ROASTED MALTS FOR SCOTCH MALT WHISKY:

AROMA DEVELOPMENT DURING FERMENTATION

Rūtelė Marčiulionytė
PhD student

ASBC
THE SCIENCE OF BEER

BREWING SUMMIT 2022
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Origins of flavour in Scotch whisky

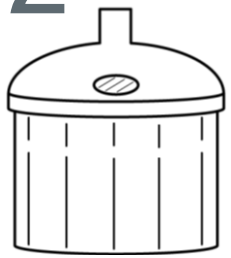
1

MALTING

Grain type and origin

Peat and its origin

2

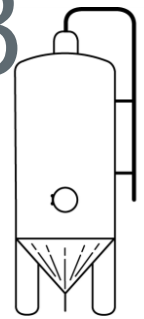


MASHING

Wort clarity

Wort gravity

3



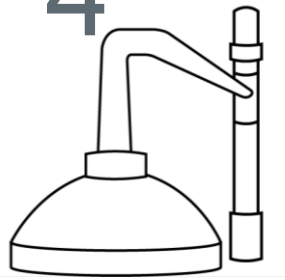
FERMENTATION

Yeast type and strain

Duration

Washbacks: wild yeast and bacteria

4



DISTILLATION

Spirit cuts

Still type

Still shape

Condenser type

Times distilled

5

MATURATION

Predecessor liquid

Cask size

Wood type

Toasting/charring

Cask reuse

Maturation time

6

BOTTLING

Blending

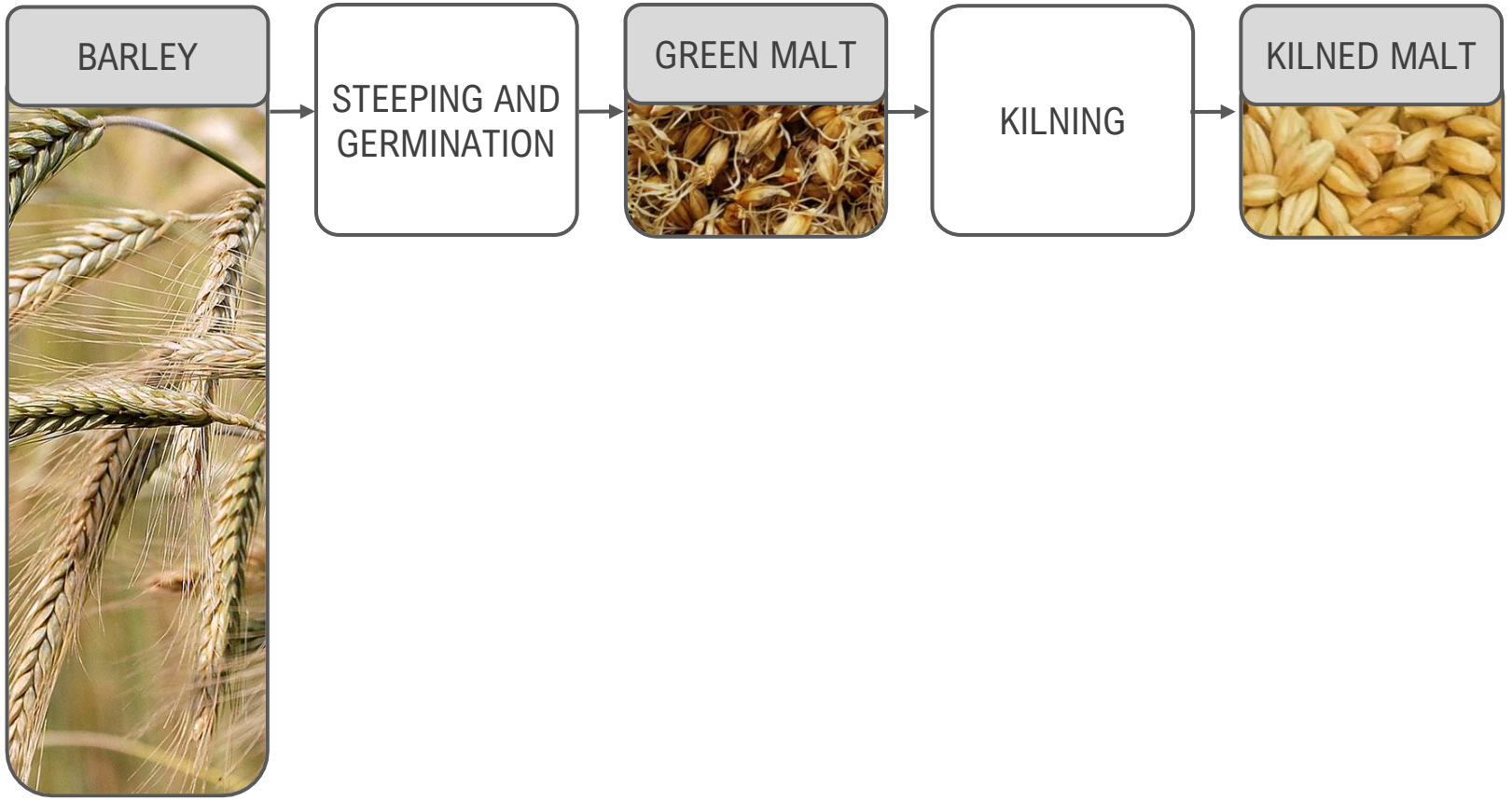
Dilution

Colouring

Filtration

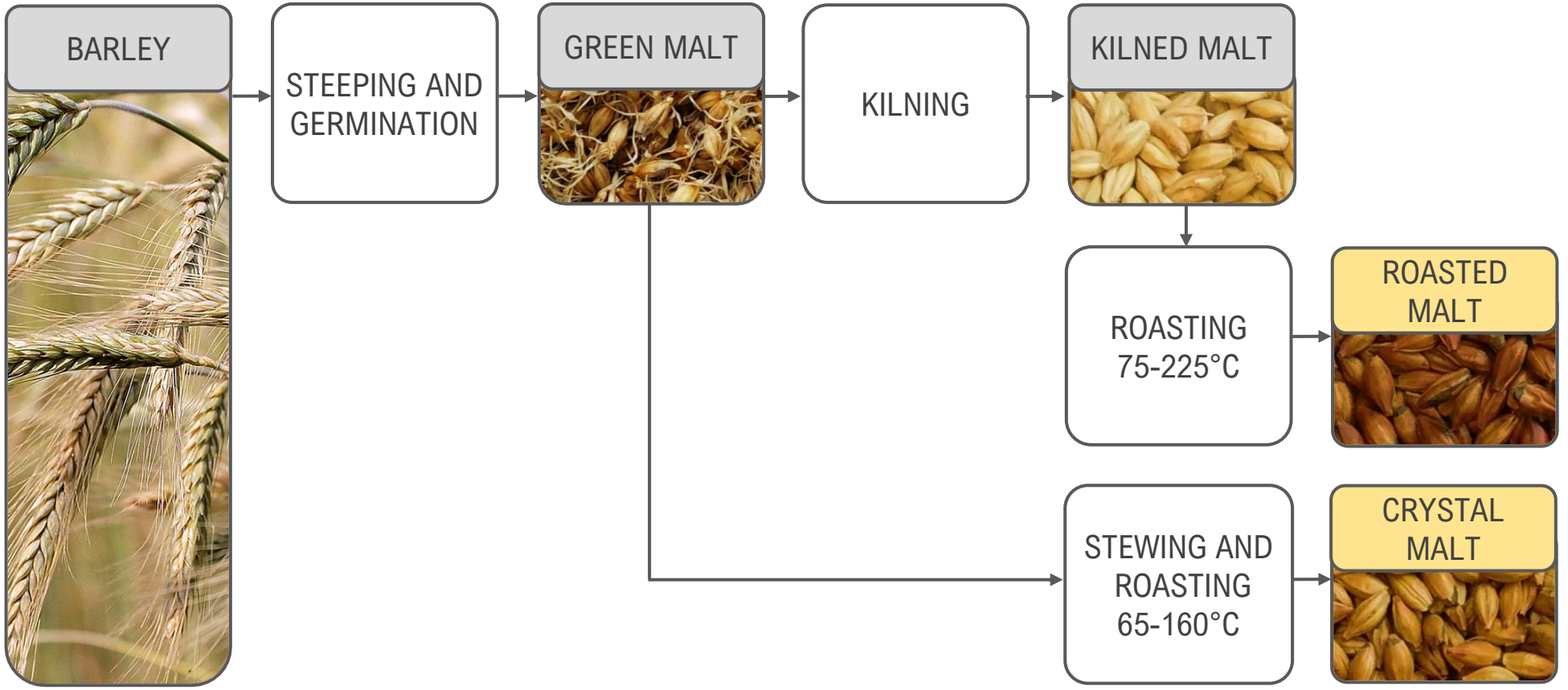
Rūtelė Marčiulionytė (Heriot-Watt University, Edinburgh, UK)

