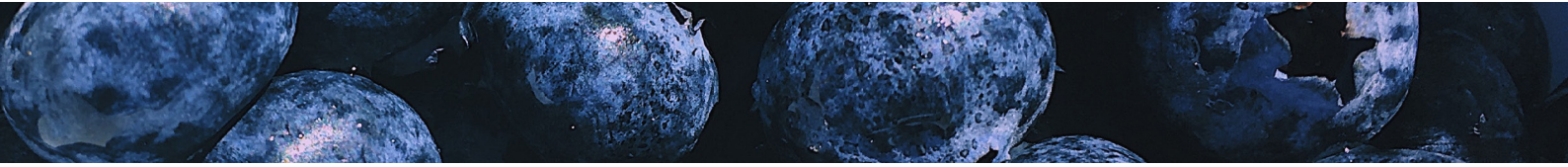


VacCAP

Improving Fruit Quality

Breeder Spotlight: Dr. Sushan Ru \ 8

A Tribute to Bernadine Strik – Berry Goddess \ 5

Issue 7 | June 2023

VacCAP Objective

The Vaccinium Coordinated Agricultural Project (VacCAP) is a nationwide project aimed at developing new genetic tools to enhance breeding for improved fruit quality of cranberries and blueberries.

VacCAP is a nationwide coordinated transdisciplinary project focused on addressing major bottlenecks limiting the growth of the U.S. *Vaccinium* industry by developing and implementing marker assisted selection (MAS) capacity in breeding programs.

This will enable breeders to select and pyramid fruit characteristics that positively contribute to fruit quality and market value.

Long term, the scientific resources developed will increase production of fruit with improved characteristics that meet ever-changing industry, market, and consumer preferences.

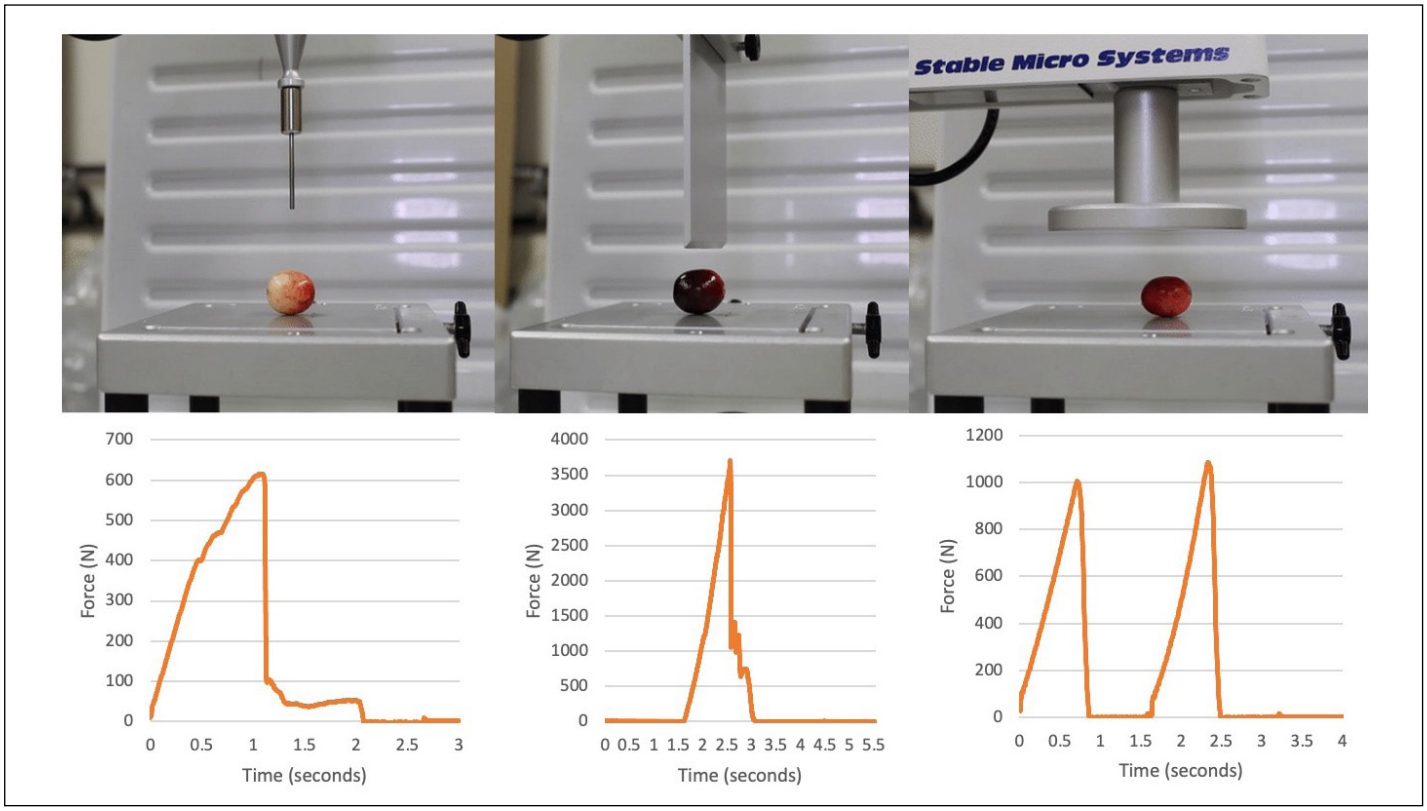
Survey Says: How the Zalapa Team Is Identifying the Best Methods for Measuring Texture Traits in Cranberry

