PennState
College of Agricultural Sciences

PROPOSAL TRANSMITTAL

Date: 6/18/2025

PSU Ref. No: 254048

Title: **Evaluating oxidative degradation of hop phenolic and hard resin fractions during aging**

EIN: 24-60000376
DUNS No: 00-340-3953
UEI: NPM2J7MSCF61

Submitted to: Alicia Adler
Hop Research Council
3467 3rd St.
Hubbard, OR 97032

Subject: Proposal Submission

The Pennsylvania State University is pleased to submit its proposal for project entitled '**Evaluating oxidative degradation of hop phenolic and hard resin fractions during aging**' on behalf of Misha Kwasniewski, Food Science. Support for this proposal is requested at $35,582 for the period of 3/1/2026 - 2/28/2026.

The Pennsylvania State University employs individuals and accepts students and graduate research students from a multitude of national backgrounds. As an entity, the University is subject to, and works diligently to obey, federal regulations regarding the export of controlled technologies and data. Sponsor, as an independent entity, is individually responsible for ascertaining its compliance with federal export laws and procedures. If Sponsor anticipates disclosure or provision of controlled technology or data to University as part of the proposed sponsored project, Sponsor should inform University, in writing, of the existence of, and information concerning the scope and extent of, such anticipated disclosures or provisions.

Send Award Documents to:
Office of Sponsored Programs
110 Technology Center Building
University Park, PA 16802-7000
Tel:814-865-1372; Email: osp@psu.edu

For Technical Questions contact:
Misha Kwasniewski
Food Science
Tel: (814) 8656842
Email: mtk5407@psu.edu

Proposed Project Period: **3/1/2026 - 2/28/2026**

Total Project Request: **$35,582**

Total Request:
$35,582

Jenna Neff DATE 6/18/2025

Jenna Neff
Research Administrator
College of Agricultural Sciences
107 Agricultural Administration Building
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Robin Riglin DATE 6/18/2025

Robin B. Riglin, JD, AUTHORIZED UNIVERSITY OFFICIAL
Assistant Vice President for Research
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Please use PSU Ref. No. in all correspondence.

Evaluating oxidative degradation of hop phenolic and hard resin fractions during aging

Project Summary

Hop aging during storage significantly affects phenolic and resin compounds which undergo oxidative degradation. These chemical changes directly impact beer quality primarily by reducing bitterness and altering mouthfeel. Traditional metrics like the Hop Storage Index (HSI) quantity hop "freshness" by measuring the ratio of soft resins to their oxidation products. However, HSI does not account for broader compositional changes and is strongly influenced by hop cultivar and crop year (Chenot et al., 2025).

While resin degradation products during storage are well characterized (Krofta et al., 2012), the degradation of hop phenolics remains poorly understood. Phenolics including tannins and glycosidically bound flavonols (Calvert et al., 2025), make up 5-8% of a dried hop cone and vary by cultivar and growing region (Schmidt et al., 2023). Hop phenolics play a significant role in brewing due to their antioxidant, sensory and protein binding properties which influence beer freshness and stability. As phenolics degrade during hop storage, these functional properties likely diminish. Additionally, the accumulation of phenolic degradation products may also negatively affect beer quality.

This study will track phenolics and their degradation products over time to characterize their transformation during storage. Resin degradation products, although previously studied will also be evaluated for comparison. This study will use LC-MS/MS methods that have been developed to analyze the resin and phenolic composition of hops and beer. These findings will lay the groundwork for the development of a more comprehensive storage index. Ultimately the aim is to help brewers better predict hop characteristics using a simple low-cost method.

Proposed duration

New Proposal-1 year (03/01/2026 - 02/28/2027)

Project Leader:

Misha Kwasniewski, PhD

Associate Research Professor of Food Science, The Pennsylvania State University

Email mtk5407@psu.edu Office 814-865-6842

555 Curtin Rd, 326 Food Science Building, University Park, PA 16802

Co-PL:

Helene Hopfer, PhD

Associate Professor of Food Science, The Pennsylvania State University

Email hxh83@psu.edu Office 814-863-5572

555 Curtin Rd, 221 Food Science Building, University Park, PA 16802

Co-PL

Duncan Calvert, PhD

Postdoctoral scholar

555 Curtin Rd, 220 Food Science Building, University Park, PA 16802

Email dqc5839@psu.edu

Cooperator(s):

John I Haas have committed to providing hop samples for this project. Hop samples (crop year 2025) will be selected in fall of 2025 during a visit of the John I Haas facilities in Yakima.

Amount requested:

$35,582

Other Funding Sources and Support

NA

Send Funding To:

Robin Riglin, Assistant Vice President for Research, and Director, Office of Sponsored Programs

The Pennsylvania State University, Office of Sponsored Programs

200 Innovation Blvd., Suite 110, University Park, PA 16802-7000

Email osp@psu.edu Phone 814-865-1372

Evaluating oxidative degradation of hop phenolic and hard resin fractions during aging

Statement of problem

The current standard for assessing hop aging, the Hop Storage Index (HSI), is limited in scope and does not reflect the full range of chemical changes that occur during storage. While hop phenolics are extracted at significant levels during hopping (Forster et al., 2013), their composition and degradation over time are not accounted for by HSI. This is problematic because hop-derived phenolics influence sensory attributes, flavor stability, haze formation, and likely provide antioxidant protection during hop and beer aging. However, the effects of the degradation products formed throughout the brewing process remain poorly understood.

