To:	Macpherson Trustees Maltsters' Association of Great Britain 31b Castlegate Newark NG24 1AZ
From:	Maria Josey Heriot Watt University Currie, U.K. EH14 4AS
Date:	1 June 2016
Re:	Report on Ph.D. travels to the Young Scientists Symposium in Chico in April, 2016

I would like to thank the Macpherson Trustees for granting the award of £500 for my attendance and presentation at the Young Scientists Symposium in Chico in April, 2016. The generous award covered my registration fees to the conference and the accommodations while at the symposium.

I presented my findings that correlated the increase in certain flavour compound levels post fermentation to how rapid that fermentation had progressed (See Appendix 1). The environment and general aura of the symposium was positive and it served as great practice before I go on to present new research findings at the World Brewing Congress in August, 2016. Presenting at this symposium helped me gain the confidence to present in front of academics and people from the industry. As well, with the supportive crowd at the Young Scientists Symposium, I gained constructive feedback that will help make my research better and improve future presentations. Since the conference, I've been back at Heriot Watt University and giving smaller presentations to colleagues and supervisors. I've already noticed an improvement in my public speaking and presentation skills showing more confidence and clarity than before.

As well as gaining experience presenting, the conference itself was a great experience. I learned about the on-going research in my area at other universities in Germany, Finland, and a few other countries (See Appendix 2). I also got to hear and learn about on-going brewing and distilling research that was outside my area. One presentation that I found very interesting was discussing the use of glycosidic enzymes to optimize hop aroma when dry hopped. There was also wonderful work being done on determining different perceived aromas with chemical compounds and detecting them with GC-MS/MS. Along with the presentations, I thoroughly enjoyed touring the brewery and laboratories at Sierra Nevada Brewery. It was great to see a brewery at that size and see all their efforts and commitment to becoming as sustainable as possible including growing some of their own hops and installing a composter called the "hot rot" that produced a small amount of biodiesel!

Coming from a new academic perspective, this conference specifically was excellent because it was at a brewery. It provided me the opportunity to see some of the types of jobs in the industry available for a Ph.D. graduate.

Again, many thanks for granting this award allowing me to have this unforgettable experience.

All the best,

Maria Josey
Ph.D Candidate
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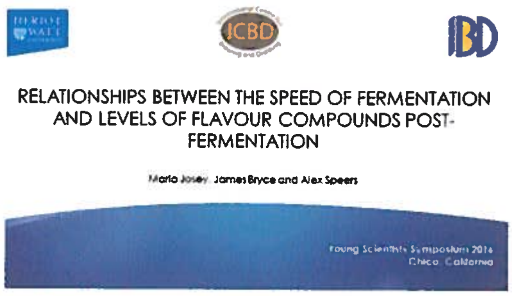
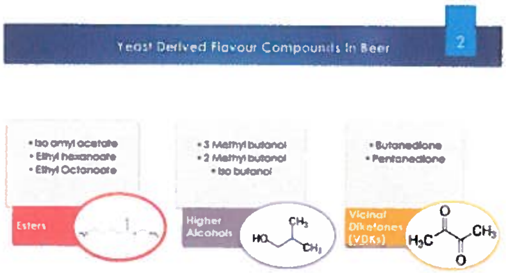
EH14 4AS