Too hard. Too soft. Just right. It's a tale as old as time, always searching to find the "just right". It is usually about a girl with golden locks looking for which bed is "just right" in the home of three bears. But in our VacCAP story, Dr. Juan Zalapa's team steps into the starring role, looking for ways to measure texture traits in cranberry that are "just right".

"The main objective of this study was to identify what is the best way to evaluate texture in cranberry. Texture traits are the most important traits in cranberry for the industry and the research [community]," Hector Lopez-Moreno, a PhD student in Zalapa's lab, said. "But we don't have a standard methodology to evaluate these kinds of attributes. We focus on these traits, based on different approaches."

Zalapa and Lopez-Moreno have detailed their research in their latest paper, "A Survey of Key Methods, Traits, Parameters, and Conditions for Measuring Texture in Cranberry".

"Currently, the industry is measuring texture based only on force—the amount of force you need to compress the fruit. But texture is more complex than that," Lopez-Moreno said. "We use different approaches to evaluate these attributes based on puncture, shearing, and other different methodologies, in order to have



The top row of images shows the probes of three methodologies: puncture (left), shearing (middle) and compression (right). The row below shows the profile curves that each methodology produces. Images and figures provided by Hector Lopez-Moreno.

a more complete picture of what is the difference between cultivars about these attributes."

Firmness is one of the traits that the industry considers important for sweetened dried cranberry (SDC) production, and how they determine what fruit is more suitable to go through the SDC process. The less firm a fruit is, the less likely it will make it to the end as a quality final product.

"When the fruit is not firm, it disintegrates during the processing," Zalapa said. "There's a lot of mechanical agitation, there's a lot of soaking, heating, all kinds of different processes that go into making [SDCs], that by the time it gets to the other side of the line, there is a loss."

According to anecdotal accounts there could be up to 50% loss of cranberries in the SDC production line. While there are several characteristics believed to impact this process—fruit size, internal structure, and color, etc.—Zalapa and his team focused on measuring firmness in this first paper.

"This is more of a survey of many different ways of doing the firmness measurements, and then playing with the parameters that we can change in the test." Zalapa said.

The survey looked at several different key methods, traits, parameters, and conditions for measuring texture in cranberry.

