A Closer Look at Diacetyl

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EDITION 5/2015

Outline

What is VDK?

Where is diacetyl present?

Why does diacetyl occur?

How to avoid it in your brewery

Diacetyl in different products

Vicinal Diketones (VDK)

Two major compounds

- 2,3 butanedione (Diacetyl)
- 2,3 pentanedione

- Both have similar flavor and aroma descriptions- butterscotch
- Flavor threshold is ten times less for diacetyl
- (i.e- if you can taste 50 ppb of diacetyl, typically you can taste 500 ppb of 2,3 pentanedione)

Diacetyl will always be present in a fermentation

Diacetyl is a part of fermentation and will always be there – the residual amount is dependent on the quality of the fermentation

Diacetyl is acceptable in some styles – typically top fermented is most common (up to 600 ppb)

Also very apparent in wines (8000 ppb)

Diacetyl is produced in 2 ways

1) Yeast Metabolism

- During yeast growth in fermentation
- When the yeast has to make a specific amino acid - valine
- An intermediate in this pathway is the pre-cursor of diacetyl
- The precursor leaks out of the cell
- Outside the cell it is CHEMICALLY converted to diacetyl
- The reaction is favored by high temperatures and low pH
- It goes back into the cell as diacetyl
- The yeast changes it into less flavor-active compounds

2) Insufficient reduction of diacetyl from yeast

3) Lactobacillus and Pediococcus spp contamination

- For a long time, it was thought that all diacetyl came from the “disease of beer” (Early 1930s)
- Good example of this is Greek yogurt
  Sour milk aroma is diacetyl in very high concentrations

YEAST FLAVOR DEVELOPMENT

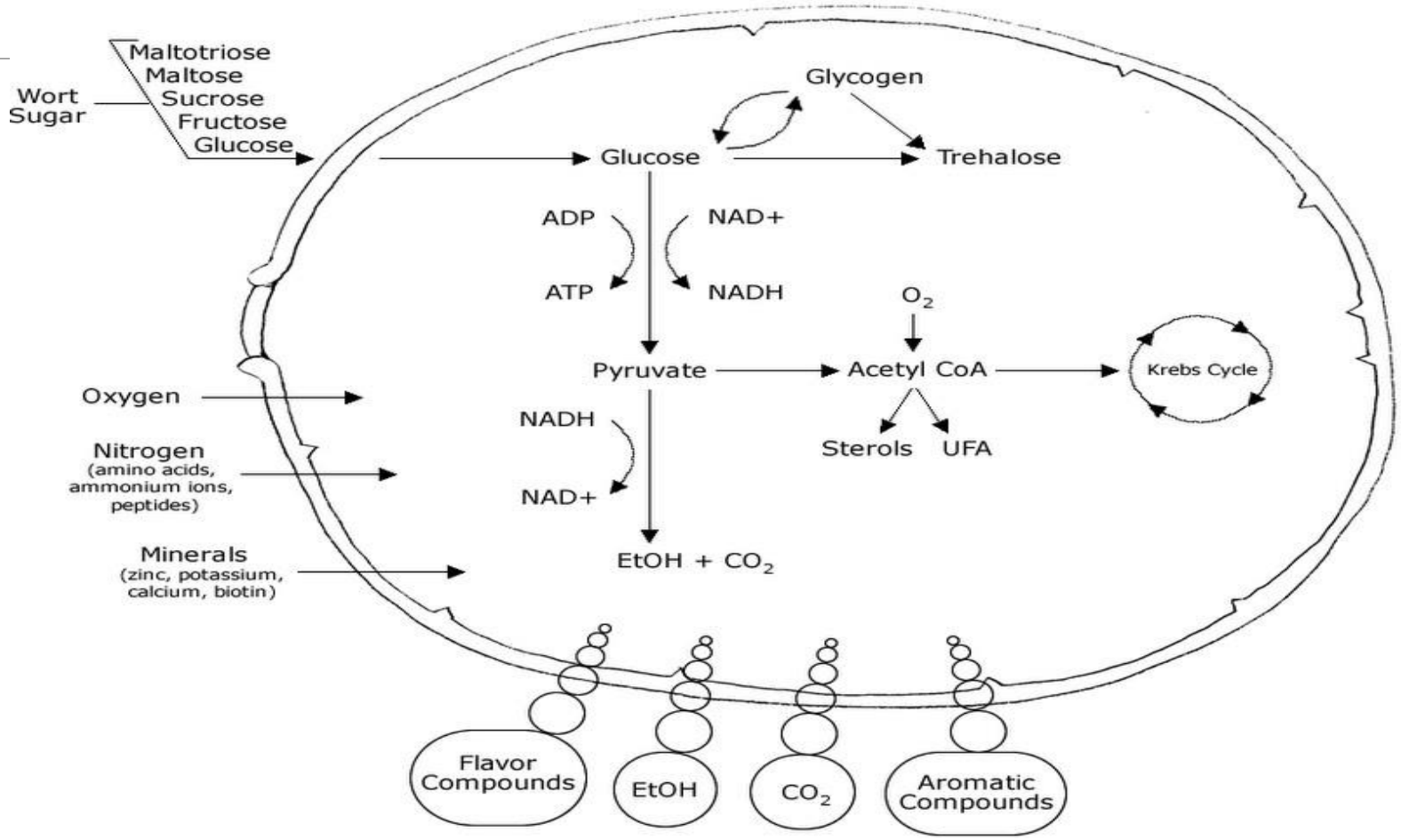


Fig 2.3 Yeast: The Practical Guide to Beer Fermentation, White and Zainasheff 2010

Why does yeast make this compound?

