

# Penn State Fine Flavor Cocoa Visiting Scientist Program

2019 - 2020

## Fellowship Report

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### Research Abstract (~ 300 words)

Chocolate, one of the most complex food matrices known to sensory science, displays an incredibly unique and diverse flavor profile. Cocoa bean fermentation and drying are fundamental to the development of these diverse sensory profiles. Complex physical, chemical and biochemical processes convert fresh, highly bitter and astringent beans into flavorful dried seeds with lower bitterness and astringency. These dried seeds also contain the important precursor flavor compounds which, during roasting, are converted into the flavor compounds that make high-quality chocolate the global sensory treat that it is.

High-quality chocolate does not, therefore, begin at the chocolate maker's workshop, but instead at the farms on which cocoa beans are grown and processed into dried, saleable product. Cocoa bean genetics, the growing environment (climate, soil, on-farm diversity) and postharvest processing (fermentation, drying, storage) altogether influence the final flavors and overall physical quality attributes that chocolate makers seek. Tremendous responsibility therefore lies in the hands of cocoa producers. In the specialty

chocolate market, the ability to consistently source high-quality beans, continues to be rewarded with better farmgate prices. It has also fueled more consistent, longer-term buying relationships between chocolate makers and farmers who can produce such high-quality beans. As a result, both sides are rewarded for their investments.

To develop these processing skills however, farmers must develop a practical understanding of the science associated with high-quality bean processing. In order to do so, they require access to suitable tools and evaluation methods. Bean processing involves the use of the human senses of sight, taste, smell, audio, and touch to manage a successful postharvest process. Human Sensory Science has developed many tools that can be used to guide the management of bean quality throughout the process. These sensory tools are highly accurate, easy to learn and execute, and are extremely low-cost. Once well-demonstrated to farmers and bean processors, they become indispensable for developing and maintaining high quality processing and control at farm level. This work therefore aims to expand the existing postharvest quality management toolkit with current human sensory methods that will positively impact farmers' abilities to successfully and consistently produce high-quality bean lots, earning them better prices for their products.

## Introduction

*What motivated the application and project? Brief explanation of the background and rationale for the proposal?*

The offer of training in advanced sensory science at Penn State University (PSU) fit perfectly into my next round of professional development for the work that I continue to do primarily with farmers both in my home country, as well as in the wider Caribbean region. Besides working with and training farmers, I also work with industry associates (value-added product makers) and the interested public (consumers seeking knowledge about the industry).

For the past 2 years, I have been experimenting with a modified fermentation method that shows promising and fairly consistent results. Said method, if shown to be reliable and repeatable in its positive impact on bean quality, could greatly influence how high-quality cocoa processing is done – particularly at the smallholder farm level where bean quality variation tends to be high.

To begin assessments of a) the method's impact on bean quality, and b) its possible reliability for repeated use, required beans, derived from such treatments, to be evaluated in a more scientifically robust manner than my current resources and skillsets could allow. The fellowship therefore provided an invaluable opportunity to realize these assessments.

With the training received and the extremely useful data generated from this work, I will be able to resume my field-based training efforts in an even more focused manner. I will now be able to provide farmers and processors with a viable range of tools which they can successfully employ at minimal cost to them; tools which will quickly and consistently inform their

preparation of high-quality beans. This will in turn, benefit them financially as well as personally and professionally.

## Project Objectives

*Including problem statement and the aims of the project at the outset*

The overall aim of this work was to determine

a) the quantifiable sensory, physical and chemical differences between cocoa bean samples processed using a modified fermentation method and,

b) how these differences affect consumer acceptance of the final chocolate product.

The objectives of this work therefore included

- Training a sensory panel to evaluate 19 cocoa bean samples
- Using Compusense sensory software to collect and collate the relevant data derived from the trained panel
- Selection of the most diverse samples for further sensory evaluation and acceptability by chocolate consumers
- Determination of the physico-chemical parameters of cocoa quality, including pH, titratable acidity, fermentation index, color differences and volatile composition of these 19 cocoa samples

## Materials and Methods

Cocoa bean samples, a mix of Trinidad Selected Hybrid (TSH) varieties sourced from a private farm in East Trinidad, were fermented and dried in-country in June 2019. A total of 18 samples (2 kg each) were derived from the experiments conducted. These 36 kg of dried beans were sealed in labelled food-grade plastic bags and stored in sealed GrainPro® bags until they were sent to the Food Science Department at PSU in November 2019.