- Methods: using different probes in the texture analyzer. Here they used single compression, double compression, puncture, shearing, and Kramer shear cell.
- Traits: traits are created out of the formulas and raw data gathered from the methodologies (there are 47 in this study).
- Parameters: have to do with the machine itself, different aspects of the tests. In this study, those were the speed at which the probe goes down, and strain—the percentage of the size of the fruit to which the probe has to go down.
- Conditions: aspects like temperature, fruit orientation and storage time that factor into results.

Some aspects of the survey were the first of their kind. Zalapa explained that nobody has ever conducted a double compression test, and that a single compression test is the only method that has been used in cranberry. A double compression test provides two different sets of data on a fruit's texture allowing for more comprehensive trait analysis, while the industry has traditionally only been using one.

"Essentially, the industry has been using one trait, and now we have the ability to calculate dozens of traits that relate to this [first compression] peak, and this second [compression] peak," Zalapa said.

According to Zalapa, the industry has traditionally used the raw data that comes from the single compression test. In this survey, Lopez-Moreno has been taking the data from all of their tests and putting it into models and formulas. This allowed for using specific parameters and conditions, which was also a new concept.

"Before this study, all the other authors that reported on textural firmness evaluation in cranberry, they used, I would say, kind of random parameters or conditions. But no one had investigated what is the best way to do it," Lopez-Moreno said. "The values you can get from the textural machine can be widely

different just because you test the fruits in different orientations, or if you use a different speed of the probe. Even if the values should be the same, it is misleading because you're using different parameters."

Lopez-Moreno gave the example that if someone in the industry is using the speed of three millimeters per second, and another is using 10 millimeters per seconds, probably the firmness values will be quite different.

"He's going to report probably higher values compared to the second just because of the difference of the parameters. Not because the fruit is firmer itself," Lopez-Moreno said. "That's why we have to develop and understand the methodology in order to evaluate these traits in the same conditions and to have resources that are comparable to each other."

This survey is the first step in creating a universal standardization in measuring cranberry texture traits. Variability of equipment, measurements, and priorities are some of the things that led the Zalapa lab to take a closer look.

Everybody using different machines is an issue. According to Zalapa, the most used machine is automated, meaning there is no way to adjust any parameters. It was also developed for grapes and blueberries, much softer fruits that require less pressure from the machine. If the machines set up for softer fruits try to measure cranberries, they may not have enough pressure to accurately determine its firmness.

Zalapa knows they can't make everyone use the same machine—despite that being the ideal scenario—but they at least want to make the industry aware that there are machines that are adjustable and those that are not, so, even if the machines are different they could be adjusted to use similar parameters.

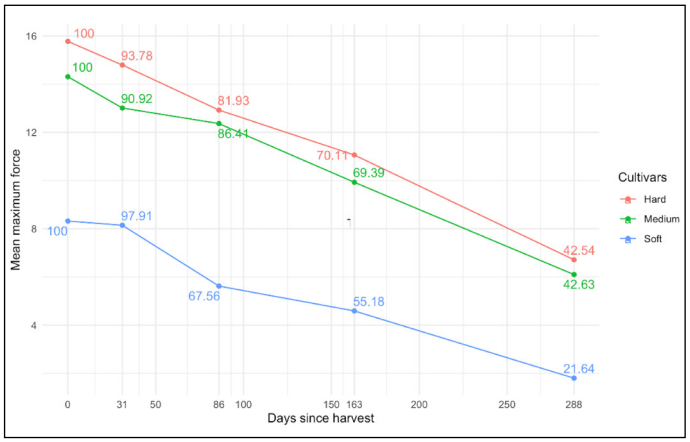
It is important to use the same amount of compression force that the machine puts on a cranberry. Strain is the percentage of the size of the fruit to which it will be compressed. For example, if a fruit is one centimeter wide and it will be compressed at 10%, then the probe will go down 10 millimeters. The machine the industry typically uses has a strain of 2%. The Zalapa lab didn't feel this was enough and set their minimum at 5%, testing upwards from there, determining the best strain is between 5% and 10%.

"Anything higher, the cranberry starts developing cracks. Anything below that is just not enough force to actually measure the firmness," Zalapa said.