HSI values are also highly influenced by hop cultivar and crop year, reducing its reliability as a standalone indicator of hop quality. As modern brewing increasingly prioritizes aroma, flavor stability, and complex bittering profiles, the industry lacks a practical and reliable instrumental method for evaluating hop aging beyond bitter resin oxidation. Without a more comprehensive metric, brewers face uncertainty in predicting the performance of aged hops, leading to variability in beer quality.

Justification and Importance of Proposed Research

This research aims to establish the scientific basis for the development of a new hop storage index that accounts for changes in non-volatile continuants of hops during storage (including phenolics and resins). This could lead to future work on the impact of phenolic degradation on the oxidative stability and sensory characteristics of beer. Especially as the techniques used are highly selective and will allow monitoring of specific chemical changes over time. The outcomes will benefit multiple sectors of the hop and brewing industries: brewers will be better equipped to manage the use of aged hops, while hop breeders could use identified chemical markers to guide cultivar development and selection. This research aims to compliment previous work evaluating resin degradation products formed during hop storage, as well as ongoing work by Shellhammer's group on the volatile fraction. This is particularly relevant for hop forward beer styles, as aroma compounds are more susceptible to oxidation and important for product quality.

Statement: Rationale for Dr. Misha T. Kwasniewski as Project Leader

Dr. Misha T. Kwasniewski is uniquely qualified to direct a Hop Research Council project on the chemical evolution of flavor-active compounds in hops during aging. As an Associate Research Professor of Food Science at Penn State, he has built a nationally recognized program in beverage chemistry that integrates cutting-edge LC-MS/MS analytics with

practical, industry-driven questions. His laboratory has pioneered “tannin-fragmentation fingerprinting” to map subtle structural changes in polyphenols during wine and spirits maturation—expertise that directly parallels the oxidative, hydrolytic, and polymerization reactions that transform hop acids, terpenoids, and polyphenols in storage.

Key strengths Dr. Kwasniewski brings to the HRC:

- **Proven analytical toolkit:** He routinely develops high-throughput, quantitative workflows for complex plant-derived matrices, including the targeted and untargeted MS methods needed to follow hop metabolites across months of storage.
- **Translational focus:** His collaborative projects with wineries, distilleries, and cideries have generated actionable guidelines adopted by industry partners; this same extension mindset will ensure hop growers and brewers obtain clear, data-driven recommendations on cone handling and product shelf life.
- **Track record of competitive funding & publication:** Dr. Kwasniewski has secured federal, state, and commodity-board support exceeding $4 million and has authored 40+ peer-reviewed articles on beverage flavor chemistry, demonstrating the capacity to deliver rigorous science and timely reports to stakeholders.
- **Interdisciplinary leadership:** He mentors graduate students and post-docs across chemistry, plant science, and sensory analysis, fostering the multi-disciplinary team required to link chemical changes in hops to sensory outcomes in beer.
- **Institutional resources:** Penn State’s Food Science Department houses state-of-the-art MS platforms, incubation chambers, and pilot-scale brewing facilities, ensuring the project’s logistical feasibility without additional capital outlay.

Given his complementary expertise in plant secondary metabolites, his established record of turning complex datasets into industry guidance, and the robust infrastructure at his disposal, Dr. Kwasniewski is exceptionally well suited to lead this new HRC initiative and to deliver impactful results for hop producers and brewers alike.

Objectives

We identified 4 aims to address our overall project goal:

Aim 1. Collect representative (randomized and replicated) samples of freshly pelletized hops from Washington State of three different cultivars (Including non-proprietary cultivars typically used for bittering and aroma).

Aim 2. Aging of hop materials under controlled conditions and extraction of phenolics/resins throughout aging period (Q1-Q3).

Aim 3. Characterization of hop phenolics/resins using LC-MS/MS and spectrophotometry (Q2-Q4).

Aim 4. Dissemination of findings to stakeholder through industry meetings and scholarly presentations and publications.

A2-Aging of 3 different hop cultivars and extraction of phenolics/resins

Location- 555 Curtin Rd, 319 Food Science Bldg, The Pennsylvania State University campus, University Park, PA, 16802

Method

Hop T90 pellets from three different commercially important hop cultivars will be sourced from John I Haas, all grown in Yakima in 2025. Pellets to be sourced from three separate 'lots' from the same batch per cultivar. Hop samples will be stored under ambient room conditions (18–20 °C, aerobic). Samples will be analyzed monthly over a six-month period (including no aging), although weekly sampling during the first few weeks will assess whether the rate of degradation is appropriate for the planned duration of the study. Slow degradation during this period may result in higher temperatures being employed or evaluating over a longer period. Hop materials will be milled and target compounds will be extracted using aqueous acetone (70%). Preliminary analysis from our group at Penn State indicates these extraction conditions are suited for the range of compounds targeted in this project. Extracts to be stored at -80 °C until analysis.

A3-Characterization of hop phenolics/resins using LC-MS/MS and spectrophotometry

Location- 555 Curtin Rd, 319 Food Science Bldg, The Pennsylvania State University campus, University Park, PA, 16802

Method

A wide range of phenolic compounds in hop extracts will be analyzed by complementary methods, including HSI, Total Phenol Content (TPC) and Proanthocyanidin Content (PAC), alongside targeted and untargeted LC-MS/MS to identify and quantify individual compounds.

LC-MS/MS methods have been previously developed and optimized by our group for the analysis of phenolics and resins in hops and beer, using an in-house compound library with identities supported by MS/MS fragmentation patterns and authentic reference standards. These include flavonol glycosides, B-type procyanidins, chlorogenic acids, prenylflavonoids, and oxidized/isomerized resins.

