

Final Technical Report

Nicole E Shriner, PhD

Department of Chemical Engineering and Materials Science

428 S Shaw Ln #2100, East Lansing, MI 48824

Email: shrinern@msu.edu

Phone: 517-896-4635

Grant 21*1196 Diacetyl Production, Reduction and Control in Beers Brewed with Raspberries and Other Adjunct Sugar Sources

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Goals and Objectives

The usage of fruits in beers is one way that craft breweries in Michigan can create their individual identity while embracing Michigan made products. Michigan's climate allows the growth of a variety of fruit including blueberries, tart cherries, apples, peaches, plums, grapes, strawberries, raspberries and more. While these fruits can be grown in many states, the climate and soil vary based on location and thus each produce slightly different varieties of fruit. As Michigan breweries begin to expand their beer brands and hopefully their use of local raw materials, it is important to be aware of the implications ingredients can have on the final product.

Diacetyl is one of the key off-flavors in beer giving a buttery, butterscotch like flavor to beer. The flavor threshold is very low at around 0.1ppm in light beer, making it very easy to sense for the consumer. Diacetyl therefore is an industry standard indicator of a beer's quality and readiness. Moreover, the total Vicinal Diketones (VDKs) are a group of flavor components in beer, most notably 2,3-butanedione (generally referred to as diacetyl) and 2,3-pentanedione. The formation and degradation of total VDK is dependent on many factors including fermentation temperature, aeration level, nutrients including protein and amino acids, bacterial contamination, and yeast strain. In the making of fruit beers, it has been noticed when raspberries and/or raspberry puree is added to the beer, VDK levels are increased via GC analysis however on a sensory panel the presence is not readily perceived. Most of the time, after a VDK spike, the yeast uptake the VDK and further degrade it into other compounds which have a much higher threshold concentration. However, there are some cases when raspberries or raspberry puree is added to the beer, the total VDK concentration does not come down under ideal concentrations, thus extending the maturation time. These phenomena paired with the growing interest in fruit beers by consumers are the motivation for this research.

Specific goals are outlined below.

- Select, purchase and install GC equipment required for VDK detection in beers
- Generate calibration curves for diacetyl and 2,3-pentandione
- Generate standard total VDK curves for 'normal' beers or beers brewed without raspberries
- Observe and collect data for beer fermentations with raspberry puree additions at various points in the brewing and fermentation process
- Determine VDK concentration in multiple types of raspberry purees
- Determine VDK concentration of organic and non-organic raspberries

Results, Conclusions and Outcomes

Results

Below is a graph of total VDK versus time for three different types of fermentations.

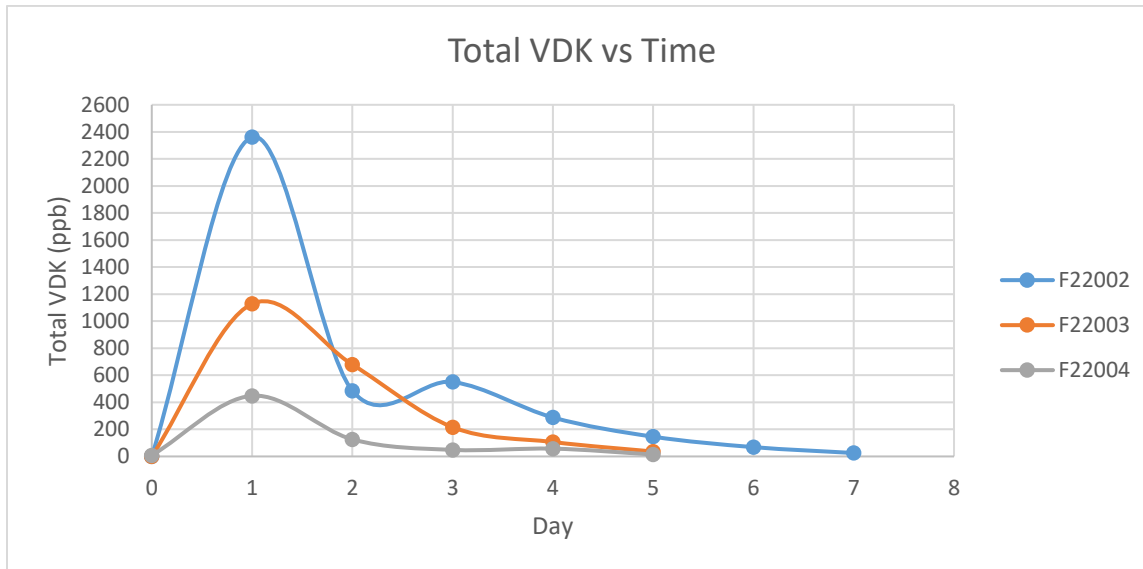


Figure 1 – VDK vs Time

F22002 – Normal Fermentation (no fruit),

F22003 – Brewer’s Orchard Raspberry Puree added on Day 4 (1,000 mL puree/ 5 gal)

F22004 – Brewer’s Orchard Raspberry Puree added pre pitch on Day 0 (2,000 mL puree/5 gal)

Below is a table of the diacetyl concentrations of various types of puree and types of raspberries.