Also, it's important to use a machine that can be outfitted with different probes. Probes used for puncture tests—another form of methodology—also vary greatly with at least 50 different types. Zalapa and his team narrowed that down to three different areas: compression, puncture, and shearing.

"It's three different general methodologies, but each probe can be considered its own methodology. We wanted to choose more or less the probes to represent three broad areas," Zalapa said.

The team also looked out how various conditions in the testing process could impact firmness data. Lopez-Moreno looked to define the optimal sample size for all the methodologies, finding 30 fruits to be a reasonable number.



Percentages of cranberry (Vaccinium macrocarpon Ait.) fruit firmness decreases for three cranberry cultivars with different levels of firmness stored at 4 °C on four different dates. Figure provided by Hector Lopez-Moreno. Additional caption details available here.

"In industry or other research [labs], they have been using 5 or 50 fruits of different sample sizes. But, if you use five fruits, you're unable to get an accurate measurement because there's a lot of variation," Lopez-Moreno said. "But if you are using 50 fruits, you probably get more accurate [data], but that many fruits are not necessary. You're just wasting fruits and time. That's why it's important to find the ultimate sample size."

The effect of storage on fruit firmness is important to consider, since firmness decreases when the fruit is left in storage for extended periods of time. The team evaluated the firmness of fruit when harvested, and then after 31, 86, 163 and 288 days of storage. They found that medium or hard cultivars had similar trends where firmness decreased slowly at first with less than 10% firmness lost in the first 30 days and about 60% firmness loss at the end of the study. In contrast, soft cultivars had initial firmness of half of the firmer cultivars, but lost less firmness initially (~2%) and then lost ~80% firmness by the end of the storage period.

"The fact that during the first month, the decrease in firmness is slow, on average, it decreases less than 10%, is important because we are trying to measure a lot of fruit, and thus time is a crucial part of the process," Lopez-Moreno said. "And the fact that the decrease is not too bad in the beginning is an indication that we have at least one month to get accurate results."

Lopez-Moreno mentioned that understanding the effect of fruit size on the performance of different parameters is key, since bigger fruits are usually firmer. It is something the team feels needs to be standardized between breeding programs and the industry, who have different sorting and weight requirements for berries.

"We need to decide as an industry, what is the ideal size for SDC—what needs to be rejected and what needs to be the

minimum. And then that way, when we measure firmness, we can just measure firmness on those berries," Zalapa said. "When cranberries in the industry get sorted, they get sorted by size. But in breeding, we're always concerned about weight. I think these are things that people are not thinking [about]. These kinds of things are important."

According to Zalapa, the industry transitioning to using the same machine or at least having the ability to input the same parameters would still be the most beneficial outcome. He believes the machines that people are using in the industry are "really not to the best standard that they need to be in order to do this kind of measurement."

"Part of our impetus for this research is to show the industry that they need to move on to something better, and that this type of machine where you can adjust parameters, use different probes, and everything [is optimal]." Zalapa said. "We're hoping that they take this and they say 'Wow, there's a lot out there instead of just measuring a 2% compression and this machine that we're using can't adjust anything or use different probes and you can't get any traits'."

Initially, the Zalapa lab pioneered the work with this type of machine in cranberry. Zalapa says the VacCAP team then decided to standardize with the same machine for cranberry and blueberry, with slight variations between the two.

"Even though [the blueberry industry] could use the older, less powerful machine, they can't calculate anything. Because they don't get a graph, all they get is a number of what the compression force is," Zalapa said. "With the graph, we can understand the time that it took for that pressure to actually build, we can understand the slope, we can understand a lot of things that you can't [with the old machine]. Firmness is a lot more complicated than people think. And that's what we're trying to show here."

Zalapa says that at least two processors in Wisconsin have bought similar adjustable machines as his team has been working on. They worked with the processors to transfer the technique of how they set up the machines, the parameters they're using, and they're doing their own test.