Untargeted LC-MS/MS analysis will be performed to identify phenolic compounds and their degradation products. Feature detection and alignment will be conducted using MZmine, enabling us to identify the molecular features most strongly associated with hop aging. Where relevant, such as in cases of strong correlation with aging or high abundance, compounds will be identified using MS/MS fragmentation and/or authentic reference standards.

High molecular weight proanthocyanidins will be characterized using in-source fragmentation (ISF) LC-MS/MS techniques previously validated by our group for wine tannin analysis (Lin et al., 2025). This approach is expected to be particularly relevant to hops, which are known to contain high molecular weight tannins (Gadon et al., 2019) linked to haze instability in beer. We will apply and adapt this method for hop samples to investigate these compounds which are difficult to analyze using conventional LC-MS/MS.

The rate of phenolic degradation and its resulting products will be compared to that of key resins and HSI values. Degradation pathways and their possible impact on beer quality for the key compositional changes will be discussed as will differences between cultivars. Multivariate statistical techniques (PCA, HCA, etc.) will also be employed to look at patterns of sample changes over time, including both relative abundances from semi-targeted and targeted analysis (Calvert et al. 2025) as well as extracted features from untargeted analysis (Awale et al., 2021).

Potential pitfalls and limitations-Hop aging conditions

A limitation of this study is that the hop ageing conditions, and sampling plan were designed to promote accelerated oxidative degradation of phenolics and resins over a six-month period. These conditions are appropriate for a short, preliminary study however do not reflect the typical storage environments used by brewers and hop merchants, who generally employ low-temperature and low-oxygen storage to preserve hop quality. However, this faster approach enables key chemical transformations to be observed within a practical project timeline. In a worst-case scenario where significant degradation has still not taken place after 6 months with these conditions, they will be evaluated for an extended period e.g. 9 months. Analysis by Mikyška et al., (2012) indicates that with these storage conditions (18–20 °C, aerobic) alpha acids decreased approx. 20-30% at 6 months compared to 50-60% at 9 months.

Outcomes

Research findings will support the development of a more comprehensive hop storage index that accounts for changes in phenolic composition. As phenolics represent one component of hop quality, it is anticipated that results will complement ongoing research into other key

hop fractions affected by storage such as hop oils, thereby contributing to a more holistic metric for assessing hop quality. This will help brewers make more informed decisions about aged hop use. In the longer term, chemical markers identified through this work could assist breeders in selecting varieties with improved storage stability.

Extension and Outreach Activities

Findings to be presented at the USA Hop Convention-2026 (Tuscon, AZ), the HRC winter meeting and will be disseminated to collaborators such as John I Haas and local breweries (Antifragile, Boal City Brewing). Findings will also be submitted to the IBD journal for open access publication for which there is no publishing access charge to Penn State researchers.

References:

Awale, M., Liu, C. and Kwasniewski, M.T., 2021. Workflow to investigate subtle differences in wine volatile metabolome induced by different root systems and irrigation regimes. *Molecules*, *26*(19), p.6010.

Calvert, D., Dew, T., Gadon, A., Gros, J. and Cook, D., 2025. Valorisation of hop leaves for their bioactive compounds: Identification and quantification of phenolics across different varieties, crop years and stages of development. *Food Chemistry*, *465*, p.142005.

Chenot, C. and Shellhammer, T.H., 2025. Hop Storage and HSI–Past, Present and Future. *Journal of the American Society of Brewing Chemists*, pp.1-9.

Forster, A. and Gahr, A., 2013. On the fate of certain hop substances during dry hopping. *Brew Sci*, *66*, pp.94-103.

Gadon, A., Linforth, R., Harding, S.E. and Cook, D., 2019. Characterisation of high molecular weight hop proanthocyanidins using Analytical Ultracentrifugation. *Scientific Reports*, *9*(1), p.12650.

Krofta, K., VrabcovÃ¡, S., Mikyska, A., JurkovÃ¡, M., Cajka, T. and HajslovÃ¡, J., 2012, September. Stability of hop beta acids and their decomposition products during natural ageing. In *III International Humulus Symposium 1010* (pp. 221-230).

Lin, Y., Hopfer, H., Zhang, Q. and Kwasniewski, M.T., 2025. Fingerprinting and Quantification of Procyanidins via LC-MS/MS and ESI In-Source Fragmentation. *Journal of agricultural and food chemistry*.

Mikyška, A. and Krofta, K., 2012. Assessment of changes in hop resins and polyphenols during long-term storage. *Journal of the Institute of Brewing*, *118*(3), pp.269-279.

Schmidt, C. and Biendl, M., 2023. Quantitative analysis of a large spectrum of hop phenolic compounds by LC-MS/MS.

Time frame for objectives

Q1-03/01/26-06/01/26

Q2-06/01/26-09/01/26

Q3-09/01/26-12/01/26

Q4-12/01/26-03/01/26

Aim 1. Collect representative (randomized and replicated) samples of freshly pelletized hops from Washington State of three different cultivars (Including non-proprietary cultivars typically used for bittering and aroma).

Aim 2. Aging of hop materials under controlled conditions and extraction of phenolics/resins throughout aging period (Q1-Q3).

Aim 3. Characterization of hop phenolics/resins using LC-MS/MS and spectrophotometry (Q2-Q4).

Aim 4. Dissemination of findings to stakeholder through industry meetings and scholarly presentations and publications.

