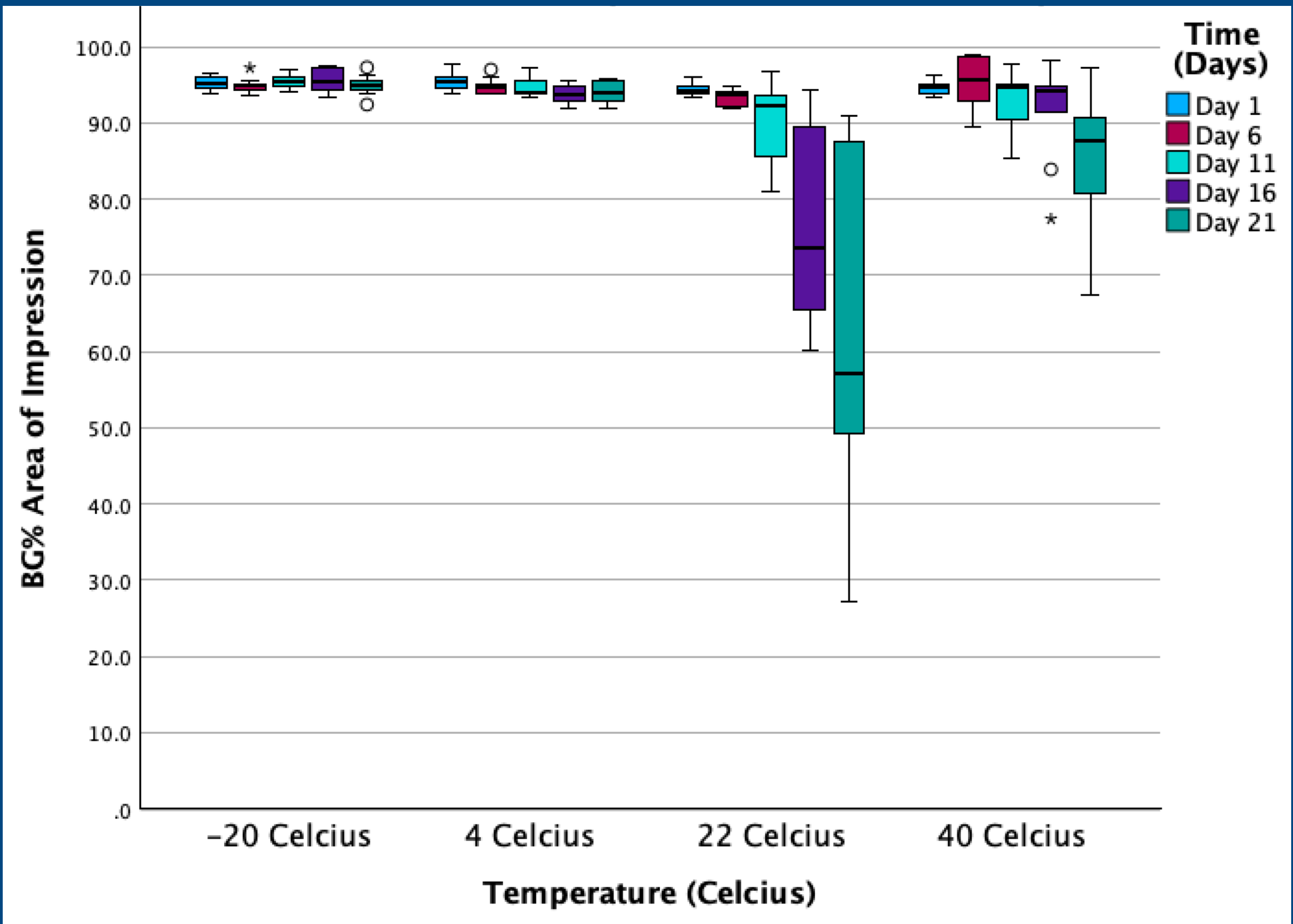

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