"And now we are getting questions from other growers and other bigger operations to actually get access so they can do the same things that we're doing. The different cranberry breeders have also started to work on [similar machines]. And we can start standardizing this work across the industry and breeding groups." Zalapa said.

There are more papers in the pipeline to delve further on impacts of characteristics such as fruit size, color, and chemical makeup. They also plan to specifically separate out the cultivars using the methodologies, which they did not intentionally do in this first paper, but there are some early indications of which trend firmer than others.

"Now that we learned how to adjust the machine, what [options are] out there, and what the conditions are, we're going to choose the best conditions, parameters, traits, and then we're going to separate cultivars," Zalapa said. "Eventually, we're going to use that for genetic mapping to understand what the genes are that control these traits."

horticulturae

MDPI

Article

A Survey of Key Methods, Traits, Parameters, and Conditions for Measuring Texture in Cranberry (*Vaccinium macrocarpon* Ait.)

Hector Lopez-Moreno [1,*], Matthew Phillips [1], Luis Diaz-Garcia [2], Maria A. Torres-Meraz [1], Fernando de La Torre [1], Ines Berro [3], Jenyne Loarca [4], Jyostna Mura [4], Shinya Ikeda [4], Amaya Atucha [5], Lara Giongo [6], Massimo Iorizzo [7] and Juan Zalapa [1,4,*]

1 Department of Horticulture, University of Wisconsin-Madison, 1575 Linden Dr., Madison, WI 53706, USA
2 Department of Viticulture and Enology, University of California Davis, One Shields Avenue, Davis, CA 95616, USA
3 Department of Agronomy, University of Wisconsin-Madison, 1575 Linden Dr., Madison, WI 53706, USA
4 USDA-ARS, Vegetable Crops Research Unit, Department of Horticulture, University of Wisconsin-Madison, 1575 Linden Dr., Madison, WI 53706, USA
5 USDA-ARS, Vegetable Crops Research Unit, Department of Food Science, University of Wisconsin-Madison, 1605 Linden Dr., Madison, WI 53706, USA
6 Fondazione Edmund Mach—Research and Innovation Centre Italy, Via Edmund Mach, 1, 38098 San Michele All'adige, TN, Italy
7 Department of Horticultural Science, Plants for Human Health Institute, North Carolina State University, NC Research Campus, 600 Laureate Way, Kannapolis, NC 28081, USA
* Correspondence: lopezmoreno@wisc.edu (H.L.-M.); juan.zalapa@ars.usda.gov or jezalapa@wisc.edu (J.Z.)

check for updates

Citation: Lopez-Moreno, H.; Phillips, M.; Diaz-Garcia, L.; Torres-Meraz, M.A.; de La Torre, F.; Berro, I.; Loarca, J.; Mura, J.; Ikeda, S.; Atucha, A.; et al. A Survey of Key Methods, Traits, Parameters, and Conditions for Measuring Texture in Cranberry (*Vaccinium macrocarpon* Ait.). *Horticulturae* **2023**, *9*, 479. https://doi.org/10.3390/horticulturae9040479

Academic Editor: Christopher M. Menzel

Received: 3 January 2023
Revised: 24 March 2023
Accepted: 27 March 2023
Published: 11 April 2023

Abstract: In the cranberry (*Vaccinium macrocarpon* Ait.) industry, the textural properties and firmness of the fruit are priority traits for producing processed products, such as sweetened dried cranberry (SDC), which have gained popularity in recent years. However, there is currently no reliable methodology for screening these traits in breeding programs. In this study, we examine the key methodologies, textural traits, parameters, and conditions that are necessary to accurately and efficiently measure the texture of cranberry fruit. Double compression, single compression, puncture, shearing and Kramer shear cell methodologies were successfully implemented in cranberry, resulting in a total of 47 textural features. These features allowed the evaluation of the texture of the cranberry fruit based on key factors such as flesh, structure, and skin. This study also examined factors than can affect the performance of texture measurements, including the optimal sample size, storage time, fruit texture-size correlation, fruit temperature and orientation, optimal speed/strain combinations, and the effect of probe diameter. The results of the study suggests that certain texture traits of the compression and puncture methodologies could potentially be used to test varieties and aid in breeding programs.