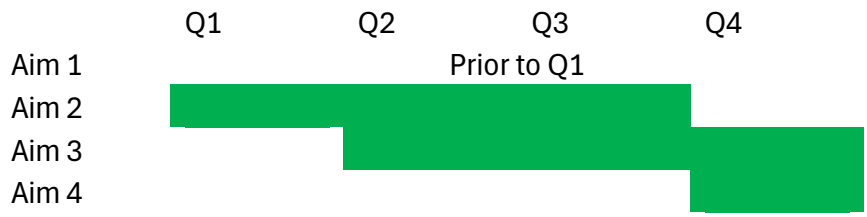

Figure 1: Ghantt chart of time frame of objectives

Project Budget: Evaluating oxidative degradation of hop phenolic and hard resin fractions during aging

Expenditure	Hop research council request	Commission/other request (specify)		Total amount requested
		State	Other	
		Amount (cash or in-kind)	Amount (cash or in-kind)	
Salaries:		-	-	
PI: M. Kwasniewski	$1,369	-	-	$1,369
Co-PI: H. Hopfer	$1,652	-	-	$1,652
Co-PI: D. Calvert	$19,541	-	-	$19,541
Total Salaries:	**$22,562**	**-**	**-**	**$22,562**
Employee Benefits:		-	-	
PI: M. Kwasniewski (39.9%)	$546	-	-	$546
Co-PI: H. Hopfer (39.9%)	$659	-	-	$659
Co-PI: D. Calvert (27.2% - postdoc rate)	$5,315	-	-	$5,315
Total Fringe Benefits:	**$6,520**	**-**	**-**	**$6,520**
Travel	$2,700	-	-	$2,600
Travel: USA hop convention registration	$800	-	-	$800
Other (Purchased Services - analytical)	$2,000	-	-	$2,000
Other (Lab supplies)	$1,000	-	-	$1,000
Total	$35,582	-	-	$35,582

Salaries/Wages - $22,562

The principal investigator is budgeted at the percentage of time shown using his/her actual salary in the calculation. The principal investigator's time includes both technical and project management functions. Any other individuals/positions shown are technical staff with the percentage of time shown and actual salaries used. For project time occurring

after July 1 of any given year, the salaries have been adjusted at the University approved rate of 4%.

Funds are requested to cover 1% of the salaries, approximately 20-30 hours annually for each PI Kwasniewski and Co-PI Hopfer for the 12-month project (Hopfer $1,652 and Kwasniewski $1,369). Co-PI Calvert (post-doctoral associate) will be primarily responsible for conducting the proposed work and coordinating the chemical and sensory analysis of samples. Funding is requested to support 30% effort for this post-doctoral associate for 12 months ($19,541).

Fringe Benefits - $6,520

FY25 – FIXED RATES

Fringe benefits are computed using the fixed rates of 39.9% applicable to Category I Salaries, 12.9% applicable to Category II Graduate Assistants, 8.0% applicable to Category III Wages, 0.3% applicable to Category IV Student Wages, and 27.2% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2025 (July 1, 2024, through June 30, 2025). If this proposal is funded, the rates quoted above shall, at the time of funding, be subject to adjustment for any period subsequent to June 30, 2025, if superseding Government approved rates have been established. Fringe benefit rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency.

FY26 – PROVISIONAL RATES

Fringe benefits are computed using the provisional rates of 39.9% applicable to Category I Salaries, 12.9% applicable to Category II Graduate Assistants, 8.0% applicable to Category III Wages, 0.3% applicable to Category IV Student Wages, and 27.2% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2026 (July 1, 2025, through June 30, 2026). If this proposal is funded, the rates quoted above shall, at the time of funding, be subject to adjustment for any period subsequent to June 30, 2026, if superseding Government approved rates have been established. Fringe benefit rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency.

TRAVEL - $3,500

Funds are requested to attend HRC winter meeting and USA hop convention (Tuscon, AZ) to present project findings. Travel costs include a round-trip airfare from State College plus accommodation for 3-4 nights and per diem based on past trip expenses. Mileage estimates are based on the travel rate posted on the Penn State travel web site. All travel

will be in accordance with University travel regulations and mileage will be charged at the current rate on the date of travel.

NOTES:

Export Control:

The Pennsylvania State University employs individuals and accepts students and graduate research students from a multitude of national backgrounds. As an entity, the University is subject to, and works diligently to obey, federal regulations regarding the export of controlled technologies and data. Sponsor, as an independent entity, is individually responsible for ascertaining its compliance with federal export laws and procedures. If Sponsor anticipates disclosure or provision of controlled technology or data to University as part of the proposed sponsored project, Sponsor should inform University, in writing, of the existence of, and information concerning the scope and extent of, such anticipated disclosures or provisions.

Terms:

If this proposal is selected for funding, The Pennsylvania State University shall negotiate terms and conditions of the grant which are applicable to non-profit educational institutions.

Dr. Misha T. Kwasniewski
Curriculum Vitae
The Pennsylvania State University
AG - Food Science
326 Erickson Food Science Building
(814) 865-6842
Email: mtk5407@psu.edu

Education

Ph D, Cornell University, College of Agriculture and Life Sciences, Ithaca, NY, USA, 2013. Major: Food Science
Dissertation Title: The Significance of Viticultural Management and Vinification Decisions on Wine Quality Parameters- Elemental Sulfur Residues and C13 Norisoprenoid Precursors

BS, Cornell University, College of Agriculture and Life Sciences, Ithaca, NY, USA, 2008. Major: Plant Science
Supporting Areas of Emphasis: Minor in Food Science
Dissertation Title: Leaf Removal Timing Effect on TDN (1,1,6-trimethy-1,2,-dihydronapthalene) Potential in Riesling Juice

Professional Positions

Academic

• Associate Research Professor, Food Science, Pennsylvania State University. (February 2024 - Present).
• Assistant Research Professor, Food Science, Pennsylvania State University. (February 2020 - 2024).
• Visiting Professor, Food Science, University of Missouri. (February 2020 - Present).
• Adjunct Assistant Professor, Plant Science, University of Missouri. (November 2014 - February 2020).
• Enology Program Leader, Grape and Wine Institute, University of Missouri. (January 2013 - February 2020).
• Assistant Research Professor, University of Missouri. (January 3, 2013 - February 15, 2020).