Appendix 1
PowerPoint Slides from Presentation





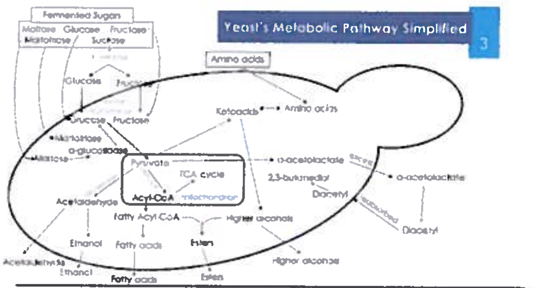
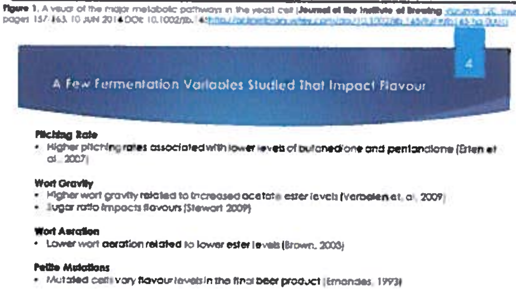
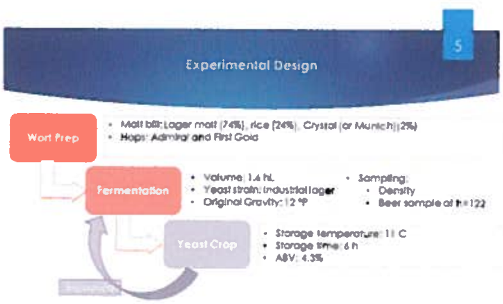


Figure 1. A visual of the major metabolic pathways in the yeast cell (Journal of the Institute of Brewing, pages 157-163, 10 JUN 2014 DOI: 10.1002/jib.14)





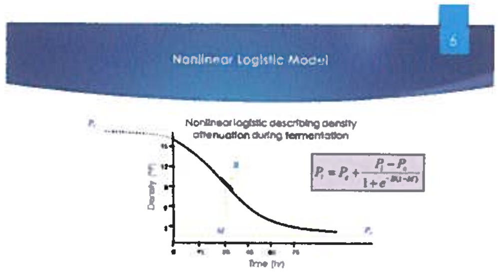
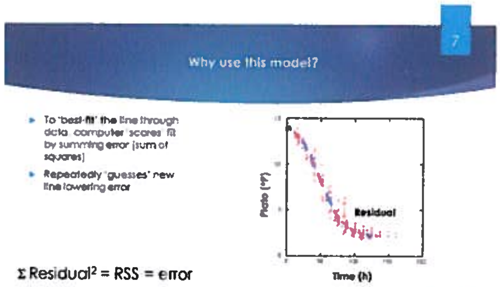


Figure 2. Fermentation Nonlinear Logistic from ASBC Yeast 14



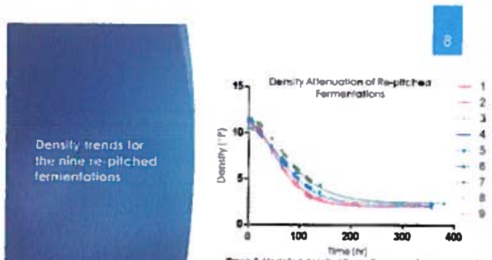


Figure 3. Modelled density attenuation curve for nine re-pitched fermentations

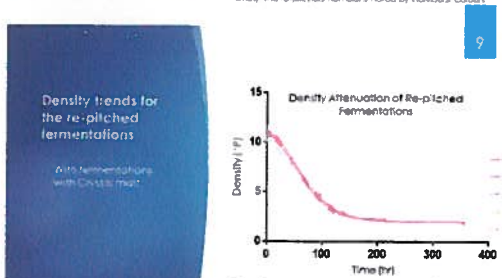


Figure 4. Modelled density attenuation curve for re-pitched fermentations that contained 2% Crystal malt

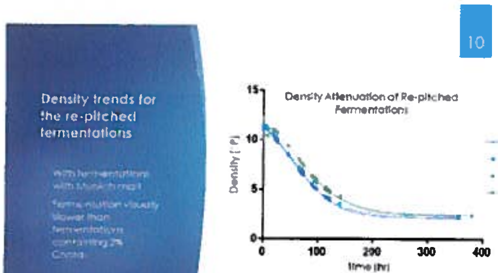


Figure 5. Modelled density attenuation curve for re-pitched fermentations that contained 2% Munich malt

11 Flavour Compounds and Re-pitched Number

- No obvious trends related to the re-pitched number

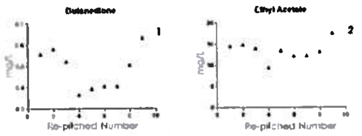


Figure 6. Butanedione (1) and ethyl acetate (2) levels present at the end of fermentation for nine re-pitched fermentations