In December 2019, an additional batch of Trinidad beans was purchased from Meridian Cocoa Company (Oregon) to provide a national (standard) reference to which the 18 experimental samples could be compared. This standard reference was derived from the state-owned research estate La Reunion in Trinidad, and also represented a mix of TSH varieties. This purchased batch was derived from beans harvested and processed in the same season/year as the 18 experimental samples.

Liquor samples were then prepared from all 19 bean lots, following a standardized protocol for batch roasting of 500 g of dried cocoa beans and liquor making. The finished liquor samples were portioned out into glass jars (1.5-1.8 g per jar) for sensory evaluation by a trained descriptive analysis panel.

Three replicates of 2 g liquor samples were prepared per beans sample for colorimetry tests. Samples were dispensed into Petri dishes for later evaluation.

Three replicates of 2 g liquor samples were prepared and used for pH and titratable acidity measurements using an in-house optimized method.

Three replicates of 3 g liquor samples were prepared in Petri dishes that were stored under refrigerated conditions for later use in physico-chemical analyses (butterfat determination, volatiles analysis).

The surplus cocoa liquor stock for the 19 samples was stored in sealed glass jars under refrigerated conditions for later use where needed.

The remaining dried bean samples (~500 g per sample) were kept sealed in food grade plastic containers and reserved for other physical analyses (viz. bean cut tests, fermentation index).

## Results and Conclusions

Very limited results are available at this time due to interruption of my work schedule at PSU (COVID-19-related termination). However, thus far, based on preliminary sensory evaluations of the 19 samples, there appears to be considerable variation between and within treatments. The statistical magnitude and practical relevance of this variation remains to be assessed. However, even at a purely sensory level, the wide variation is somewhat surprising considering the uniform treatment of all the samples during primary processing. However, it is critical to see variability revealed in this manner, as it has considerable practical implications for small batch processing at the smallholder farm level.

Final results from the official sensory panel testing at PSU, together with the outstanding physical and chemical data, are expected to provide key scientific insight into the observed sample variation, as well as provide useful comparative data of the experimental samples to the national standard (the La Reunion sample).

This will then guide my on-farm adaptations of processing procedures to help minimize negative impacts and maximize positive impacts on bean physical and sensory qualities.

## Discussion

In many cocoa producing countries of the Caribbean region, particularly where smallholder cocoa farmers choose to process their own beans, the quantities processed per batch are quite small (e.g. 20 kg or less). They are therefore subject to far more variation in fermentation dynamics than would their counterpart large masses (e.g. > 50 or 100 kg batches), if not appropriately handled.

In Trinidad & Tobago, we have smallholder farmers who process batches that can range from 20-500 kg per batch during the harvest season. In all cases, if the beans are not handled appropriately before, during, and after fermentation/drying, the beans risk demonstrating inconsistent flavor profiles, while appearing (physically) to be consistent from batch to batch. The true test of a successful processing cycle lies fully in the flavor of the beans after they have been converted into liquor or chocolate. Such a flavor assessment is typically not done by the farmer.

The specialty cocoa market has a vested interest in being fair to the cocoa producers by paying commensurate higher prices for unique, diverse and consistent flavor quality per origin. This in turn, places considerable

responsibility on smallholder farmers to replicate a minimum amount of consistency in bean quality parameters for every batch processed within and across seasons, as well as from year to year. Currently, many of our smallholder farmers in the Caribbean region use bean processing techniques which they understand mainly at a superficial level. In many cases, they are not fully aware of the impact of variable processing conditions on the flavor of the chocolate made from their beans. This is partly linked to the fact that many of them have spent years selling their processed beans to intermediate buyers solely on the basis of bean physical characteristics – and not flavor. However, as consumer interests in craft chocolate continue to rise, many of these farmers who wish to sell to the specialty market, now find themselves heavily challenged to produce consistently high-quality (flavor) beans despite their limited understanding of how their on-farm practices influence the final chocolate product. This situation creates much frustration for both the cocoa producers as well as the chocolate makers, because far too often, neither party understands the intricate needs of the other.

This is where bridging the knowledge gap becomes essential for both sides of the chocolate equation: chocolate makers know which quality of beans gives them the best value for money, but they do not always understand the intricacies of the post-harvest process that helps to create that sought-after bean quality. Farmers on the other hand, generally do not know the intricacies of making high quality chocolate and how post-harvest bean preparation decisively influences that quality. Thus, they are generally not aware of how their (in)actions can improve upon (or greatly reduce) bean quality desired by the chocolate maker. This in turn influences the prices paid for the beans, as well as buyer interest in longer-term purchasing relationships.