RESEARCH

Intellectual Contributions

https://orcid.org/0000-0003-3097-9638

Articles Published in Refereed Journals (Last three years)

Warren, Ezekiel R., Alex Fredrickson, and Misha T. Kwasniewski. "Assessment of On-Skin Microvinification in the Evaluation of Berry-Derived Wine Flavor Components." *American Journal of Enology and Viticulture* 76.1 (2025).

Lin, Y., Hopfer, H., Zhang, Q., & Kwasniewski, M. T. (2025). Fingerprinting and Quantification of Procyanidins via LC-MS/MS and ESI In-Source Fragmentation. Journal of agricultural and food chemistry..

Cook, B. S., Brown, M. G., Lin, Y., Kwasniewski, M. (Author), Ac-Pangan, M. F., Stewart, A. C., & Peck, G. M. (2024). Foliar urea applications to apple trees increase yeast assimilable nitrogen, amino acids, and flavor volatiles in fruit and hard cider. *Journal of Agriculture and Food Research, 16*. DOI: 10.1016/j.jafr.2024.101136, ISBN/ISSN: 26661543

Lin, Y., Warmund, M. R., & Kwasniewski, M. (Author) (2024). Characterization of the Volatile Composition of Fermented Ciders Made From Dessert Apple Cultivars With and Without Maceration. *Journal of the American Society of Brewing Chemists*, 1-16. DOI: 10.1080/03610470.2024.2319931, ISBN/ISSN: 0361-0470

Migicovsky, Z., Swift, J. F., Helget, Z., Klein, L., Ly, A., Maimaitiyiming, M., Woodhouse, K., Fennell, A., Kwasniewski, M. (Author), Miller, A. J., Chitwood, D. H., & Cousins, P. (2024). Grapevine leaf size influences canopy temperature. *Oeno One, 58*(2). DOI: 10.20870/oeno-one.2024.58.2.7735, ISBN/ISSN: 24941271

Harris, Z. N., Pratt, J. E., Kovacs, L. G., Klein, L. L., Kwasniewski, M. (Author), Londo, J. P., Wu, A. S., & Miller, A. J. (2023). Grapevine scion gene expression is driven by rootstock and environment interaction. *BMC plant biology, 23*(1), 211. DOI: https://doi.org/10.1186/s12870-023-04223-w

Harris, Z. N., Pratt, J. E., Bhakta, N., Frawley, E., Klein, L., Kwasniewski, M. (Author), Migicovsky, Z., & Miller, A. J. (2022). Temporal and environmental factors interact with rootstock genotype to shape leaf elemental composition in grafted grapevines. *Plant Direct, 6*(8). DOI: 10.1002/pld3.440, ISBN/ISSN: 2475-4455

Contracts, Grants, and Sponsored Research (current)
Contract
Centinari, M. (Co-Investigator), Hickey, C. (Principal Investigator), Kelly, M. (Co-Investigator), Kwasniewski, M. (Co-Investigator), Contract, 25% credit, "Development of a fruit maturation reporting system for the Pennsylvania grape and wine industry: Post-veraison in Pennsylvania (PVIP)," COP: PA Wine Marketing and Research Board, Commonwealth of Pennsylvania. Total requested: $89,241.00, Total Anticipated: $89241, Amount Funded (Total or To Date, as applicable): $89241. (submitted: May 18, 2022, date funding awarded: September 29, 2022, total start and end of funding: July 1, 2022 - December 31, 2025.
Grant
Curry, K. (Co-Investigator), Hayes, J. E. (Co-Investigator), Hopfer, H. (Principal Investigator), Keller, K. L. (Co-Investigator), Kwasniewski, M. (Co-Investigator), Lambert, J. D. (Co-Investigator), Masterson, T. D. (Co-Investigator), Zhang, Y. (Co-Investigator), Grant, 10% credit, "Training of Future Professionals along the Human-Food Interface through Research and Experimental Learning for Undergraduates," USDA National Institute of Food and Agriculture, Federal Agencies. Total requested: $750,000.00, Total Anticipated: $750000, Amount Funded (Total or To Date, as applicable): $145876. (submitted: August 15, 2023, date funding awarded: October 17, 2024, total start and end of funding: September 1, 2024 - August 31, 2029.

Amendments: OSP Number: 249841, Total awarded: $604,124.00. Total anticipated: $750,000.00. September 1, 2024 - August 31, 2029

Kwasniewski, M. (Principal Investigator), Grant, 100% credit, "Collaborative Research: RESEARCH-PGR: Deconstructing plasticity in perennial plants: Genomic and epigenomic architecture of scion and rootstock traits in grafted grapevines," National Science Foundation, Federal Agencies. Total requested: $606,030.00, Total Anticipated: $606030, Amount Funded (Total or To Date, as applicable): $606030. (submitted: May 1, 2024, date funding awarded: February 10, 2025, total start and end of funding: February 15, 2025 - January 31, 2029.

