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The Impact of Yeast Assimilable Nitrogen Concentration and Composition on Fermentation Kinetics and Hydrogen Sulfide Production during Cider Fermentation

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Abstract

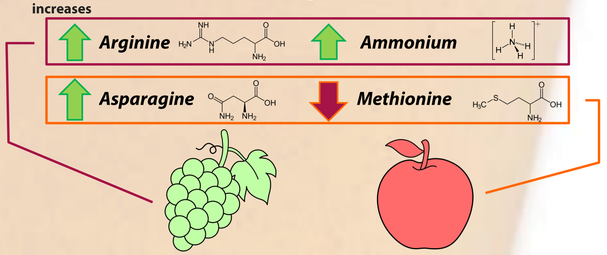
Yeast assimilable nitrogen (YAN) concentration and composition is known to significantly impact hydrogen sulfide (H_2S) production and fermentation kinetics during wine fermentation but has not been extensively studied in cider fermentations. Nitrogen-deficient apple juice was supplemented with asparagine, arginine, methionine and ammonium and fermented with two yeast strains. There was no difference in H_2S production between sources of nitrogen added as asparagine, arginine, and ammonium. Additions of methionine decreased H_2S production at concentrations as low as 5 mg L^{-1} in nitrogen-deficient juice in one yeast strain, but only high concentrations of methionine decreased H_2S production when juice was supplemented with moderate YAN concentrations, and did not influence H_2S production at high YAN concentrations. When juice was supplemented to 153 mg L^{-1} YAN there was an increase in H_2S production regardless of methionine treatment. H_2S production decreased when juice was supplemented to 253 mg L^{-1} YAN. Following sensory evaluation, panelists were able to discern differences in the aroma of samples supplemented with ammonium and methionine, which corresponds to an increase and decrease in H_2S production during fermentation, respectively.

Background & Objectives

Hydrogen sulfide (H_2S) is a prominent off-aroma formed during cider fermentations as compared to wine fermentations, suggesting differences in apple and grape chemistry may lead to differential H_2S production. One possible cause of H_2S is **yeast assimilable nitrogen (YAN)** concentration and composition. The most prominent YAN components in grapes are typically **arginine** and **ammonium**, where as the most prominent YAN component in apples is **asparagine**. Additionally, grapes typically contain higher concentrations of **methionine**, which is known to decrease H_2S, as compared to apples. As a whole, low YAN concentrations are known to increase H_2S production. The objective of this study is to investigate these differences in apple and grape chemistry on H_2S production in ciders.

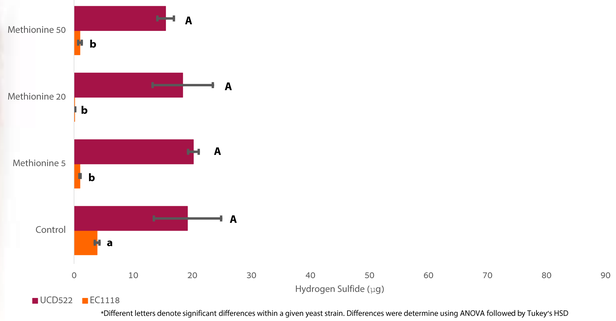
Hypotheses

- Additions of **asparagine** will lead to **higher H_2S production** as compared to additions of arginine or ammonium
- Additions of **methionine** will lead to **lower H_2S production**
- Additions of **methionine will decrease H_2S** production when total **YAN concentration increases**



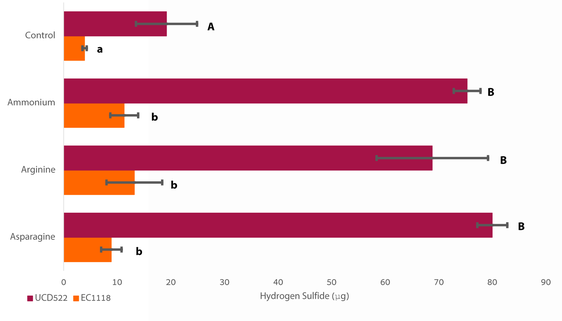
Results

Figure 1 – Total H_2S production during fermentations with added methionine*



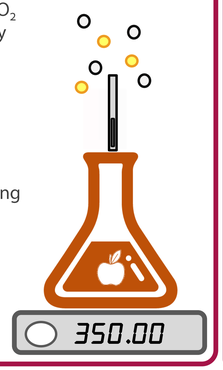
*Different letters denote significant differences within a given yeast strain. Differences were determine using ANOVA followed by Tukey's HSD