Distiller's malt



Colour: 2-50 EBC
Flavour: grassy, green, cereal, malty
Uses: brewing and distilling

Specialty malts



Colour: 2-50 EBC
Flavour: grassy, green, cereal, malty
Uses: brewing and distilling

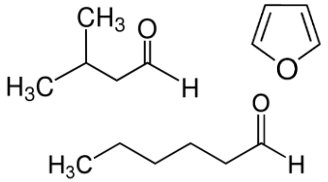
Colour: 40-1400 EBC
Flavour: biscuits, nuts, chocolate, coffee, smoky
Uses: ales, porter, sweet stout

Colour: 20-500 EBC
Flavour: sweet, toffee, burnt sugar, dried fruit
Uses: ales, bock, bitter, barley wine

Roasted malts

65-70°C
LIGHTLY
KILNED MALT

aldehydes, furans

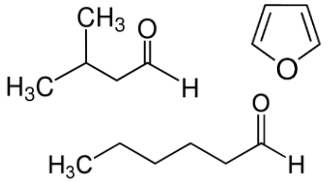


Roasted malts

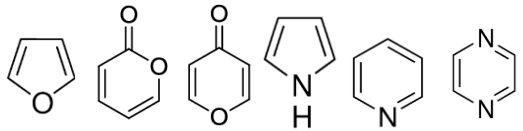
65-70°C
LIGHTLY KILNED MALT

>50°C
MAILLARD REACTION
(initiated by condensation of amine and reducing sugar)

aldehydes, furans



furans, pyrones, pyrroles, pyridines, pyrazines



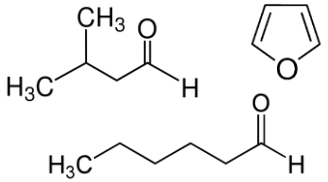
Roasted malts

65-70°C
LIGHTLY KILNED MALT

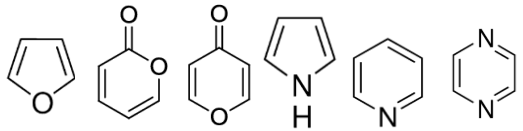
>50°C
MAILLARD REACTION
(initiated by condensation of amine and reducing sugar)

120-200°C
CARAMELISATION
(sugar dehydration)

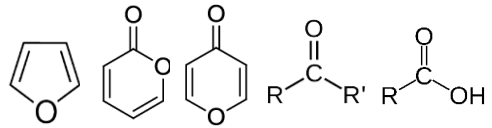
aldehydes, furans



furans, pyrones, pyrroles, pyridines, pyrazines



furans, pyrones, carbonyls, acids



Roasted malts

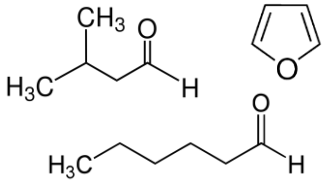
65-70°C
LIGHTLY KILNED MALT

>50°C
MAILLARD REACTION
(initiated by condensation of amine and reducing sugar)

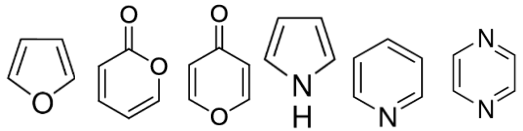
120-200°C
CARAMELISATION
(sugar dehydration)

>220°C
PYROLYSIS
(thermal decomposition)

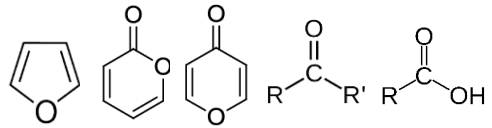
aldehydes, furans



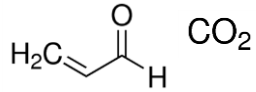
furans, pyrones, pyrroles, pyridines, pyrazines



furans, pyrones, carbonyls, acids



small organic molecules, carbonaceous char



What we know about roasted malts already

Roasted Malt for Distilling: Impact on Malt Whisky New Make Spirit Production and Aroma Volatile Development

Rūtelė Marčiulionytė[a], Colin Johnston[b], Dawn L. Maskell[a], Jack Mayo[c], David Robertson[c], David Griggs[b] and Calum P. Holmes[a]

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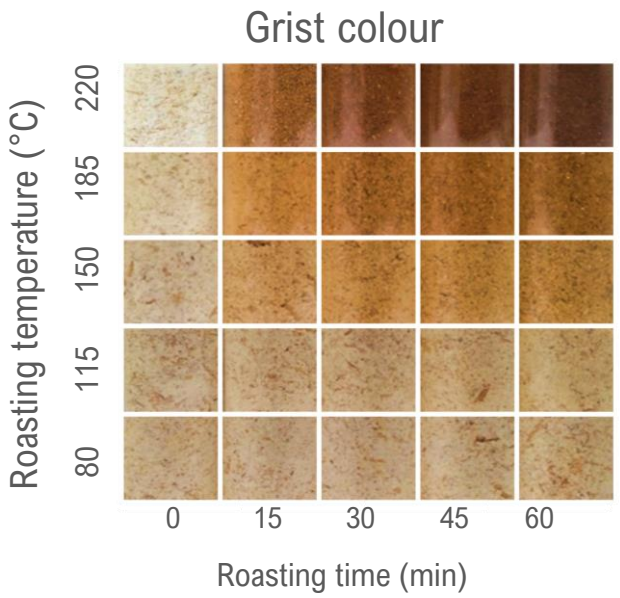
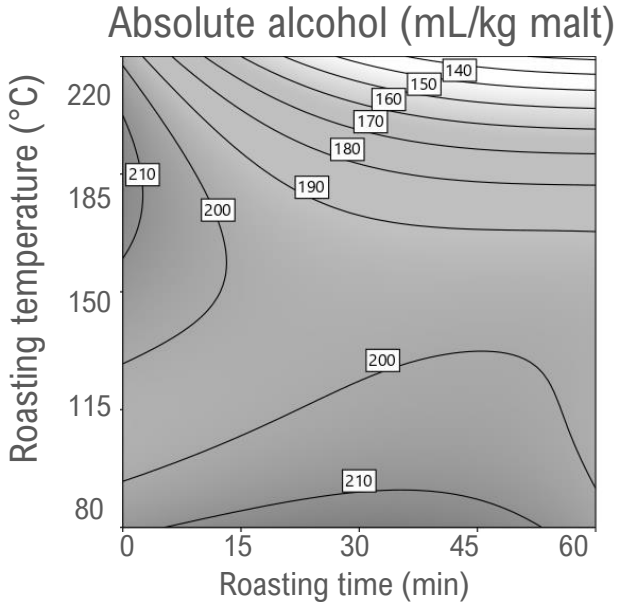
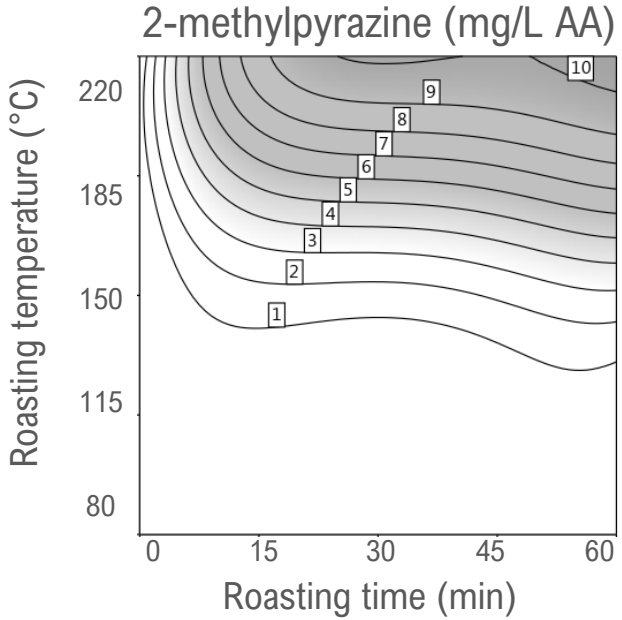