Burkhart, E. P. (Co-Investigator), Chopra, S. (Co-Investigator), Connolly, E. L. (Co-Investigator), Di Gioia, F. (Co-Investigator), Drohan, P. J. (Co-Investigator), Elias, R. J. (Co-Investigator), Guiltinan, M. (Co-Investigator), Hopfer, H. (Co-Investigator), Kellogg, J. J. (Co-Investigator), Kwasniewski, M. (Co-Investigator), Lambert, J. D. (Principal Investigator), Lasky, J. R. (Co-Investigator), Maximova, S. (Co-Investigator), Spencer, M. (Co-Investigator), Grant, 5% credit, "INTERNAL-Soils, Plants, and Consumers: A Systems-Based Approach to the Relationship Between Plants and Human Health - With Salaries," USDA National Institute of Food and Agriculture, Federal Agencies. Total requested: $262,500.00, Total Anticipated: $262500, Amount Funded (Total or To Date, as applicable): $262500. (submitted: June 8, 2023, date funding awarded: December 11, 2023, total start and end of funding: November 15, 2023 - November 14, 2028.

Elias, R. J. (Co-Principal Investigator), Hopfer, H. (Co-Principal Investigator), Kwasniewski, M. (Principal Investigator), Grant, 20% credit, "Evaluation of Exogenous Acetaldehyde Additions in Beverage Matrixes," USDA National Institute of Food and Agriculture, Federal Agencies. Total requested: $180,000.00, Total Anticipated: $180000, Amount Funded (Total or To Date, as applicable): $180000. (submitted: October 20, 2023, date funding awarded: October 16, 42024, total start and end of funding: August 15, 2024 - August 14, 2027.

Acevedo, F. (Principal Investigator), Centinari, M. (Co-Principal Investigator), Kwasniewski, M. (Co-Principal Investigator), Schmidt, C. (Co-Principal Investigator), Grant, 25% credit, "Development of action thresholds for managing spotted lanternfly in vineyards," USDA National Institute of Food and Agriculture, Federal Agencies. Total requested: $200,000.00, Total Anticipated: $200000, Amount Funded (Total or To Date, as applicable): $200000. (submitted: February 10, 2023, date funding awarded: July 20, 2023, total start and end of funding: September 1, 2023 - July 31, 2026.

Centinari, M. (Principal Investigator), Hickey, C. (Co-Investigator), Kwasniewski, M. (Co-Investigator), Grant, 33% credit, "WINE Evaluating bird deterrent measures in a vineyard setting (ACT39 Wine 8)," COP: Liquor Control Board $, Commonwealth of Pennsylvania. Total requested: $86,324.00, Total Anticipated: $86321, Amount Funded (Total or To Date, as applicable): $86321. (submitted: June 9, 2023, date funding awarded: February 14, 2024, total start and end of funding: January 17, 2024 - October 14, 2025.

Curriculum Vitae

Helene Hopfer, Ph.D. Associate Professor of Food Science

EDUCATION & TRAINING

Institution	*Degree*	*Year*	*Area*
U. of Leoben, Austria	BS	2004	Polymer Sci. & Eng.
U. of Leoben, Austria	MS	2006	Polymer Sci. & Eng.
Graz U. of Techn., Austria	PhD	2010	Flavor Chem., Food Sci.
UC Davis, CA, USA	Postdoc	2010-2014	Sensory Sci., Flavor Chem.
UC Davis, CA, USA	Certificate	2015	Ag Entrepreneurship

RESEARCH & PROFESSIONAL EXPERIENCE

2024 - Director of Graduate Studies, Department of Food Science, Penn State
2022 - Associate Professor, Department of Food Science, Penn State
2022 - Affiliate, Center for Chemical Ecology, Penn State
2021 - Affiliate, SAFES, Penn State
2019 - Program Chair, Graduate Certificate Sensory & Consumer Science, Penn State
2018 - Associate Director, Sensory Evaluation Center, Penn State
2016 - 2023 Rasmussen Career Development Professor in Food Science
2016 - 2022 Assistant Professor, Department of Food Science, Penn State
2015 - 2016 Research Director, Food Safety & Measurement Facility, UC Davis
2014 - 2015 Research Project Manager in Fruit Biochemistry, HM.Clause, Davis, CA
2010 - 2014 Postdoctoral Scholar, Department of Viticulture & Enology, UC Davis
2006 - 2010 Doctoral Researcher, Graz U. of Technology, Austria
2005 - 2006 Graduate Researcher, University of Leoben, Austria
2005 Summer Research Assistant, Queen Mary, University of London, UK
2002 - 2004 Student Research Assistant, University of Leoben, Austria

TEACHING EXPERIENCE

2020 Guest Lecturer: PLANT/ANTH/HIST129N-Chocolate Worlds; Penn State
2019, 2022 Co-Instructor: FDSC/INTAG460-International Food Production; Penn State
2018 - Instructor: FDSC410-Food Chemistry & Analysis II; Penn State
2018 Co-Instructor: FDSC602-Supervised Exp. in College Teaching; Penn State
2017 - Instructor: FDSC515-Sensometrics; Penn State
2016 - Guest Lecturer: CHEM316, FDSC201, FDSC497, HORT412; Penn State
2014, 2016 Lecturer: FST298-Experimental Design & Chemometrics; UC Davis
2012 Co-Instructor: VEN213-Flavor Chemistry; UC Davis

SYNERGISTIC & PROFESSIONAL ACTIVITIES

Student Advising & Mentoring (since 2016):

Advisor:

UG: Dolan (’17), Parlow (’17), Cotter (’18), Donohue (’18), Mobley (’18), Brady (’19), Ziegler (’19), Ginn (’20), Potter (’21), Haines (’21), Hou (’22), Wiedemer (’22), Spahn (’23), Taraboletti (‘23), Deakyne (’25), Gerstner (’25)

MS: Wang (‘18), Poveromo (’19), Keller (’20), Donohue (’20), Gutierrez (’21), Riak (’21), Meneses-Marentes (’22), Ziegler (’22), Loi (’24), D’Andrea (’25), Tankard (’25), Sullivan (’25), Gruman, Tarrance, Leong-Fern