This is where my work aims to help fill that knowledge gap - first and foremost for the farmers, because they are the 'first-responders' in the bean space. Secondly, the chocolate makers will be able to develop a better working knowledge of the origin of their key ingredient, and will be more likely to support the farmers' efforts in a more informed manner. By using tools, especially sensory indicators, such as changes in appearance, smells, taste, and sounds, I can provide a hands-on training for farmers in all aspects of cocoa post-harvest processing, leading ultimately to consistently higher bean quality that benefits both parties.

Although the currently available project results do not allow for any firm conclusions, the preliminary qualitative information affords us a small, but valuable window into the level of variation and complexity of the flavor profiles found among the samples. Already, the large variation seen highlights key issues related to the importance of adequate and appropriate monitoring of cocoa post-harvest parameters. Aspects such as microbial load in the fermentation mass, proper aeration etc. are crucial to the management of final bean quality as it relates to final chocolate flavor, and not only the bean's physical characteristics as assessed by the cut test.

Should the completed physical, chemical and sensory analyses reveal confirmation of the current qualitative findings, they would collectively provide ample justification for further investigation of the observed trends via more focused experiments.

## Project Outcomes (~ 200 words)

*What do you feel were the significant outcomes in terms of the research but also in terms of personal development?*

These include, but are certainly not limited to the following:

- A crucial re-introduction to a vibrant space that has considerable relevance to my field- and human-based work. Re-introduction into the space, with enthusiastic collaborators and knowledgeable researchers, has reinforced the importance of functional networking beyond the duration of this fellowship.
- A new perspective on the wide array of human sensory methodology that can easily be adapted to a farming community.
- A necessary hiatus from the fieldwork that I do in order to re-calibrate and reassess my strategies and overall approaches to my chosen work. This ensures that my ongoing service to farmers and wider industry stakeholders will be more impactful. In applying for this fellowship, I wanted to be mentored in as many ways as possible. This program disrupted my comfort zone at all levels and gave me opportunity to aim for a higher bar in both my learning and ability to deal with very unfamiliar social/academic situations. Thanks to the collective experience, I am deeply motivated to continue on my currently chosen path, with greater focus tied to wider perspectives and approaches in the agricultural space.

## Publications, Presentations and Products

*Are there papers or articles submitted or in preparation as a result of the Project?*

At least 1 paper is proposed from this work. However, this is completely dependent on completion of at least the physical and chemical analyses, which are likely to be achieved this year. The sensory evaluation will likely have to wait until next year when human-based testing may be officially allowed at PSU.

*Have you made presentations as a result of the Fellowship?*

Presentations made at PSU:

- Cocoa and Chocolate Research Network (CCRN) meeting: "**Sarah and the beans talk: Building a practical sensory toolkit for field-based work with specialty cocoa and its stewards.**" (January 2020).
- International Agriculture and Development (INTAD) Global Gallery 2020 seminars: "**Using chocolate and sensory exploration to redefine cocoa sourcing at origin**" (February 2020).
- International Agriculture (INTAG) class lecture (spring semester guest speaker, Zoom): "**How the politics of Trinidad & Tobago have influenced the agricultural sector and policy development**" (April 2020)

Presentations made at Towson University, Baltimore:

- International Perspectives of Women (class course, 2 lectures delivered): ***“My role and experiences as a female scientist and extension services provider using sensory science in the male-dominated cocoa/agricultural space”*** (March 2020)

Presentation made to students at Van Hall Larenstein University of Applied Sciences, The Netherlands (invited guest Zoom lecture in the course “Chain Analysis for creating socio-economic impact: case study of the Ghanaian cocoa smallholder):

- ***“Learning to navigate the dynamic world of farmer training. My story 1998-present”*** (June 2020)

*Are there significant products as a result that will have use beyond the Fellowship for yourself or others?*

Yes, these products include, but are not limited to:

- New sensory tools (execution and data analysis) have been added to my field-kit of strategies through which even more meaningful farmer engagement can now occur.
- Conversation and presentation strategies that can effectively encourage clients (farmers, other industry collaborators etc.) to constructively and concisely present on their work, so that the outputs can help to serve both themselves and the wider community. This is particularly important for my efforts at building farmer-led training sessions and opportunities.