Keywords: cranberry; fruit quality; texture analysis; fruit phenotyping

1. Introduction

The American cranberry (*Vaccinium macrocarpon* Ait.) is a native North American fruit crop with growing popularity due to its nutraceutical potential [1–4]. Cranberry phytochemicals have been associated with a wide variety of health benefits including improvement of digestive and urinary tract health, cancer prevention as well as reduction of cardiometabolic risk factors [5–8]. The dissemination of these attributes of this super fruit has led to a steady increase in cranberry production in the US over the past two decades, and as a result, current production is almost double what it was in 1990 [9]. As the cranberry supply has often exceeded demand, cranberry breeders have begun to shift their focus from improving yield to improving fruit quality, which has become increasingly important

The entire original paper PDF and citations can be found at the link here.

A Tribute to Bernadine Strik – Berry Goddess

It is sometimes said to never meet your heroes for fear that they will disappoint. However, this was certainly not the case for those that had the opportunity to meet and know Dr. Bernadine Strik, Professor Emeritus and Berry Specialist at Oregon State University.

Sadly, after a 34 year-long career and retiring in 2021, Dr. Strik succumbed to cancer and died peacefully in April 2023. She was only 60 years of age. Despite leaving the world too soon, her life and career left a positive impact on so many.

Dr. Strik, or simply Bernadine to many, was a legendary scientist that conducted applied horticultural research that had a tremendous impact on the berry industry, including Vaccinium species. Her horticultural research on highbush blueberry is perhaps best known among the VacCAP team, as it transformed our knowledge of blueberry plant physiology and production techniques such as pruning, plant spacing, mulching, trellising, nutrient management, cultivar adaptation, and more. Her research on organic blueberry production was also revolutionary and guided the growth of the organic blueberry industry.

She also worked closely Dr. Chad Finn, berry breeder with the USDA and another member of the VacCAP team gone too soon. The product of their collaborations was the release of new cultivars paired with horticultural advice on how to optimally grow them. This partnership also created a model of how breeders and horticulturists can work together to accelerate and improve the process of selecting and releasing new berry cultivars to the industry.

The work led by Dr. Strik was also recognized nationally and internationally by the berry industry and fellow academics. Aside of numerous industry awards bestowed upon her pre- and post-retirement, she was awarded the prestigious International Society for Horticultural Science Fellow Award in recognition for her outstanding contributions worldwide to berry crop production and science.

Among all of these accomplishments, Dr. Strik was also a gracious human being well loved by her colleagues, the growers she worked with, and family. She mentored numerous students, staff, and faculty during her lifetime. She guided them with her wisdom but also infectious enthusiasm for berry crops and supporting the industry through applied research and extension. She was also a beloved wife and mother of two phenomenal girls

Photo by Ted Mackey

who will also feel the immense void left behind by her departure.

While the berry community grieves Dr. Strik's untimely passing, it is also useful to look at her legacy and draw inspiration from the positive energy and accomplishments she brought about throughout her lifetime. Not only was her research abundant and transformative, but she also traveled the world and seamlessly blended work with pleasure. Among all of her accomplishments, she always made time for people including several members of the VacCAP team and family. She was in essence the "real-deal", berry goddess extraordinaire, and the type of hero many of us will continue to admire within the berry community.

Photo from Dr. Bernadine Strik

The VacCAP 2023 Annual Meeting

This March, the VacCAP team assembled in-person and virtually to host the 2023 Annual Meeting. Each Objective team gave updates on their projects over the two day gathering in Charlotte, North Carolina. VacCAP Partners and Advisory Panel members also presented.

Thank you to everyone who contributed and attended, and to Massimo Iorizzo and Marti Pottorff for organizing the event.