12 Flavour compounds correlated to the function of the slope (B) at the midpoint

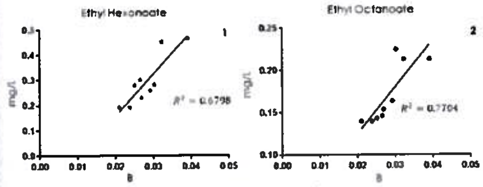


Figure 7. The function of the slope (B) at the midpoint of the fermentation correlated to ethyl hexanoate (1) and ethyl octanoate (2) at the end of fermentation

13 Similar trends found with ethyl butyrate, and iso butyl acetate

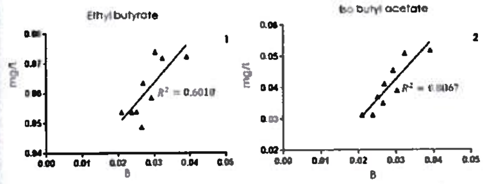


Figure 8. The function of the slope (B) at the midpoint of the fermentation correlated to ethyl butyrate (1) and isobutyl acetate (2) at the end of fermentation

14 Effect that the function of the slope (B) has on butanedione and pentanedione levels

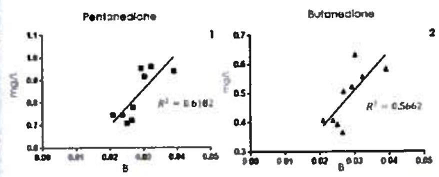


Figure 9. The function of the slope (B) at the midpoint of the fermentation correlated to pentanedione (1) and butanedione (2) levels at the end of fermentation

15 Apparent Degree of Fermentation (ADF)

- $ADF = \frac{P_0 - P_{122}}{P_0} \times 100$
- ADF calculated at P_{122}

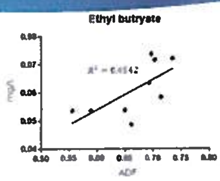


Figure 10. The correlation between ethyl butyrate levels at the end of fermentation and the Apparent Degree of Fermentation (ADF)

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Table 1. [illegible]

Flavour Compounds	B vs. Flavours R^2	ADF vs. Flavours R^2
Acetaldehyde	0.458	0.0004484
Acetone	0.005931	0.000220
Ethyl acetate	0.2592	0.2344
Isobutyl acetate	[illegible]	0.783
Ethyl butyrate	[illegible]	0.4542
Propan-1-ol	0.004436	0.03588
Isobutanol	0.3988	0.4366
Iso amyl acetate	0.6121	[illegible]
2 Methyl butanol	[illegible]	0.5482
3-Methyl-butanol	0.3167	0.4484
Ethyl hexanoate	[illegible]	0.4808
Ethyl Octanoate	[illegible]	0.4828
Butanedione	[illegible]	0.5238
Pentanedione	[illegible]	0.5398

Key: Higher R^2 | Significant (p<0.05) | Not Significant

17 Summary and Applications

- The function of the slope (B) is a better predictor than the ADF to correlate to certain flavour levels
- There is a correlation between the speed of the fermentation and various flavour compounds
  - Butanedione, pentanedione, ethyl hexanoate, ethyl octanoate, iso amyl acetate, iso butyl acetate, ethyl butyrate, 2 methyl butanol
- Some flavour compounds were not significantly impacted by the slope
  - Acetaldehyde, ethyl acetate, acetone, 3 methyl butanol, isobutanol, and propan-1-ol

18 Acknowledgements

- IBD
- Macpherson Memorial Trust
- Jim MacKinley
  Analytical Services, Heriot Watt University
- Graham McKernan
  Brewer Manager, Heriot Watt University