## Capacity Building, Education and Outreach Activities (~ 200 words)

*As a result of the Fellowship did you engage in educational and/or outreach activities before/during/after your visit? Did you meet with students to explain your work? Was there any publicity about your visit - either in your host country or your home country?*

- Introductory training in execution of consumer-based sensory testing with ***Alan McClure*** (PhD candidate, University of Missouri & owner/chocolate maker at Patric Chocolate) at the PSU Sensory Evaluation Center.
- Meeting with ***Dr. Hugo Hector Alarte*** (Director, Research and Development, Casa Luker, Colombia) to discuss my work and possibilities for contributing my expertise to their company and associated farmers.
- Participation at Critical Collaboration #GLAG20, Global Learning in Agriculture. Formed part of PSU’s PhD candidate Allison Brown’s tasting panel for [GLAG Virtual Interactive Chocolate Tasting](#).
- Meeting with ***Dr. Melanie Foster*** (Office of International Programs) & ***Dr. Daniel Foster*** (Agriculture and Extension Education) to discuss collaborative projects with Trinidad & Tobago.

- Networking dinner with **Dr. Maricelis Acevedo** (Associate Director for Science, Cornell University) and **Dr. Filiberto Penados** (co-founder, CELA Belize and Maya scholar) to discuss my outreach efforts and desire for further training in this regard.
- Meeting with **Dr. Nicole Webster** (Youth and International Development and African Studies, PSU) to discuss my work in the Caribbean and at PSU, with a view to developing collaborative rural sociology projects that can benefit from our collective expertise.
- Meetings with **Lindsay Barr** (co-founder/sensory specialist, DraughtLab software) to trial DraughtLab's chocolate sensory evaluation platform among farmers and consumers in Trinidad.
- Course participation: Penn State's Ice-Cream Short Course, Sensometrics & Sensory Evaluation (semester-long), Introduction to Sensory Short Course.

### Future Plans and Follow-ups (~ 100 words)

*Do you plan to continue contact with the host institute and others you met as a result of the project? What will be the nature of the future work?*

I intend to complete and publish from my research. Development of new field-based projects (sensory science, rural sociology) is the next step. This collective experience has highlighted the immense value that these colleagues can help bring to the producer world in which I operate. Having long desired to return to academia in a more practical way, this experience has exceeded initial expectations. It reinforces my keen interest in forging alliances with these progressive academics who have the academic expertise and official resources to further much-needed research that I (and others) can then apply to real-world producer situations.

### Personal Impact

*How do you feel the Fellowship has and will continue to impact your research and career objectives?*

This fellowship has greatly expanded my areas of research and work interests in several key ways:

- The kind of resonance I experienced at PSU is key to successful collaborative efforts. The strengthening of the professional relationships with my new PSU colleagues to achieve shared goals is a must. I see much possibility for collaborations that can help to bring immediate, practical relevance to dynamic field situations whose outcomes will contribute to increasing the agency of the farmers and their communities.
- I have started developing skillsets that, with increased experience and ongoing mentorship, will allow me to systematically examine familiar problems and challenges with new/modified perspectives and strategies. These skillsets also now afford me the opportunity to address unfamiliar challenges from new angles, as well as the chance to liaise with these experts to find novel solutions together.

- Having met with colleagues external to the Food Science Department/PSU (viz. Dr. Acevedo, Dr. Penados, Drs. Foster, Dr. Webster, Dr. Alarte and Mr. McClure), I now see multiple strategies for building my teaching and outreach approaches. Individually, these professionals have a wealth of experience in very different domains that share common themes linked to my farmer-based work. Our exchanges have already guided my thinking on future efforts with my own personal/professional training and ongoing outreach work at home and abroad.
- Upon my return to Trinidad, when COVID-19 restrictions were lifted, I started practicing some of what I had learned from the fellowship via discussions about the implications of the experiments and preliminary results, as well as, pilot sensory evaluation sessions with farmers and chocolate consumers. These sessions have led to extremely useful feedback, and have fueled further ideas for refinement of currently available digital tools that can serve in the evaluation and management of quality in the cocoa/chocolate domain.

Overall, having realized this fellowship (after several years of applying for similar opportunities), has been a crucial window into understanding how I can and should move forward with my field-based research interests. It has shown me that, through appropriate mentorship and collaboration, coupled with access to suitable resources, many challenges can be successfully addressed. In turn, such an experience then pays itself forward in what I am able to now share and develop with the farmers whom I serve. The fellowship has therefore granted me tremendous opportunity to make good on my personal and professional motto “share, teach, learn, grow”.