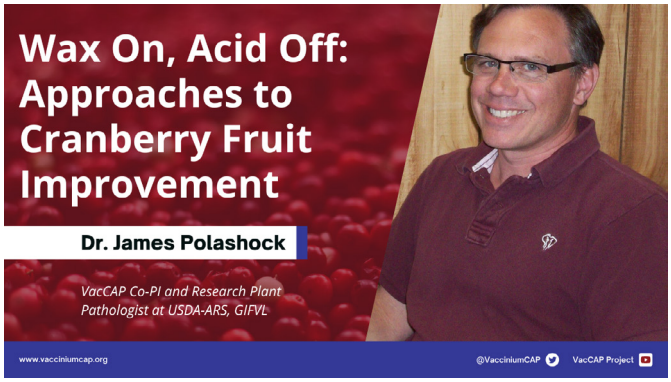
Photos courtsey of Marti Pottorff and Josie Russo.

Check Out the Latest VacCAP Webinars

Dr. James Polashock (USDA-ARS, GIFVL) presented the webinar "Wax On, Acid Off: Approaches to Cranberry Fruit Improvement" in April. This webinar discussed the importance of epicuticular wax in resistance to heat scald; the value in reducing organic acids in the fruit (to lower the amount of added sugar needed for palatability); and the development of markers for these traits to be used in breeding and selection.

In May, Dr. Sara Montanari of The New Zealand Institute for Plant and Food Research Limited presented on "Understanding the Genetic Control of Anthocyanin Content in Blueberry". Dr. Montanari covered the construction of high-density linkage maps for autotetraploid highbush blueberry and the detection of quantitative trait loci (QTLs) for fruit anthocyanin content and profile, combining results from two studies. She also shared some preliminary data on functional validation of candidate genes, as well as identification of the causative variant for marker development for marker assisted selection (MAS).

All webinar recordings are on our YouTube channel. Subscribe to the channel to never miss another recording.



Student Spotlight: Sara Knowles

In our Student Spotlight Series, we want to introduce you to the students who help make VacCAP possible through their passion and hard work. In this segment, get to know ***Sara Knowles****, a Lab Technician at The Philip E. Marucci Center for Blueberry and Cranberry Research and Extension with advisor Dr. Jim Simon, formerly Dr. Nicholi Vorsa.*

What is the project you're working on for VacCAP about?

I am working on phenotyping for fruit quality and disease resistance traits in the cranberry mapping population segregating for fruit rot resistance. I collect and analyze data on the fruit organic acid concentrations within the population and then send those along for QTL discovery. I also help with almost every aspect of phenotyping the other traits of interest in this population, from the field to the lab. This population is genotyped and highly replicated, so we are taking full advantage of the experimental design by gathering as much phenotypic data as we can.

What is something you like or find most interesting about your work?

Plant breeding is so exciting to me, because it can solve global problems through natural trait variation. I have always been interested in the relationships between humans and plants, and plant breeding is a great field for investigating and harnessing those relationships directly. There is a balance in the potential of discovering unique or superior phenotypes, and making realistic and practical decisions using data. My work requires a variety of laboratory and field techniques, so I am always learning new things, as well as getting my hands dirty.

What do you hope to do in the future after your work here?

I hope to work in a supportive role within a breeding program. I would love to continue researching fruit metabolites and their roles in plant stress resistance, consumer preferences, and human health.

Anything else you would like to add?

I feel very privileged to have worked with Dr. Vorsa before his retirement, as he is such a brilliant and prolific scientist, who contributed so much to *Vaccinium* research. I look forward to working further with Dr. Simon, another talented scientist, to finish my degree.

Breeder Spotlight: Dr. Sushan Ru

In our Breeder Spotlight Series, we interview blueberry and cranberry breeders to learn more about their roles, challenges in their breeding programs, and have them highlight some of their favorite new cultivars. In this spotlight, we spoke to ***Dr. Sushan Ru****, a Assistant Professor of Small Fruit Breeding and Genetics at Auburn University.*

Please describe your role in the blueberry industry.