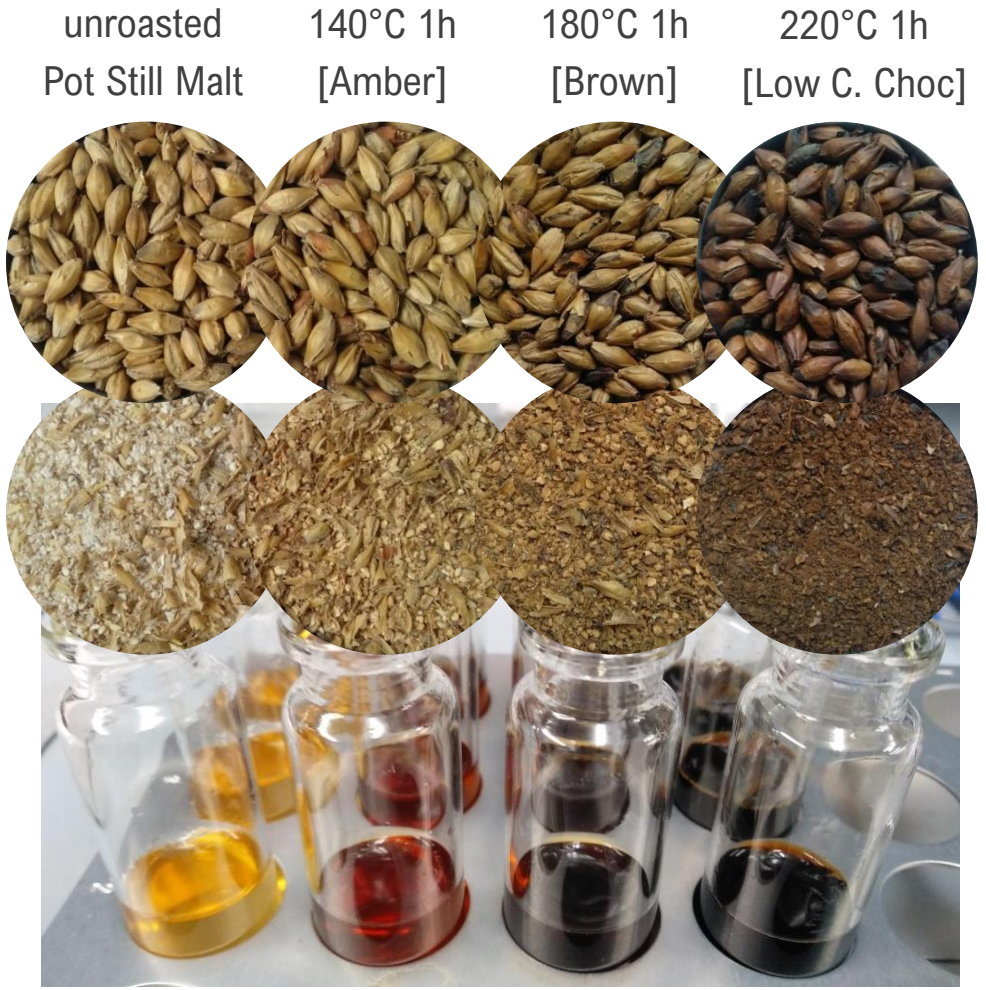
Roasted malts and aroma development in yeast

Malt roasting creates new aromas.

Aromas are retained throughout the spirit production

How does yeast react to roasted malt?

- wort/wash quality characteristics
- yeast health
- yeast gene expression
- generation of aroma volatiles



Wash production

MALT (30% roasted)

mill
0.7 mm

GRIST

add water, mash
for 1h at 65°C
(EBC 4.6)

