2001 FINAL REPORT

American Vineyard Foundation

I. Project Title: **MONITORING OF WINE HEAT EXPOSURE DURING COMMERCIAL SHIPMENTS**

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III. Summary

The goal of this project was to accurately monitor and document heat exposure of wine during a significantly large and representative number of shipments from winery to distributors across the country under the most extreme conditions that can be expected for commercial freight during the months of summer. The shipping project showed quite dramatically the impact of wine shipments in regular non-refrigerated trucks with different types of insulation. During the summer months, wines shipped to or via hot geographic locations are frequently exposed to temperatures above 75°F, and often for extended periods of time. Under the most extreme shipping conditions the wine would have been exposed to temperatures above 110°F. A substantial daily fluctuation in temperature was observed with the potential consequences for the sealing capabilities of the bottle closures in use. We observed a large variation of temperatures within one shipment based on the location of the wine case within the shipping container. Different models of aging kinetics were applied to compare the heat exposure to the aging of wine under ideal cellar conditions. When applying a general rule of thumb for chemical reactions, it was calculated that the wines were exposed to heat that represented an aging time equivalent to between one month and six years. While the aging reaction of and between different components in a wine vary substantially, we obtained a best but weak fit for ethyl

carbamate (EC) formation kinetics that may be used to predict maximum EC formation in wine under different shipping conditions.

IV. Objectives and Experiments Conducted to Meet Stated Objectives

The goal of this project was to precisely monitor and document heat exposure of wine during a significantly large and representative number of shipments from winery to distributors across the country under the most extreme conditions that can be expected for commercial freight during the months of summer. The monitoring program was performed in cooperation with two commercial wineries, the Robert Mondavi Family of Wineries and Delicato Vineyards. We prepared packages consisted of a sealed standard wine bottle filled with a wine-like alcohol-water mix, and containing a temperature sensor in the center of the liquid attached to an external temperature data logger that recorded a temperature every 15 minutes. The package also consisted of a bottle with an alcohol-water model solution that contained 10 mg/L of urea. The sample was analyzed for EC by a collaborating laboratory after the package had been shipped back by the distributor via USPS priority mail to either the cooperating winery or the university. At this point, the data loggers were extracted and the time/temperature data entered into MS Excel spreadsheets. The packages accompanied about twenty commercial cross-country shipments mostly with multiple packages in different positions within the container.

V. Summary of Major Research Accomplishments and Results

The shipping project showed quite dramatically the impact of wine shipments in regular non-refrigerated trucks with different types of insulation. During the summer months, wines shipped to or via hot geographic locations (Slide #1) are frequently exposed to temperatures above 75°F, and often for extended periods of time, fluctuating with the time of day and direction of sunlight. At the same time, we documented a much less rapid warming of the wines than the air temperature in the truck which tends to be about 2-7 °F higher than that of the actual wine (Slides #3 and close-up #4). Nevertheless, we saw most extreme shipping conditions during which the wine would have been exposed to temperatures above 110°F (Slide #6) if it had not be covered with an insulating blanket. The substantial fluctuation (Slides #3-6) in temperature is also troublesome as they results in an expansion and contraction ("piston-effect") of the wine as a liquid with the consequence of potentially compromising the sealing capabilities of the bottle closures in use. During the coldest months or shipments to cooler locations, exposure to extremely low temperatures may contribute to similar physical effects as well as tartrate stability issues (Slide #6).

We observed a large variation of temperatures within one shipment based on the location of the wine case within the shipping container. Logically, the top right side of any shipment that travels in a west-east direction is especially prone to excessive heat exposure if no additional insulation is provided (Slide #2).

We integrated the temperature data over time to generate comparable information on the total heat exposure during shipment. Subsequently, we applied different models of aging kinetics (Slide #8) to compare the heat exposure to the aging of wine under ideal cellar conditions (55°F).

The calculations showed a wide variation of summarized heat exposure between different shipments (Slides #9-13) and also a correspondingly wide variation of heat exposure even within one shipping based on the location of the wine in the shipping container or truck. When applying the general rule of thumb that a typical chemical reaction is ten times faster when the temperature increase by ten degrees Celsius (+18°F), we observed that the wines were exposed to heat that represented an aging time equivalent to ideal cellar conditions between one month and six years (Slide #9 and #12). We fitted the EC formation kinetics to different models, and obtained a best but weak fit at a temperature of 94 °F for an increase in reaction speed by one magnitude. In this scenario the heat exposure resulted in a much shorter equivalent aging time, however the aging reaction of and between different aroma components in a wine vary substantially, and the impact of bottle bouquet and wine aroma cannot be concluded from the EC kinetics. The model constants obtained may be used to predict maximum EC formation in wine under different shipping conditions.