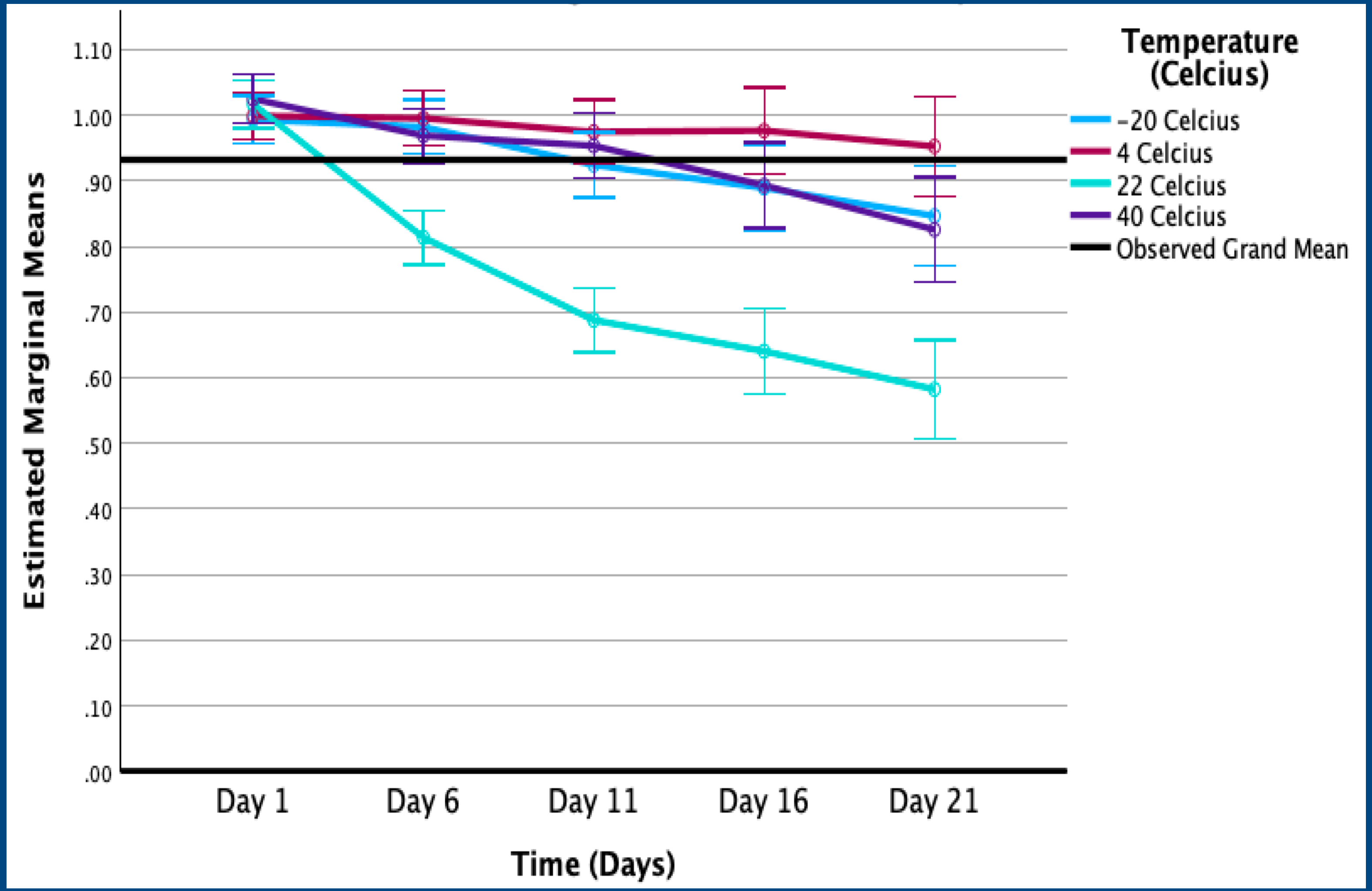

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