MASH

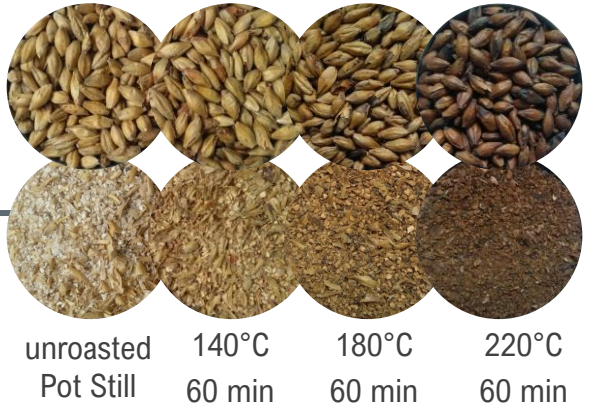
filter

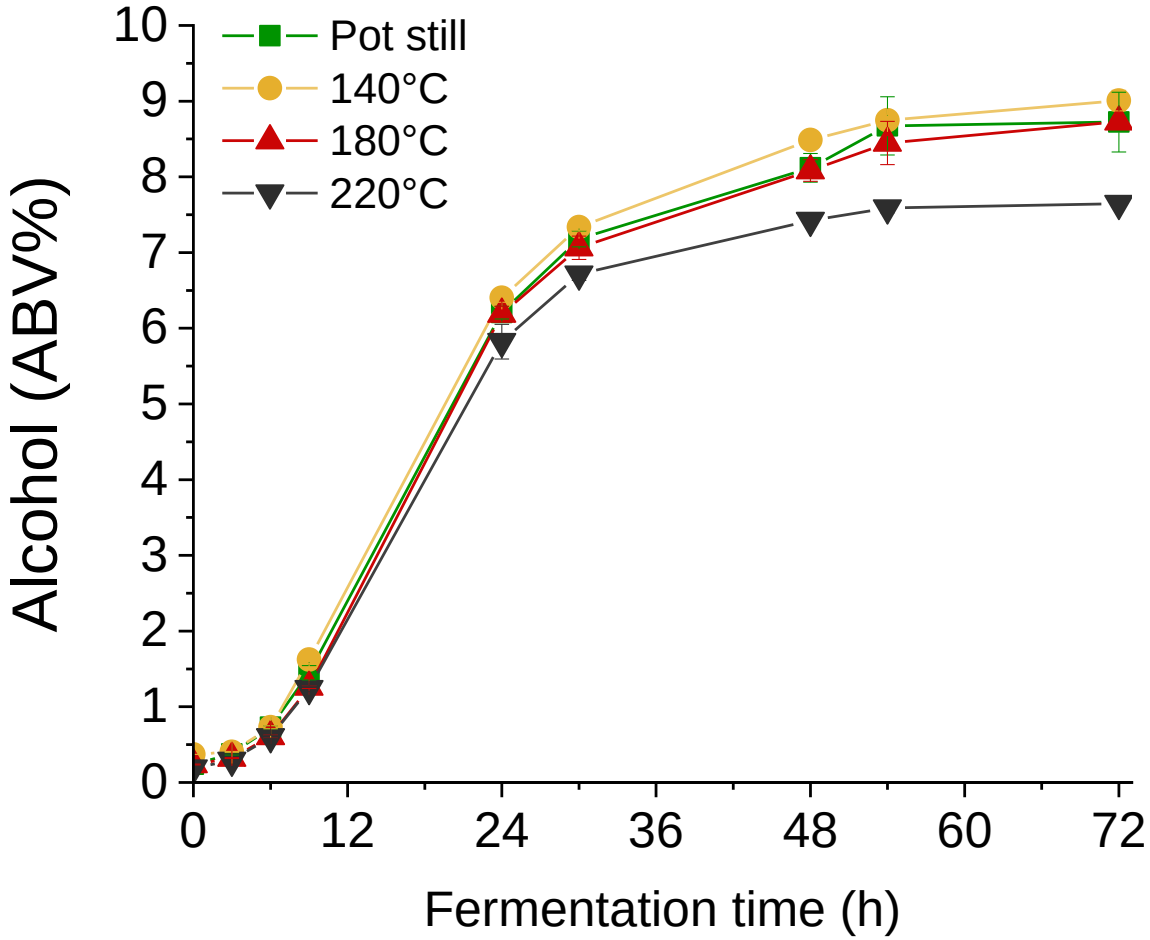
WORT

add 1g/L DY502
yeast, ferment
for 72h at 30°C

WASH (~9% ABV)

Wort - wash quality



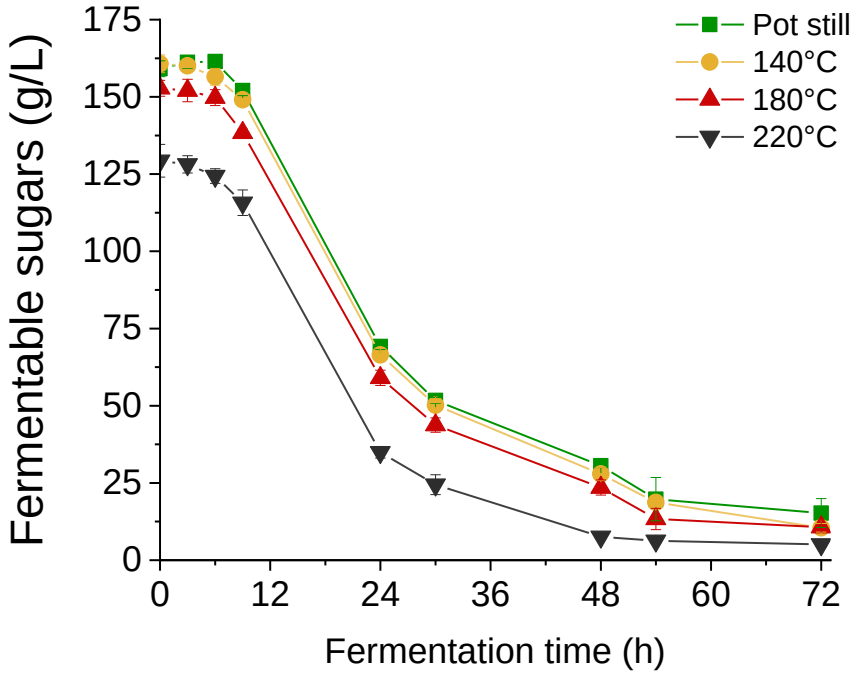


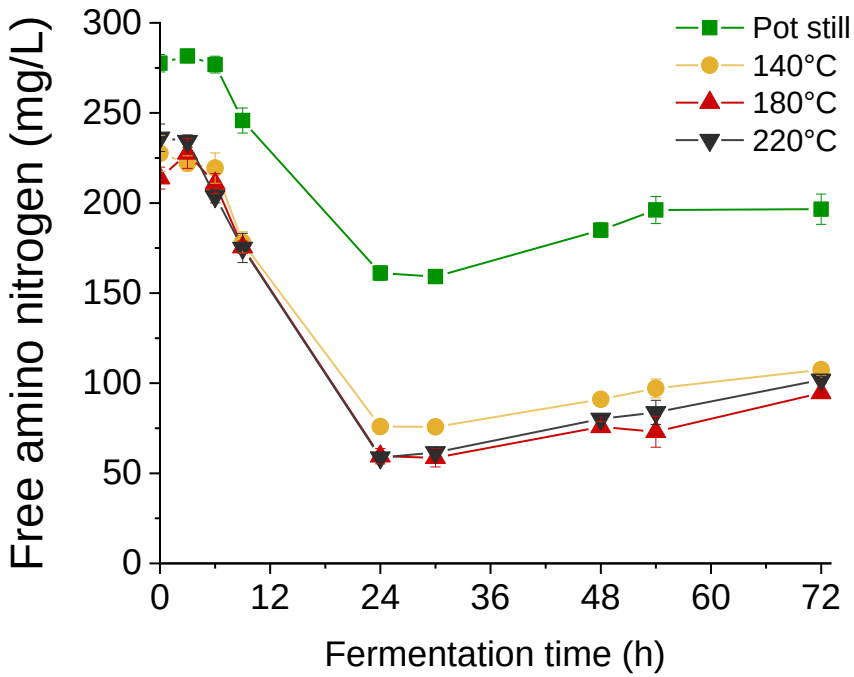
Alcohol yield (compared to unroasted):

- preserved in low/medium roasts
- 12% lower in dark roast inclusion (30% w/w)

Why?

Wort - wash quality





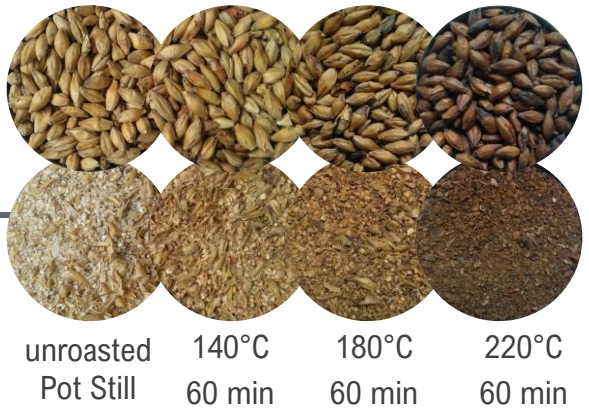
Sugars (for ethanol production):

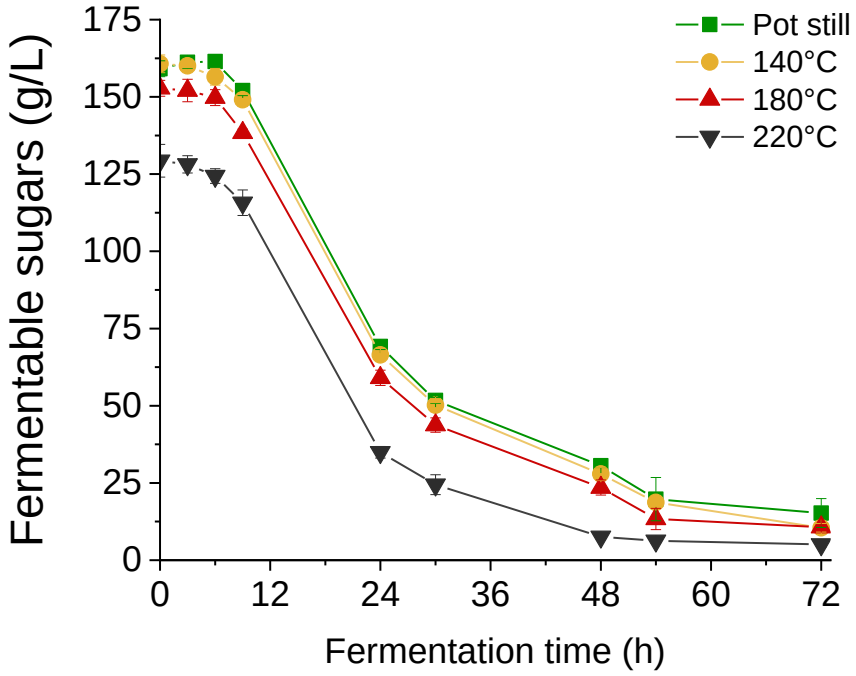
- preserved in low/medium roast wort
- 19% lower in dark roast wort