Figure 2 – Total H_2S production during fermentations with added nitrogen sources*



Methods

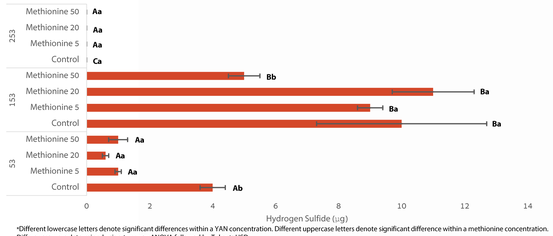
Laboratory-scale fermentations were conducted with commercially-produced apple juice fermented in 200 mL aliquots. Two yeast strains were used to represent low (EC1118) and high (UCD522) H_2S-producing commercial yeasts. Fermentation treatments were conducted in triplicate. Fermentation mass was measured twice daily to monitor fermentation rate as a proxy fro CO_2 production. H_2S production was quantified by affixing a silica-packed aspirator tube as an airlock to the fermenter. CO_2 formed during fermentation carried H_2S through the silica, creating a darkened band proportional to the total mass of H_2S produced.



Fermentations were conducted in the following treatments in two yeast strains each:

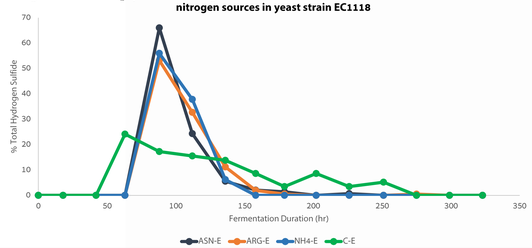
- Control with no added nitrogen
- 140 mg N/L each asparagine, arginine and ammonium
- 5, 20 and 50 mg/L methionine

Figure 3 – Total H_2S production during fermentations with added methionine at 3 YAN concentrations*

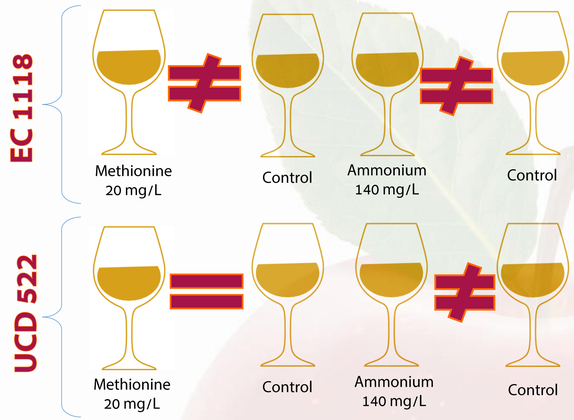


*Different lowercase letters denote significant differences within a YAN concentration. Different uppercase letters denote significant difference within a methionine concentration. Differences were determined using two-way ANOVA followed by Tukey's HSD

Figure 4 – Percent H_2S produced during the time course of fermentation for fermentations with added nitrogen sources in yeast strain EC1118



Sensory Analysis



Aroma difference testing (triangle test) was conducted on 4 sample sets, with the following results:

EC1118

- Methionine at 20 mg/L (0.6 µg H_2S) ≠ Control (4 µg H_2S)
- NH4 at 140 mg N/L (11 µg H_2S) ≠ Control (4 µg H_2S)

UCD522

- Methionine at 20 mg/L (19 µg H_2S) = Control (18 µg H_2S)
- NH4 at 140 mg N/L (75 µg H_2S) ≠ Control (18 µg H_2S)

Conclusion

Based on the results of this study and given our hypotheses, we can make the following conclusions:

- There is **no difference in H_2S production** between nitrogen sources **ammonium, arginine and asparagine**
- In one yeast strain, additions of **methionine decrease H_2S** at all concentrations
- **Increasing YAN concentration decreases the beneficial effects of methionine**
- Contrary to general practice, **moderate YAN concentrations** (153 mg/L) **increased H_2S** as compared to low (53 mg/L) or high (253 mg/L) YAN
- There are **perceived aroma differences** correlating to treatments with both **increased and decreased H_2S production**

These results indicate that the differences in apple and grape chemistry may lead to differences in H_2S production during cider fermentation. Although primary nitrogen source does not affect H_2S production, low concentrations of methionine observed in apples may lead to increased H_2S production. Cidermakers should be aware of the adverse effects of low YAN concentrations on cider aroma and quality. The beneficial effects of methionine may lead to the production of yeast nutrients which can inhibit H_2S production during cider fermentation.

Acknowledgements

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