First and foremost : Valine synthesis

- Yeast needs amino acids to create proteins
  - These can typically be assimilated from the wort
  - In worts low in FAN, yeast have to make more amino acids like Valine
  - Research shows worts low in FAN, higher levels of Diacetyl are seen (Quain 2006)

If there is excess valine, acetolactate production will stay low

-Almost impossible to get rid of all diacetyl in high amounts because of low FAN

Excess alpha acetolactate is re-absorbed by the yeast though multiple processes

Why? Generates NADH needed to make energy

Enzymatic vs Non Enzymatic?

Why is this important?

The transition from alpha acetolactate to diacetyl happens outside of the cell – meaning no enzymes available from the yeast

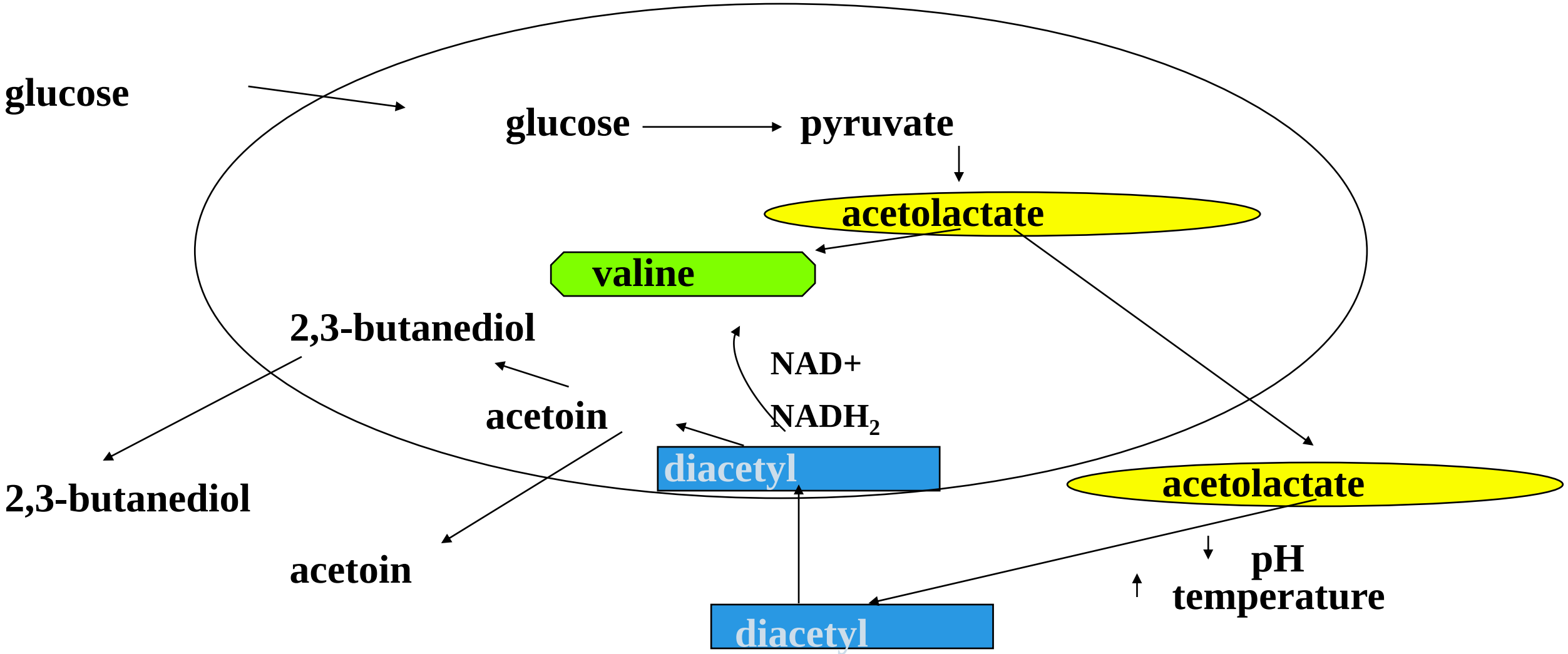
Therefore the reaction is chemical (oxidative) and temperature is important

When you raise temperature- reactions will happen quicker

I.e- Diacetyl Rest : Increase in temp is necessary to convert

Research shows that yeast will quickly reabsorb Diacetyl

DIACETYL


glucose
glucose
pyruvate
acetolactate
valine
2,3-butanediol
NAD+
NADH2
acetoin
diacetyl
acetolactate
2,3-butanediol
acetoin
pH
temperature
diacetyl

Diacetyl: Total vs As-is

Why does a beer develop a butter aroma 6 weeks after shelf life?