PhD: Chrisfield (’20; USDA pre-doc), Brown (’21; USDA pre-doc), Goza (’22), Failla (USDA pre-doc)

Committee member (Graduated/all): PhD: 8/18; MS: 14/23

Postdocs, visiting scholars & visiting students: 6

Society member: Society of Sensory Professionals (SSP), Institute of Food Technology (IFT), European Sensory Science Society (E3S), Sensory Network Austria (SNÖ)

Collaborators: Nutrition, Penn State (Masterson); Plant Sci., Penn State (Centinari, Guiltinan, di Gioia, Kelley, Maximova); Poli. Sci., Penn State (Hatemi); Plant Sci., UMD (Farcuh); FHIA, Honduras (Gonzalez, Diaz); Dandelion Chocolate, San Francisco CA (D'Alesandre); Blommer (Potts, Stauffer); Hershey's (Hess, Crozier); Patric Food & Beverage Development, Columbia MO (McClure); Monash U., Australia (Marriott); U. Florence (Monteleone, Spinelli)

Service

Conference Chair, Pangborn Conference (2025, Philadelphia)	2021 -
Gamma Sigma Delta Officer, Penn State, College of Ag.	2022 - 2025
Human Research Protection Prgm Advisory Committee, Penn State	2021 -
AC-14 Academic Administration Evaluation Committee	2021
Faculty Development Committee, Penn State, College of Ag.	2023 -
Scientific Committee, Pangborn Conference	2017, 2021, 2023
Graduate Faculty Review Committee, Penn State, College of Ag.	2020 - 2023
PhD Qualifying Exam Committee, Penn State, Dept. Food Science	2020 - 2024
Scientific Committee, XIIIth International Terroir Congress, Adelaide, AUS	2019 - 2020
Strategic Planning Committee, Penn State, Dept. Food Science	2019 - 2023
Associate Editor, American Journal of Enology & Viticulture	2017 -
Nominations & Elections Committee, Penn State, College of Ag.	2017 - 2020
Hot Topics group, IFT17 Annual Meeting, Las Vegas, NV	2017
Graduate Program Committee, Penn State, Dept. Food Science	2016 -
Faculty Advisory Committee, Penn State, Dept. Food Science	2016 - 2023
Reviewer for CAS Grad Student Competitive grants, Penn State	2016 -
Guest Editor, Topical Collection "Wine Chemistry", Molecules	2014 - 2016

Invited Reviewer (funding agencies):

NIFA AFRI	2022 - 2023
Univ. Maryland MIPS Program	2018
FFAR New Innovator Award	2017

Invited Reviewer (peer-reviewed journals):

Aus. J. Grape & Wine Res., Am. J. Enology & Vitic., Analyt. Chem., Appl. Food Sci., Beverages, Chem. Senses, Chemos. Percep., Clinical Otolaryngology, Foods, Food Analyt. Methods, Food Chem., Food Res. Intern., Food Struc. Food Qual. Prefer., Heliyon, J. Ag. Food Chem., J. Dairy Sci., J. Food Sci., J. Sci. Food Agric., J. Sens. Studies, J. Wine Res., Molecules, Physiol. & Behavior, Separations, Vitis

AWARDS & HONORS

2025	Gamma Sigma Delta 2024 Outstanding Teaching Award
2022	LEAD21 Leadership Development Program, Class 18
2020	NACTA Teaching Award of Merit, College of Ag., Penn State
2019	Anna & Guy Bixler Memorial Award in Food Science, Penn State
2017	Rider Endowment Research Support of Biotechnology of Food Crops, Penn State
2016 -	Rasmussen Career Development Professor in Food Science, Penn State
2014	Finalist AGRO New Investigator Award, 13th IUPAC Congress
2009, 2008	Austrian Chemical Society Travel Award
2008	Weurman Symposium Student Award
2003, 2006	Scholarship for outstanding performance, University of Leoben, Austria

GRANTS

PI and Co-PI ~ $5,500,000 total costs to date, spending authority ~ $3,300,000. Funding from USDA-NIFA, USDA-FAS, NDC, PLCB, PDA, and industrial partners.

RELEVANT PUBLICATIONS (last 5 years, in reverse chronology)
‡ graduate $ undergrad advisee/mentee ORCID: https://orcid.org/0000-0001-6925-0241

‡ D'Andrea AE, **Hopfer H**, Hayes JE (2025) Perception of citric acid and citrate salt mixtures in humans. *Chem Senses* 10.1093/chemse/bjaf017

‡ Loi C, McClure AP, Hayes JE, **H Hopfer** (2025) Olfaction modulates taste attributes in different types of chocolate. *Food Qual Prefer* 10.1016/j.foodqual.2025.105584

Lin Y, **Hopfer H**, Zhang Q, Kwasniewski MT (2025) Fingerprinting and Quantification of Procyanidins via LC-MS/MS and ESI In-Source Fragmentation. *J Agric Food Chem* 10.1021/acs.jafc.5c02379 (featured front cover)

‡ Meneses-Marentes N, Bharath SM, **Hopfer H** (2024) Effect of the addition of cocoa sweatings and time of fermentation on flavor compounds and sensory perception of 100% roasted cocoa liquor. *J Food Sci* 10.1111/1750-3841.17404

Spinelli S, **Hopfer H**, Moulinier V, Prescott J, Monteleone E, Hayes JE (2024) Distinct sensory hedonic functions for sourness in adults. *Food Qual Prefer* DOI:10.1016/j.foodqual.2024.105152