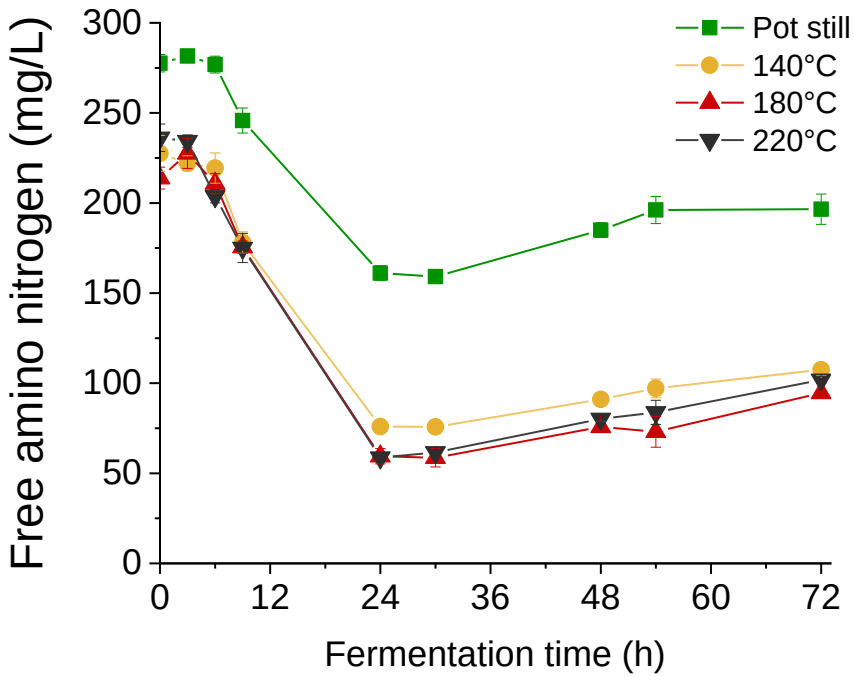
FAN (for yeast growth and aroma volatiles):

- ~20% lower in wort from any roast
- ~40% higher consumption in any roast

Wort - wash quality







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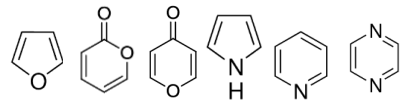
Why?

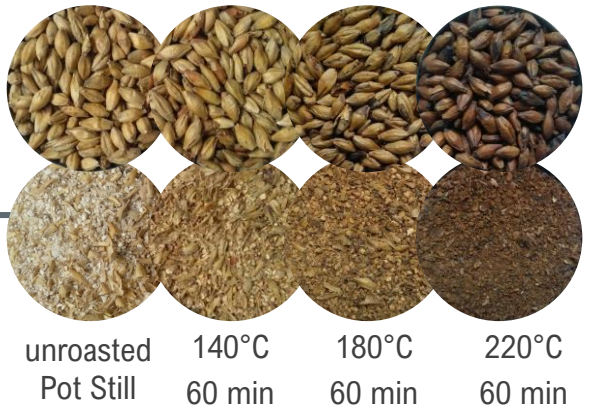
MAILLARD REACTION

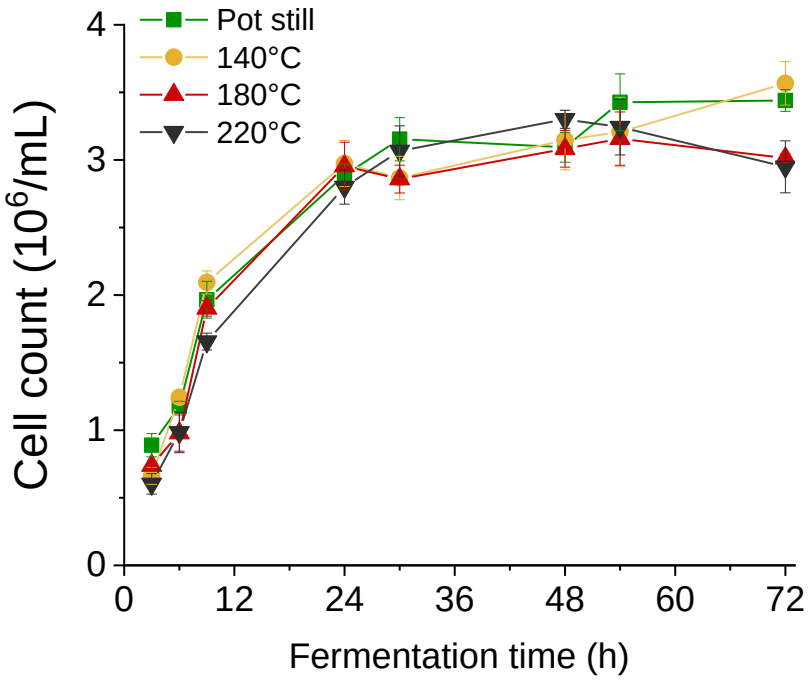
(initiated by condensation of amine and reducing sugar)

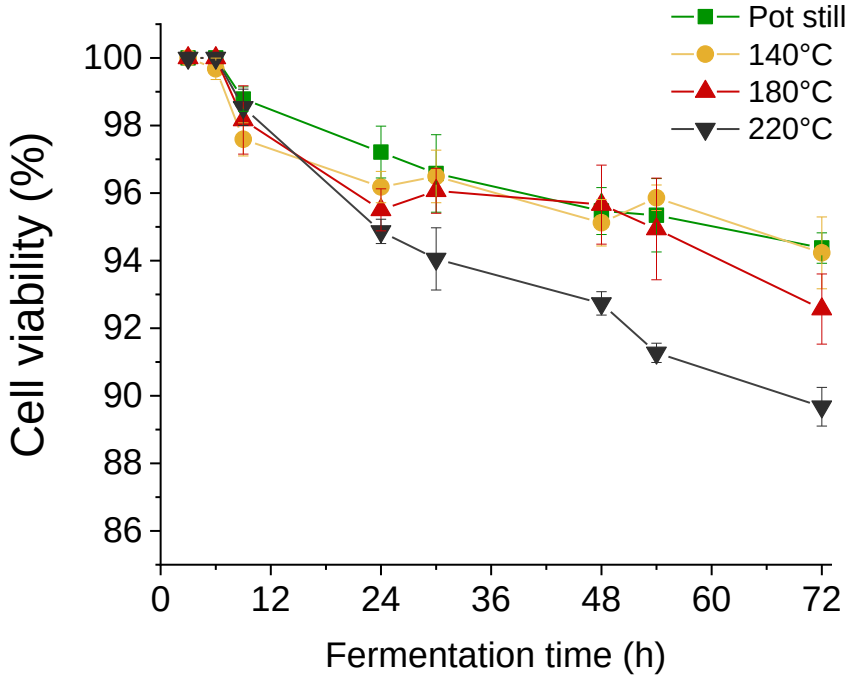
furans, pyrones, pyrroles, pyridines, pyrazines