*What was the main impact for you personally?*

On a personal level, the fellowship has created intense renewed interest in being actively connected with a vibrant research/academic community. This helps enormously to keep up-to-date with newly developed sensory training and evaluation methods for both field-based research (via structured experiments and data analysis) as well as farmer-based engagement for knowledge exchange. The interactions within and external to the Food Science department (other professors, graduate and undergraduate students, administrative staff, maintenance staff) have all been extremely rewarding. They have given me continued insight into, and deep appreciation of the aspects of human nature and sharing that are powerful reminders of the important role that positive human exchanges play in encouraging progressive learning and development.

## **Acknowledgements and References:**

Thanks must certainly go to Daniel Barcant (Cocoa Republic Company), and Dr. Elizabeth Johnson (IICA) for their support and official endorsement of my application for this fellowship. They are both personally and practically aware, for several years now, of my mission and motto when it comes to working with specialty cocoa and its farmers. Their willingness to lend their support to my quest for further training via this fellowship has been deeply appreciated.

I am extremely grateful to Dr. Helene Hopfer (PSU) for accepting me as a visiting scientist into her research group. The decision, from my point of view, was one that created a very critical personal and professional shift in my approach to why, what and how I do what I do when I engage in a) field-based research and, b) information transfer and exchange with industry stakeholders – particularly the farming communities. Her decision has already impacted many lives through what I have learnt and been able to share to date, and I am looking forward to continue this collaboration.

My experience at PSU was greatly enriched by the many student interactions I had – both with cross-faculty graduate students as well as Food Science undergraduates. I must give heartfelt, profound thanks specifically to PhD candidate Allison Brown for her willingness to work with and mentor me - in spite of her overwhelming schedule. We have shared, and continue to share, life changing experiences on both a personal and professional level, and I look forward to future projects with her.

Thanks to Allison, I was introduced to some exemplary undergraduate students like Tyler Yany and Aaron Wiedermer, as well as PSU graduate Patrick Dolan. These young men became fundamental to my labwork assignments, and have contributed in so many personal and professional ways to helping me successfully prepare my samples under very tight deadlines. I am deeply honored to know them, and will be eternally grateful for their efforts during this fellowship.

Many thanks to Dr. Siela Maximova (PSU) for her role as the principal investigator who helped to secure the grant – for both myself and all other scholars who have benefitted thus far. Her efforts in this regard contribute to important personal and professional change in the lives of the fellowship candidates.

The USDA-FAS must be sincerely thanked for the funding provided, and the kind attention and assistance paid to me by the small team responsible for administrative and other logistics related to my program: Tanya Hinnant, Heather Selig, Chen-Lun Chang and Luis Arreola are therefore gratefully acknowledged for their additional in-country support that was so warmly provided to me.

## **Feedback for the organizers:**

*This section will not be published with final report, it is for internal use.*

### **What could be done to improve the guidance and application process?**

I currently have no recommendations in this regard as my experience with the initial process was quite straightforward (except for the US embassy experience). The delayed acceptance notice for this fellowship was out of everyone's control (US government shutdown) and created quite the challenge for choice of a suitable execution time. That notwithstanding, all other administrative handling was professional and timely, and for that I am deeply grateful.

### **We like to use quotes from these reports in advertising the program. Do you have a specific quote you would like us to use?**

N/A. Please use any comment contained within that may suit your purpose in this regard.

**We are always looking to improve our activities. Are there suggestions you have that we could do to help make this programme more effective?**

From my experience, I honestly cannot identify any aspects that could make this program more effective. Having the Food Science Department at PSU be the host location for my work was the best thing that could have happened to me and, honestly, exceeded what I had initially hoped to experience.

The pandemic-related challenges that my work has faced during this fellowship were unprecedented for everyone, and therefore represent a tremendous anomaly. Had things been able to run as smoothly as we all had planned for, the fellowship work would have been a timely and tremendous success. I think that such success is still possible, but it will require a longer-than-expected timeframe for completion. It is my hope, depending on the duration of the pandemic and associated restrictions that I will be able to return to PSU to finish the work that remains on my project in order to bring complete closure to a very worthwhile experience.

**Other comments:**

N/A

*Please insert a photo or two of your visit here*