19 References

- American Society of Brewing Chemists. Methods of Analysis, 2012, 12th ed., Yeast-14 Miniature Fermentation Assay. The Society, St. Paul, MN
- Brown, A. K., & Hammond, J. R. M. (2003). Flavour control in small-scale beer fermentations. Food and Bioproducts Processing, 81(C1), 40-49. doi: 10.1205/096030803765208652
- [illegible], J. R., Williams, J. W., Russell, I., & Stewart, G. G. (1993). Respiratory deficiency in brewing yeast strains—Effects on fermentation, flocculation, and beer flavor components. Journal of the American Society of Brewing Chemists, 51(1), 16-20.
- Erten, H., Tanguler, H., & Cakiroz, H. (2007). The Effect of Pitching Rate on Fermentation and Flavour Compounds in High Gravity Brewing. Journal of the Institute of Brewing, 113(1), 75-79. doi: 10.1002/j.2050-0416.2007.tb00259.x
- He, Y., Dong, J., Yin, H., Zhao, Y., Chen, R., Wan, X., ... Chen, L. (2014). Wort Composition and its Impact on the Flavour-Active Higher Alcohol and Ester Formation of Beer – A review. Journal of the Institute of Brewing, 120, 157-163.
- Verbelen, P. J., Dekoninck, T. M. L., Saerens, S. M. G., Van Mulders, S. E., Thevelein, J. M., & Delvaux, F. R. (2009). Impact of Pitching Rate on Yeast Fermentation Performance and Beer Flavour. Applied Microbiology and Biotechnology, 82, 155-167.

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Thank you for listening

Appendix 2
Scientific Programme

Thursday April 21

	Raw Materials for brewing & distilling *Chair: Charlie Bamforth*
08:30 - 09:15	Keynote: How Craft Brewing is Transforming the Way We Think About Hops and Hop Flavor *Tom Shellhammer*
09:15 - 09:45	Towards the release of a 2-row barley variety for California craft malting and brewing *Joshua Hegarty*
09:45 - 10:15	Impact of barley varieties on malt and beer flavor *Lindsay Barr*
10:15 - 10:45	Selective pressurized liquid extraction of hop oil from hop cones *Katy Orr*
10.45 - 11:00	Break
11:00 - 11:30	Pro-oxidative effects on the storage stability of German Perle and Czech Saaz pellet hopsPro-oxidative effects on the storage stability of German Perle and Czech Saaz pellet hops *Mark Zunkel*
11:30 - 12:00	The effect of hopping regime, cultivar and yeast ß-glucosidase activity on terpene alcohol levels in beer *Daniel Sharp*
	Advances in distilled spirits and bioethanol production *Chair: Charlie Bamforth*
12:00 - 12:30	Creating a gin utilizing novel Scottish Botanicals: A University-Industry collaboration *Margaux Huismann*
12:30 - 13:15	Lunch
	Advances in distilled spirits and bioethanol production (continued) *Chair: Katherine Smart*
13:15 - 14:00	Keynote:Impact of brewing practice on yeast performance *Katherine Smart*
14:00 - 14:45	The Influence of Yeast Handling on Petite Mutant Formation (Cambridge prize lecture) *Stephen Lawrence*
	Yeast technology and innovations in fermentations *Chair: Katherine Smart*
14:45 - 15:15	Screening for the brewing ability of non-Saccharomyces yeasts *Maximilian Michel*
15:15 - 15:45	*Lachancea thermotolerans* in primary beer fermentations *Jen House*
15:45 - 16:00	Break

	Tours of the Brewery and its laboratories
	Beer pairing dinner

Friday April 22

	Breakfast
	Yeast technology and innovations in fermentations *Chair: Tom Shellhammer*
08:30 - 09:15	Gene dosage influences the functional attributes of de novo lager yeast hybrids *Kristoffer Krogerus*
09:15 - 09:45	Biodiversity of yeast and lab population isolated from Beninese African Sorghum Beer Starter *Sedjro Emile Tokpohozin*
09:45 - 10:30	Invited Speaker: Yeast culture collections *Kyria Boundy-Mills*
10.30 - 10:45	Break
10:45 - 11:15	Relationships between the speed of fermentation and levels of flavor compounds post-fermentation *Maria Josey*
11:15 - 11:45	Uptake and stress release of iron from yeast into beer *Will Cayler*
11:45 - 12:15	Omics analysis revealed multiple stress responses of lager yeast in the process of autolysis *Jinjing Wang*
	Packaging *Chair: Tom Shellhammer*
12:15 - 12:45	Energy state model for bottling plants *Isabel Osterroth*
12:45	Lunch
	Buses depart for outside visit