Yeast health





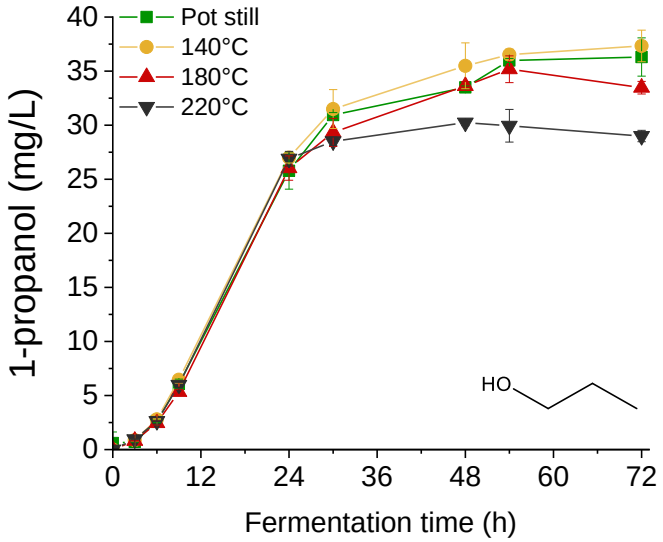


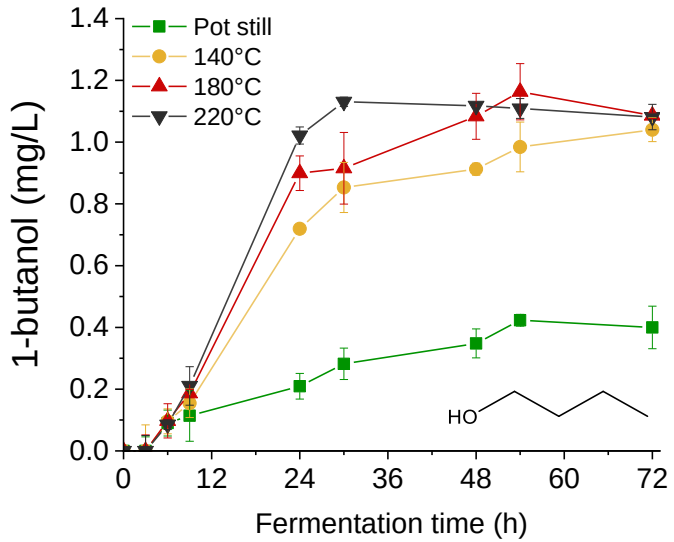
Other observations:

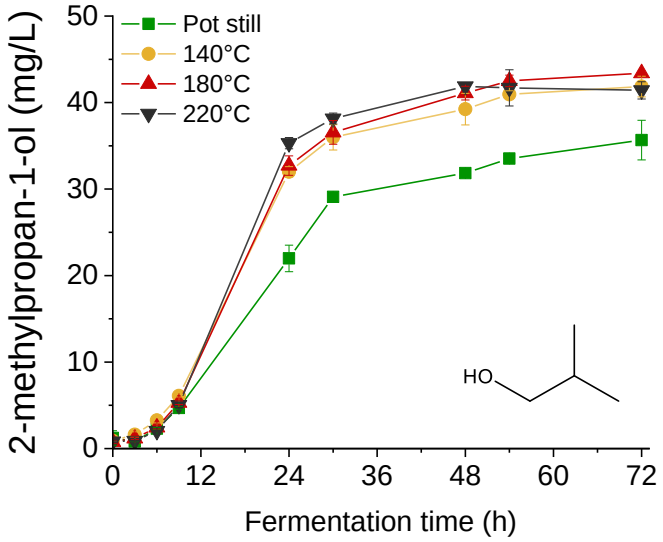
- Darker worts are lower in pH (by 0.4)
- Yeast in 220°C roast produces 25% more glycerol than in unroasted wort

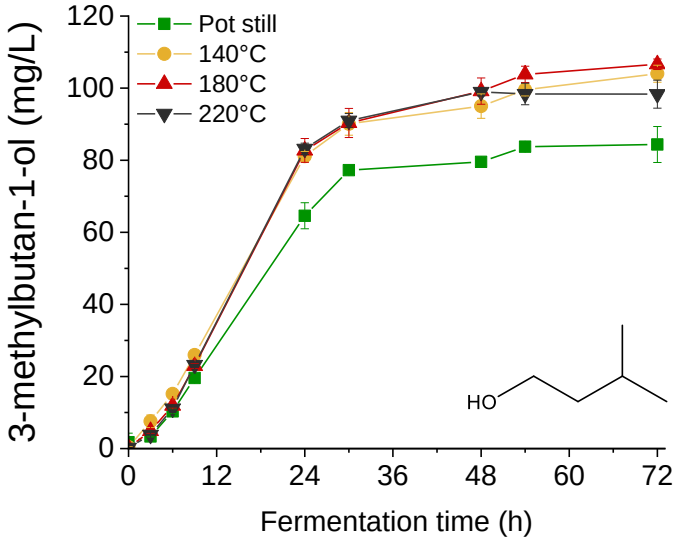
- 14% fewer cells in medium/dark wort
- yeast in dark wort ~4% less viable
- cells die, burst and can be re-digested

Aroma volatiles (GC-FID)









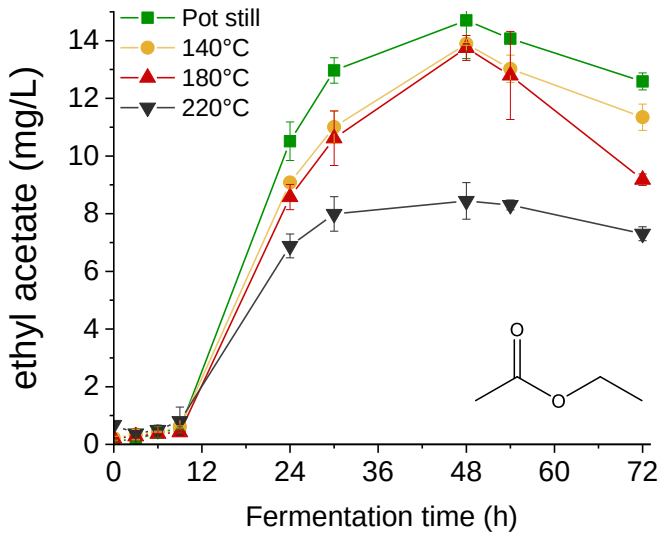
Higher alcohols

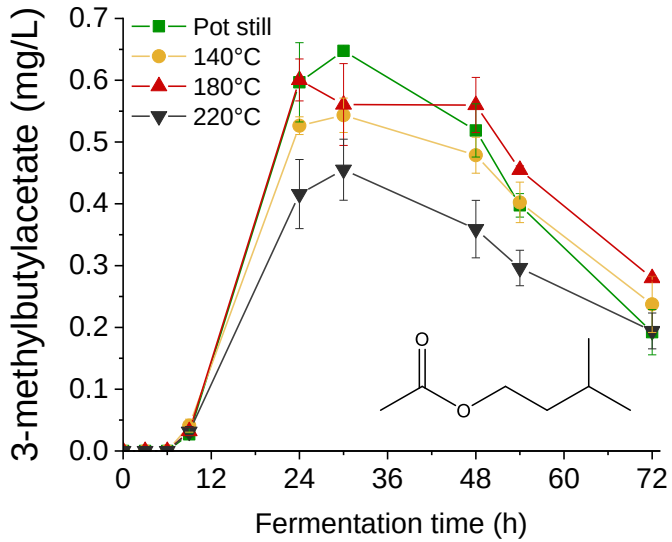
Products of amino acid metabolism by yeast (the Ehrlich pathway)