VI. <u>Outside Presentations of Research</u>

The results of this research were presented to the Wine Institute Technical Committee's subcommittee on EC on January 10, 2001, to the Napa Valley Wine Technical Group on January 18, 2001, and to over 70 winery executives during the Wine Industry Executive Program at UC Davis on January 29, 2001. The results of the temperature-monitoring part of the study research will be made available to the wine industry through a presentation by the principal investigator at the 52nd Annual Meeting of the American Society for Enology and Viticulture in San Diego, CA, June 28-30, 2001.

VII. <u>Research Success Statements</u>

Our research has provided the California wine industry with independent and highly detailed information regarding the conditions in which their wines are shipped nationwide. This survey proved to be very useful to assess the potential impact of heat exposure during shipping on both wine quality and the formation of unwanted by-products. By shipping the monitoring packages during the time of summer and early fall, we generated extensive data for the most extreme conditions under which wine may reach the consumer.

In the past, it has often been a practice to over-stabilizing a wine against potential protein haze formation at undesirable evaluated temperatures ("heat stability test"). This not only leads to a considerable problem with solid waste generation in form of depleted bentonite, but it also avoids any visual indication of an otherwise compromised wine quality from excessive heat exposure during shipment and storage ("melted ice cream analogy"). The results presented may lead to a re-thinking of stabilization practices.

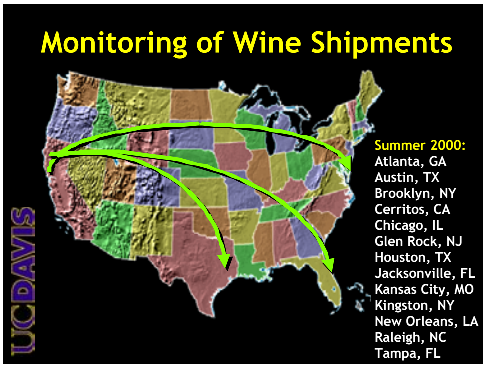
This research also addressed possible concerns by the regulatory federal agency, and demonstrates the wine industry's efforts and options to minimize the concentrations of EC in American wine. This project has created extremely valuable information for all wine producers as they ought to raise awareness among freight companies, distributors, wholesalers and retailers about the implications of the current shipping conditions with the mutual goal to minimize heat exposure by use of appropriate insulated containers, shipping schedules and storage facilities.

VIII. <u>Funds Status</u>:

100% received and spent as proposed. I was fortunate to conduct this study with a highly motivated and skilled enology graduate student, Leticia Chacon-Rodriguez. Leticia finished the compilation for data collected during the summer/fall of 2000, and was hired as Assistant Winemaker at Golden State Vintners in Monterey County as of January 15, 2001. I intend to continue the project in 2001 and remaining funds will be spent accordingly.

Slides #1-7:

Time/temperature curves for different wine shipments across the US

#1


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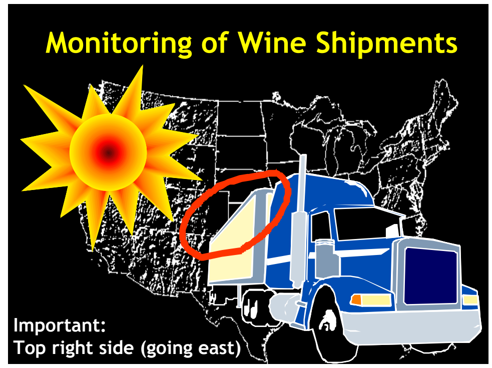

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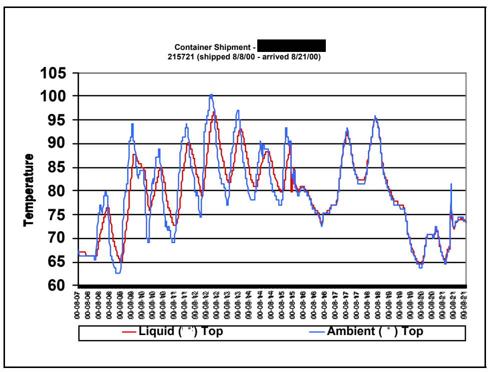

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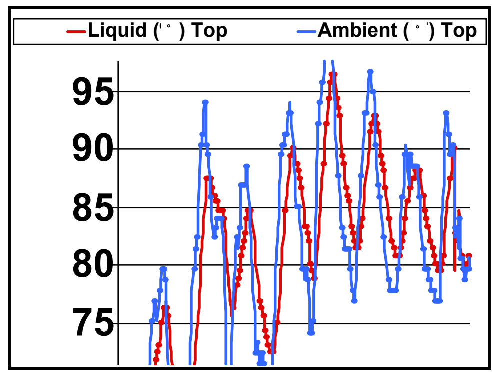

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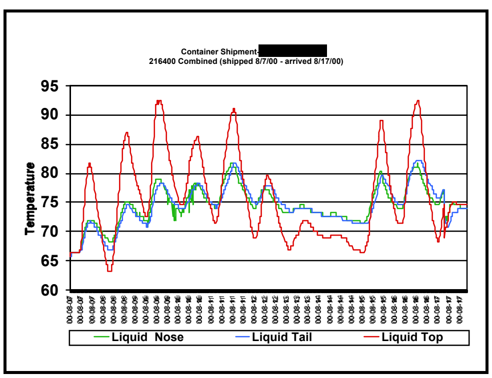