Kelley K, Centinari M, **Hopfer H** (2024) Evaluating white wine consumer interest in Grüner Veltliner: a potential signature varietal for Pennsylvania. *Int J Wine Bus Res* DOI:10.1108/IJWBR-04-2023-0020

Zhou J, **Hopfer H**, Kong L (2023) Odor-scavenging capabilities of pre-formed "empty" V-type starches for beany off-flavor compounds. *Food Hydrocolloids* DOI:10.1016/j.foodhyd.2023.109315

$ Wiedemer AM, McClure AP, Leitner E, **Hopfer H** (2023) Roasting and Cacao Origin Affect the Formation of Volatile Organic Sulfur Compounds in 100% Chocolate. *Molecules* DOI:10.3390/molecules28073038

Farcuh M, **Hopfer H** (2023) Aroma volatiles as predictors of chilling injury development during peach (Prunus persica (L) Batsch) cold storage and subsequent shelf-life. *Posthar Biol Technol* DOI:10.1016/j.postharvbio.2022.112137

‡ Goza JL, Ziegler GR, Wee J, Hayes JE, **Hopfer H** (2022) Salivary α-amylase activity and flow rate explain differences in temporal flavor perception in a chewing gum matrix comprising starch-limonene inclusion complexes. *Food Res Intern* DOI:10.1016/j.foodres.2022.111573

Ledley A, Elias RJ, **Hopfer H**, Cockburn D (2021) Modified brewing procedures significantly improve fermentable sugar generation from gluten-free malts. *Beverages* DOI:10.3390/beverages7030053

Hopfer H, McDowell EH, ‡ Nielsen LE, Hayes JE (2021) Preferred beer styles influence both perceptual maps and semantic descriptions of dry hops. *Food Qual Prefer* DOI:10.1016/j.foodqual.2021.104337

‡ Chrisfield BJ, **Hopfer H**, Elias RJ (2021) Effect of Copper-Based Fungicide Treatments on the Quality of Hop Produced in the Northeastern United States. *J Am Soc Brew Chem* DOI:10.1080/03610470.2021.1937900

‡ Chrisfield BJ, **Hopfer H**, Elias RJ (2021) Impact of Copper-Based Fungicides on the Antioxidant Quality of Ethanolic Hop Extracts. *Food Chem* DOI:10.1016/j.foodchem.2021.129551

DUNCAN CALVERT
126 e. Fairmount Ave., PA 16801
duncancalvert@hotmail.com +1 (814) 548-6489

Education

University of Nottingham, *Sutton Bonnington* **July 2021 - December 2024**
Brewing Science: ***PhD***

- 'Sustainable Uses of Hops and Their Co-Products in Brewing' (funded by AB InBev). Application of hop extraction and analytical techniques for hop material characterization and product development.
- Research presented at conferences including the European Brewing Convention (Madrid, 2022) and Trends in Brewing (Leuven, 2024) which was awarded runner-up for best oral research presentation.

Heriot Watt University - ICBD, *Edinburgh* **September 2019 - September 2021**
Brewing and Distilling: ***Distinction, MSc*** *(Hons)*

- Thesis titled 'A quality assessment on the dry-hopping value of Cascade hops grown in Dundee'.
- Awarded 'Worshipful Company of Brewers' scholarship of £500 for thesis proposal, and 'Incorporated Brewers Benevolent Society' scholarship of £2,500 towards tuition fees.

Oxford Brookes University, *Oxford* **September 2011 - June 2014**
Biological Sciences: ***2:1 BSc*** *(Hons)*

- Distinction for dissertation investigating nuclear-envelope protein structure and function in plants.
- Oxford Brookes community scholarship of £2,000.

The Windsor Boys' School, *Windsor* **September 2006 - June 2011**

- **A Levels:** B-Biology, B-History, B-Law. **GCSE:** 2 A*'s, 2 A's, 8 B's.

Publications and Conference Presentations

Calvert, D., Dew, T., Gadon, A., Gros, J. and Cook, D., 2025. *Valorisation of hop leaves for their bioactive compounds: Identification and quantification of phenolics across different varieties, crop years and stages of development*. *Food Chemistry*, *465*, p.142005.

Calvert, D., Dew, T., Gadon, A., Gros, J. and Cook, D., 2024. *Valorisation of hop leaves: Identification and quantification of antioxidant phenolics*. Presented at the European Brewing Convention, Lille, France, 26–30 May 2024.

Work Experience

Penn State University, *State College (PA, USA)* **January 2025 - Present**
Post-doctoral researcher

- Tannin characterisation of foods and beverages focusing on their sensory and bioactive properties.

University of Nottingham, *Sutton Bonnington* **July 2024 - December 2024**

Post-doctoral researcher

- Mashing and brewing trials to evaluate a novel adjunct for use in brewing (funded by Toast Brewing Company).
- Co-inventor on a patent application arising from this research.

'Lupofresh' *Yalding, Kent* **October 2015 - September 2019**
Hop Laboratory Analyst

- Operated hop analysis laboratory including HPLC and GC-FID for the quality control of hop products.

Windsor and Eton Brewery, *Windsor* **Jun 2014 - Sep 2015**
Brewery and Lab Assistant

- Brewing, packaging lab and project work.

Skills and Interests

Sport: Table Tennis (Heriot Watt 1st team)**.** Cycling (UoN Road biking club).
Music: Piano (Grade 7)**,** Violin (Grade 7, Orchestra principal violinist), Music theory (Grade 5).
Homebrewing: Experienced experimental homebrewer. UoN real ale society homebrew secretary.
Hop Cultivation: Established experimental hop cultivation in Peniche, Portugal.