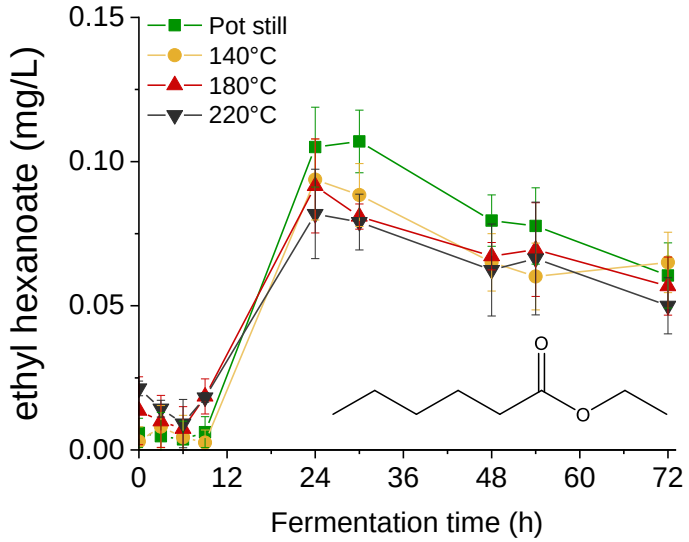
Smell like:

- Propanol: lower concentration in dark roast wash
- Other alcohols: higher concentrations in any roasts

Aroma volatiles







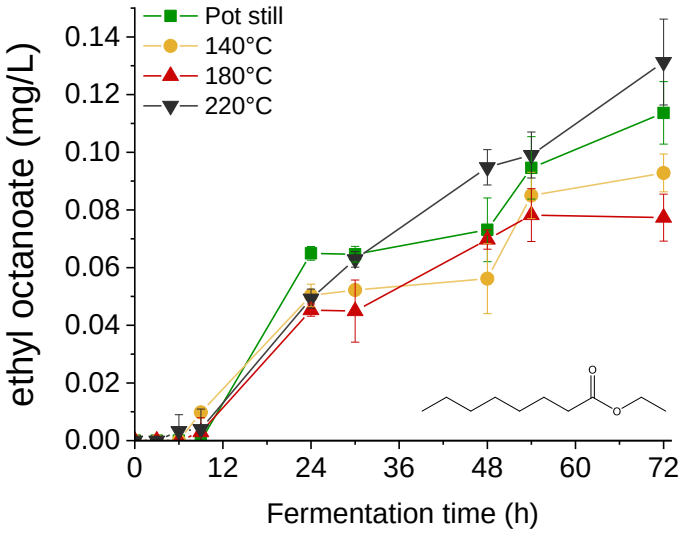
Short/medium chain esters

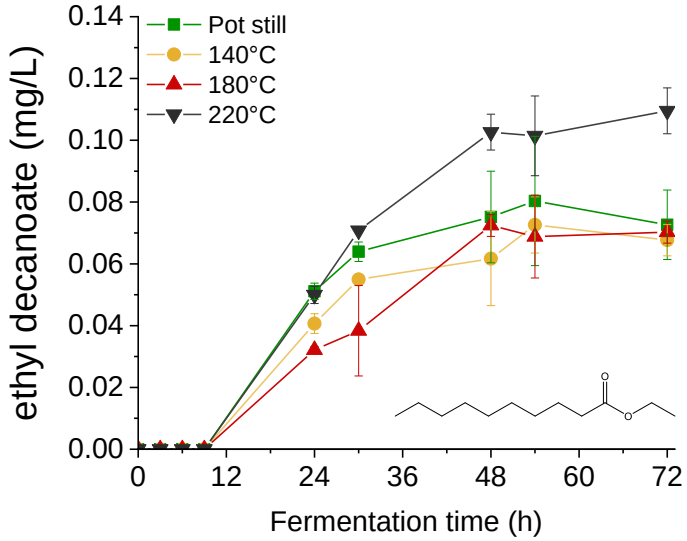
Products of acetyl-CoA and alcohol reaction in yeast

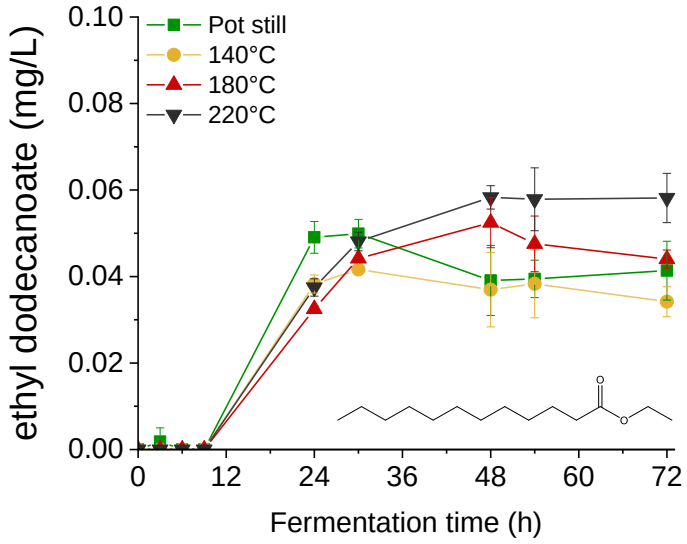
Smell like:

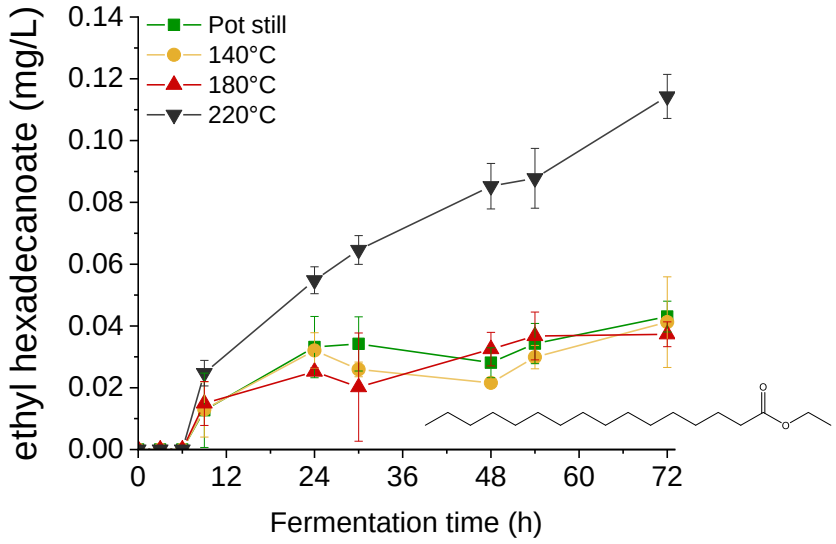
- Lower concentration in dark roast wash

Aroma volatiles









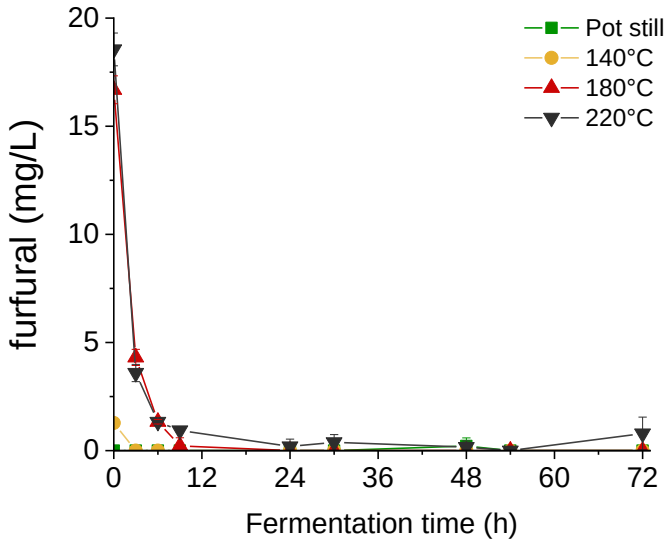
Long chain esters

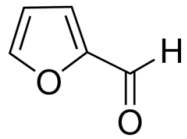
Products of ethanol and long-chain fatty acid reaction in yeast