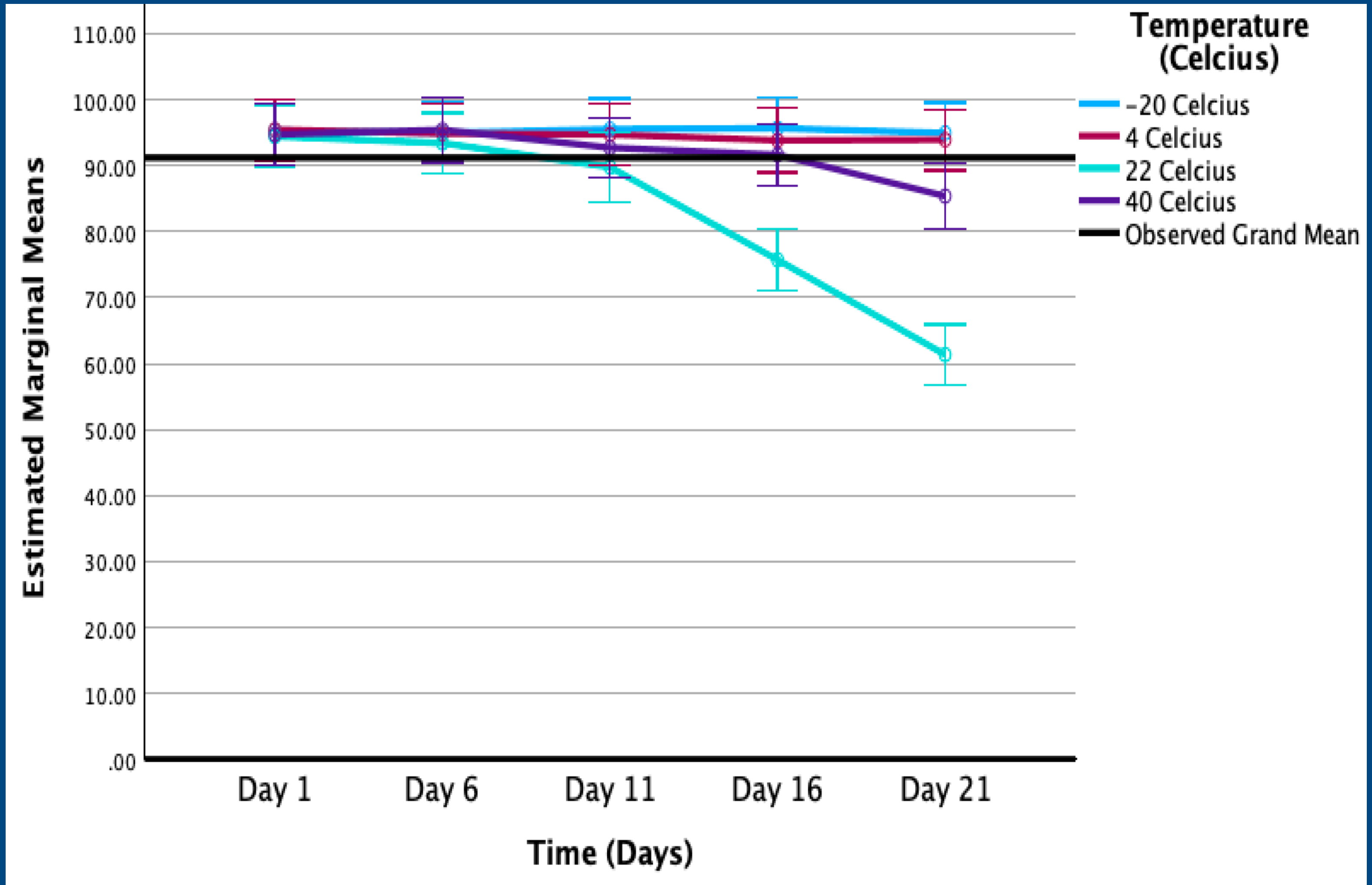

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