Table 1 – Diacetyl Concentration of Raspberry Purees and Fresh Raspberries

Product	Diacetyl (ppb)
Tides Raspberry Puree	85.7
Brewer’s Orchard Puree	BDL
Raspberries - Crushed (non organic)	BDL
Raspberries - Whole (non organic)	40.8
Raspberries - Crushed (organic)	BDL
Raspberries - Whole (organic)	BDL

More raw data including original and final gravity, pH, oxygen, sugars and VDK over time is available upon request.

Conclusions and Outcomes

As seen in Figure 1, a normal VDK curve peaks in the beginning of fermentation and decreases at nearly the same rate until the concentration is depleted. This took on average 5 days to complete the formation and degradation cycle. The orange line in Figure 1 represents the cycle when puree was added on day 4. It can be seen that the total VDK was already near depletion when raspberry puree from brewers orchard was added and it did not have an effect on VDK production or degradation. The gray line in Figure 1 represents the cycle when raspberry puree from brewers orchard was added at the same time as the aerated wort. It can be seen that the peak VDK concentration was the lowest in this fermentation. One reason for this may be that the addition of the puree caused acidification of the wort which caused the yeast not to produce as much diacetyl. It should also be noted that the degradation rate was decreased in the beers brewed with raspberry puree. It is not clear why the peak VDK concentration varied for F22002 and F22003. One speculation is the oxygen content may have varied at the beginning of the fermentation causing initial production of diacetyl to be effected.

Table 1 illustrates the variability in fruits and fruit products. Comparing the two purees, Tides and Brewer's Orchard it can be seen that Tide's puree may contain diacetyl which may be detectable in the fermentation when it is added. This mixed with a lack of oxygen and low pH upon puree addition may lend problems with degradation of total VDK. It can be gathered that the manufacturing process of fruit purees may affect the presence of VDK. The treatment of pesticides on fruits, for manufacturing of puree or general bulk fruit sale, may prevent the growth of microbes which naturally produce diacetyl. However, this is not validated as seen in the varying results in Table 1.

Timeline

Grant Effective Dates: January 21st 2021 – January 1st 2023

Work Accomplished / Methods

Cryo vials of bell's house ale yeast was grown yeast according to bells lab procedures. Wort was produced using Breiss pale malt extract, cascade hops and Bell's house ale yeast. The wort was oxygenated and cooled prior to being pitched with yeast in a 7 gal SS brewtech fermenters at 22°C. Fermentations were performed in duplicate and triplicate. One of the three fermenters were attached to a precision brewing monitor, which took readings of gravity, temperature, pH, oxygen and conductivity every 20 minutes through fermentation. For the baseline fermentation, no fruit additions were added. The raspberry puree was added either on day 0 prior to wort entering the fermenter or on day 4. Day 4 puree additions were done by opening the top of the fermenter and pouring in. Samples were taken daily and immediately ran in the GC for total VDK analysis, as well as, on the HPLC for sugar and ethanol analysis.

The quantification of total VDK concentration of raspberries was completed via two methods. The first method was to place whole raspberries into the headspace vial to avoid crushing or

breaking as much as possible. The second method was to thoroughly crush the raspberries in the vial prior to analysis.

Communication Activities, Accomplishments and Impacts.

Communication Activities

- ASBC Virtual Conference 2021
- Michigan Brewer's Guild Conference 2023

Accomplishments

- Purchased and installation of ECD/HS additions to GC, calibration of VDK's
- Standardized total VDK cycle curve
- Raspberry fermentation conditions and VDK curve established
- Determination of diacetyl concentration in raspberry purees, concentrates, fresh raspberries both organic and non-organic

Impacts

- The analysis lab now has added capabilities which aid in research, education and data collected for Michigan consumers
- Brewers are now made aware of implications fruits and fruit purees may have on diacetyl production and degradation
- Fruit growers and puree producers are made aware of implications of growing and production of fruits specifically for brewers

Budget Narrative

The project conducted was consistent with the budget proposed by the principal investigator and approved by the State of Michigan. A contribution of \$5,000 was made by Bell's brewery as part of the original budget.