Smell like:

- Higher concentration in dark roast wash

Aroma volatiles (GC-FID)



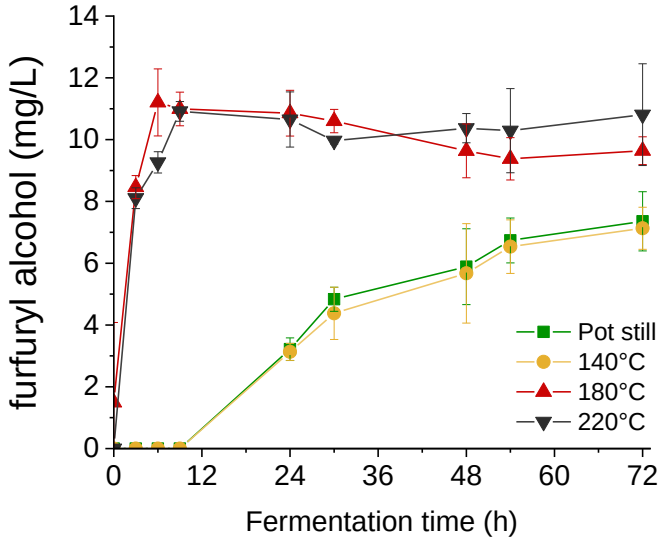


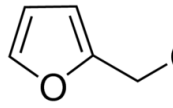
Furfural

Produced during malting & roasting through caramelisation and Maillard reactions.

Can damage cell growth, reduce enzymatic and biologic activities, break down DNA, and inhibit protein and RNA synthesis.

- High concentrations in medium/dark roast worts
- Metabolised immediately (0-6 hours)



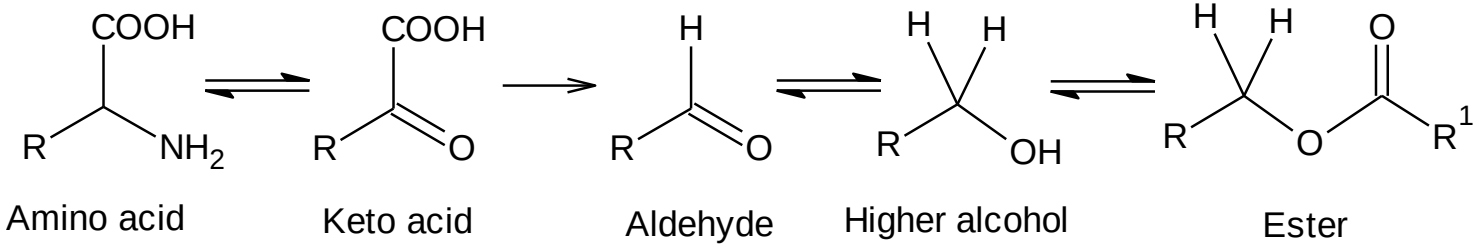


Furfuryl alcohol

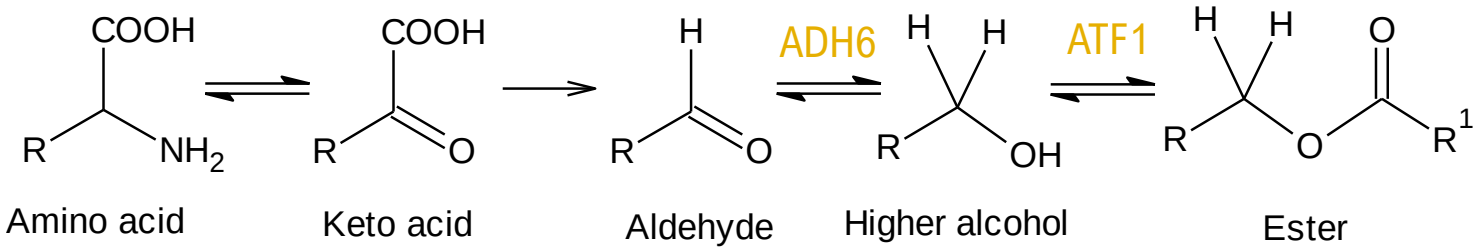
Product of furfural detoxification.

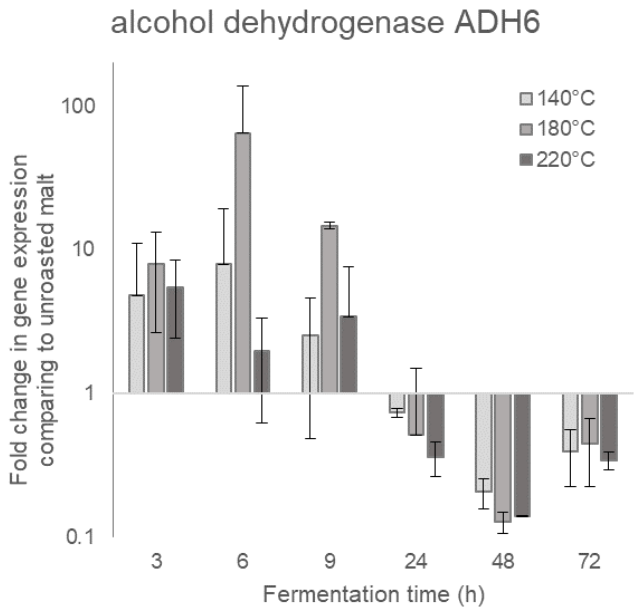
- Produced immediately (0-6 hours)
- Higher concentrations in medium/dark roast washes

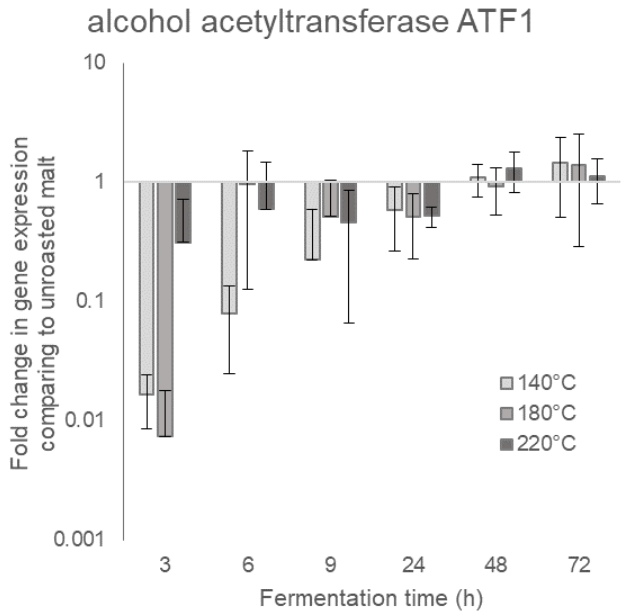
Yeast gene expression



Yeast gene expression







Take-away

Roasted malts:

- provide roasted aromas
  - mainly through furans and pyrazines
- contain less sugars and amino acids
- impact yeast-produced aromas
  - increase in higher alcohols
  - increase in long chain esters
  - decrease in short chain esters
  - substrate availability
  - enzyme activity
  - gene expression
- make a delicious spirit!

Thank you for your attention

Rutele Marciulionyte

PhD student

rm252@hw.ac.uk

linkedin.com/in/rutele-m/

Dr Calum Holmes

Project supervisor

c.holmes@hw.ac.uk

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