- - Alpha acetolactate precusor

Precursor is turned into diacetyl from heat so a keg sitting at 50F for several weeks will slowly develop the off flavor

How to prevent this?

Test every batch for diacetyl before crashing

There’s no real cure after the yeast has been taken off of the beer

Strain Specifics

What beers do we see this most commonly?

- Lagers – temperature issues
- English Ales – flocculation issues

Some research has show that some strains can produce more precursor than others, but not well categorized (Research mostly done on lager strains)

Recognize that not all strains are created equal- you will have to play around with conditioning times

Don’t expect all ales to be one way and lagers another

Contamination

- Wild yeast has little to no effect on diacetyl issues
- *Lactobacillus* and *Pediococcus* both produce diacetyl

- Alpha acetolactate formation is different than brewers yeast and therefore much more is produced.
  - Even a small amount of contamination will produce a strong diacetyl aroma
  - Brewers yeast will not “clean up” the amount of diacetyl present. Prevention is the only cure

Forced Diacetyl Testing

Forced Diacetyl testing:

Collect two fermentor samples, heat one for 30 mins at 60C. Cool both samples to room temperature and do a side by side comparison

Do not microwave!

Smelling them warm can be difficult because of the amount of ethanol given off

Analytical Methods:

VDK Testing with a spectrophotometer- requires distillation equipment

Gas Chromatography

Diacetyl Troubleshooting

If you have high amounts of diacetyl:

Recirc- Pump CO_2 to recirculate yeast throughout the beer to increase contact

If you have high amounts of pre-cursor:

Raise the temp

Fermentation specs to analyze if you're having issues:

- Fermentation time
- Yeast strain
- pH – lower than 4.8
- Health of yeast
- Temperatures
- Time
- FAN

Sensory

Admit if you are blind to diacetyl !

You can learn to identify it by practicing

Diacetyl seems to change shape when in different styles of beers

- Ie- caramel, butter, butterscotch

- Reported thresholds at 50 **ppb** to 200 **ppb**. Remember that most of this research has been done on light lagers!

Summary

Diacetyl is formed by an oxidative reaction and is speed up by acidic pH and warmer temps

Diacetyl is quickly absorbed by yeast but rousing may be necessary to increase surface area

Keep in mind that several aspects are responsible for diacetyl (Yeast health, strains, sanitation, pH, temperatures) Go through the checklist when you're having issues.

Test your fermentors, it's super easy and fast! Find the person that's really sensitive and use them (or multiples) as a marker.

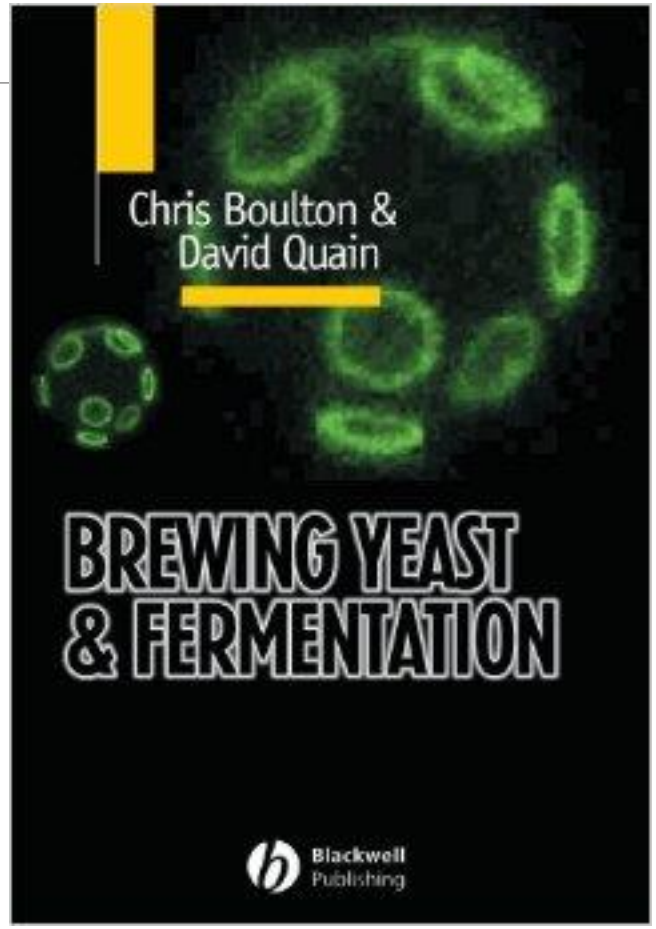
Resources

Brewing Yeast and Fermentation

(Boulton and Quain, 2006)

Yeast: The Practical Guide to Fermentation

(Chris White and Jamil Zainisheff, 2010)



Thanks!

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PURE YEAST & FERMENTATION