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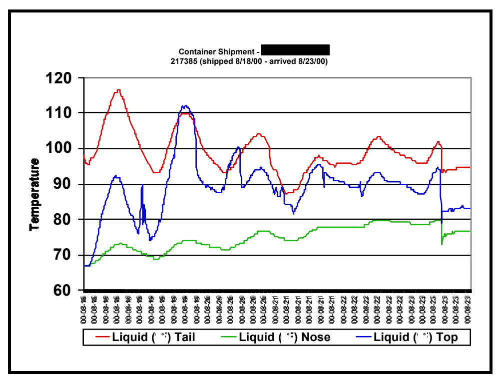

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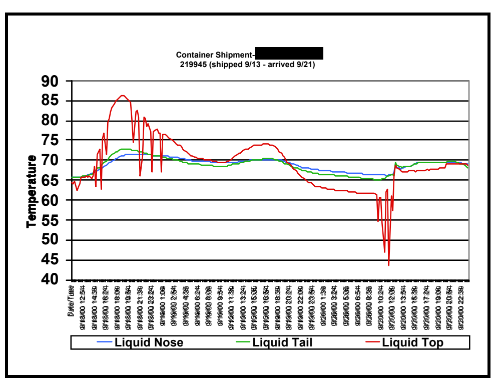
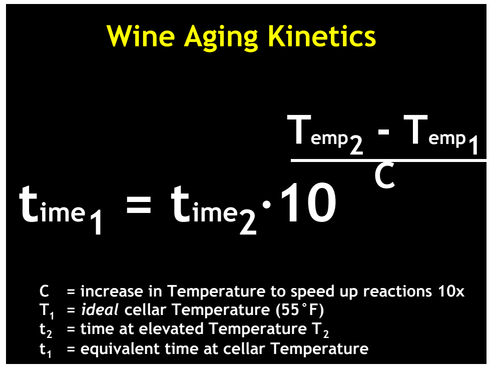
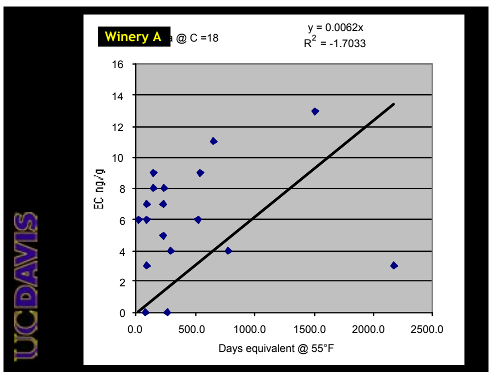
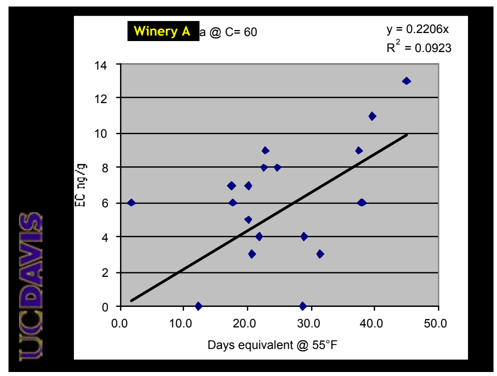


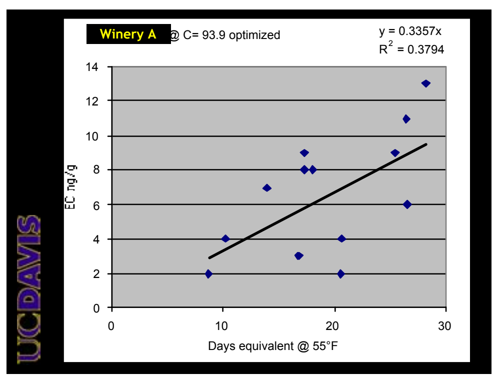
Slides #8-13:

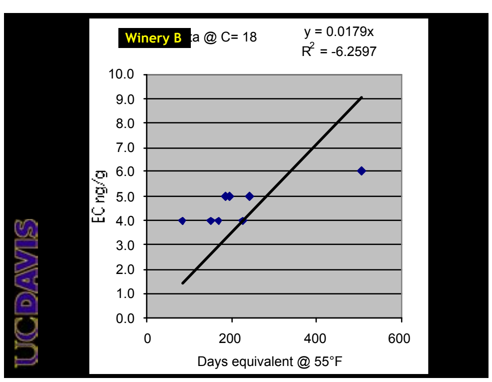
Heat summation of time/temperature data using different kinetic models

#8 

#9 

#10 

#11 

#12 

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