Saturday April 23

	Breakfast
	Process Innovations *Chair: Gil Sanchez*
08:30 - 09:00	Impact of ascorbic acid additions in mashes *Joe Williams*
09:00 - 09:30	Optimizing hop aroma in beer dry hopped with cascade Utilizing glycosidic enzymes *Kaylyn Kirkpatrick*
09:30 - 10:00	Investigating sources of variation during dry-hopping *Daniel Vollmer*
	Other

	Chair: Gil Sanchez
10:00 - 10:30	Linking brain lipidomics to improvement of cognitive function achieved by xanthohumol in a mouse model of metabolic syndrome *Parnian Lak*
10.30 - 10:45	Break
	Flavor and sensory properties of beverages *Chair: Gil Sanchez*
10:45 - 11:15	Identifying unique drivers of hop aroma in beers dry-hopped with Cascade, Centennial and Chinook *Scott Lafontaine*
11:15 - 11:45	Isolation of Foam-positive compounds from roasted barley and black malt *Emily Kultgen*
11:45 - 12:15	The Digestive Fate of Putative Prebiotics in Beer *Abby Kanyer*
	Novel analytical methods for raw materials and beverages *Chair: Gil Sanchez*
12:15 - 12:45	Chasing volatiles - gas chromatography tandem mass spectrometry (GC-MS/MS) in beer flavor analysis *Johanna Koserske*
12:45	Lunch
	Chair: Alex Speers
13:30 - 14:15	Keynote: Still Life: A Brief History of Artisan Distillation in the US *Lance Winters*
14:15 - 14:45	A new approach for assessing the intrinsic aldehyde content of beer *Jessika De Clippeleer*
	Microbiology and hygiene *Chair: Alex Speers*
14:45 - 15:15	Genetic Strain Differentiation of Lactobacillus Brevis – Know the NUMBER ONE Enemy *Robert Riedl*
15:15 - 15:30	Break
15:30 - 16:00	Different application methods of *Lactobacillus brevis* R2Δ and effects on malt and beer *Lorenzo Peyer*
16:00 - 16:30	Genetic adaptations for lactic acid bacteria BEER-spoilage revealed by rna sequencing *Jordyn Bergsveinson*
17:00 - 18:00	Poster Chats
	Closing banquet and entertainment

Posters

P01	Differentiating beer aroma, flavor and alcohol content through the use of Torulaspora delbrueckii *Panagiotis Tataridis*
P02	Determination of method variability in steam distillation of hop essential oils by gas chromatography – flame ionization detection of oxygenated terpenoids *Bradley Barnette*
P03	From after-the-fact air to instantaneous oxygen: Lessons learned to date from implementing oxygen monitoring technology *Lauren Torres*
P04	Correlation of fermentable sugar HPLC data to ending gravity and final alcohol content *Ami Rose*
P05	Evaluation of first-wort hopped beer *Christina Hahn*
P06	Influence of nitrogen fertilization in hops on nitrate acumulation in cones, pest outbreaks and crop yield and quality *Anne Iskra*
P07	Mutation Breeding in hop *Brooke Getty*
P08	A study of the effect of residual extract and ethanol on the partial molal volume of CO2 in beer *Evening Ferguson*
P09	Application of metabolomics to understand barley variety and its contribution to beer flavor *Harmonie Akers*
P10	Biotransformation of xanthohumol by intestinal bacteria *Ines Paraiso*
P11	Xanthohumol and derivatives dihydroxanthohumol and tetrahydroxanthohumol improve insulin sensitivity among obese mice *Joshua Hay*