Alabama is not on the list of major blueberry producers; however, blueberry has been an important part of the lives of many Alabama fruit growers and local communities. People enjoy growing and picking the native species rabbiteye blueberries for years and year. Nevertheless, like many other underserved regions in the Southeast, Alabama is behind on adopting newer and more competitive southern highbush cultivars.

I am a blueberry breeder at Auburn University working on establishing a new blueberry breeding program from scratch. The goal of my program is to serve small- and mid-sized growers of Alabama and potentially nearby regions with locally adapted and high quality southern highbush and rabbiteye cultivars. Thanks to the tremendous support from fellow breeders, I was able to collect germplasm materials, establish a breeding pipeline, and gradually build up the research and breeding team in the past two years. As we are about to finish our first blueberry harvesting season, I look forward to many more blueberry blasts to come.

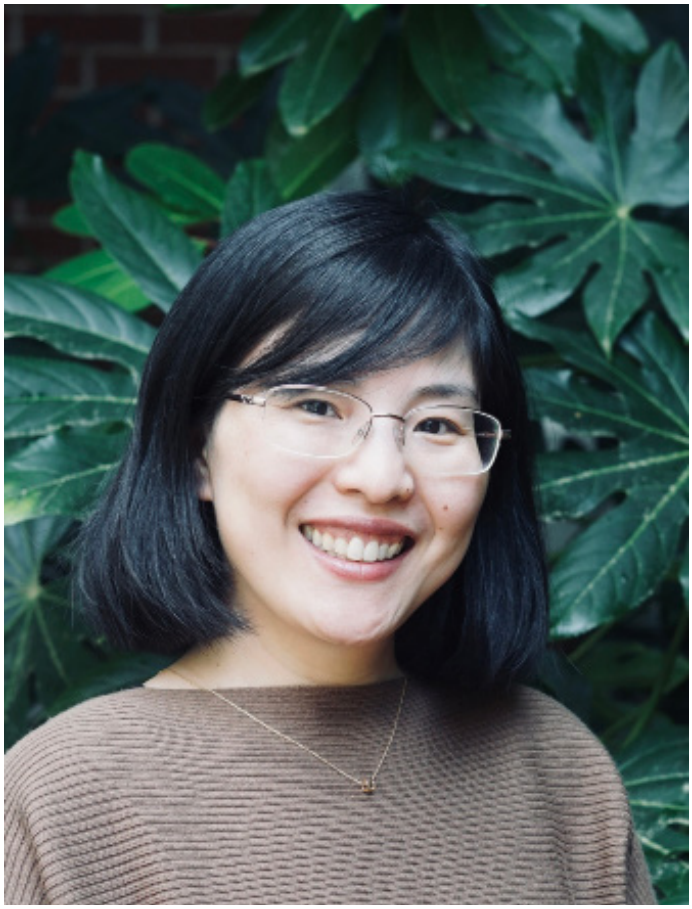
Cultivar Highlight - Please tell us about some top cultivars you're excited about and why you chose them.

As a brand-new breeding program, we are still years away from releasing our own cultivars. However, I am excited about many new releases from other breeding programs. Among the cultivars we tested, New Hanover, released from the North Carolina State University, established well in our testing locations, and showed great potential to succeed on Alabama farms with little frost protection. We will have more data on many other cultivars next year and it will be exciting to find out which cultivars/selections will win the race.

What are some challenges in the breeding program?

It is difficult to start a brand-new breeding program with no germplasm nor breeding infrastructure. On top of which, I also need to figure out how to get the most accomplished with very limited monetary resources. I am grateful for all the help and guidance I have received from many other breeders, scientists, and the Department of Horticulture at Auburn University, which means so much to a new breeder like me. It is a true pleasure to visit well-established breeding programs and learn from their amazing achievements.

Meanwhile, I couldn't help but wondering when my baby program will grow up like them in the future. My job as a breeder is to nurture the program and hope one day it will bear delicious berries.



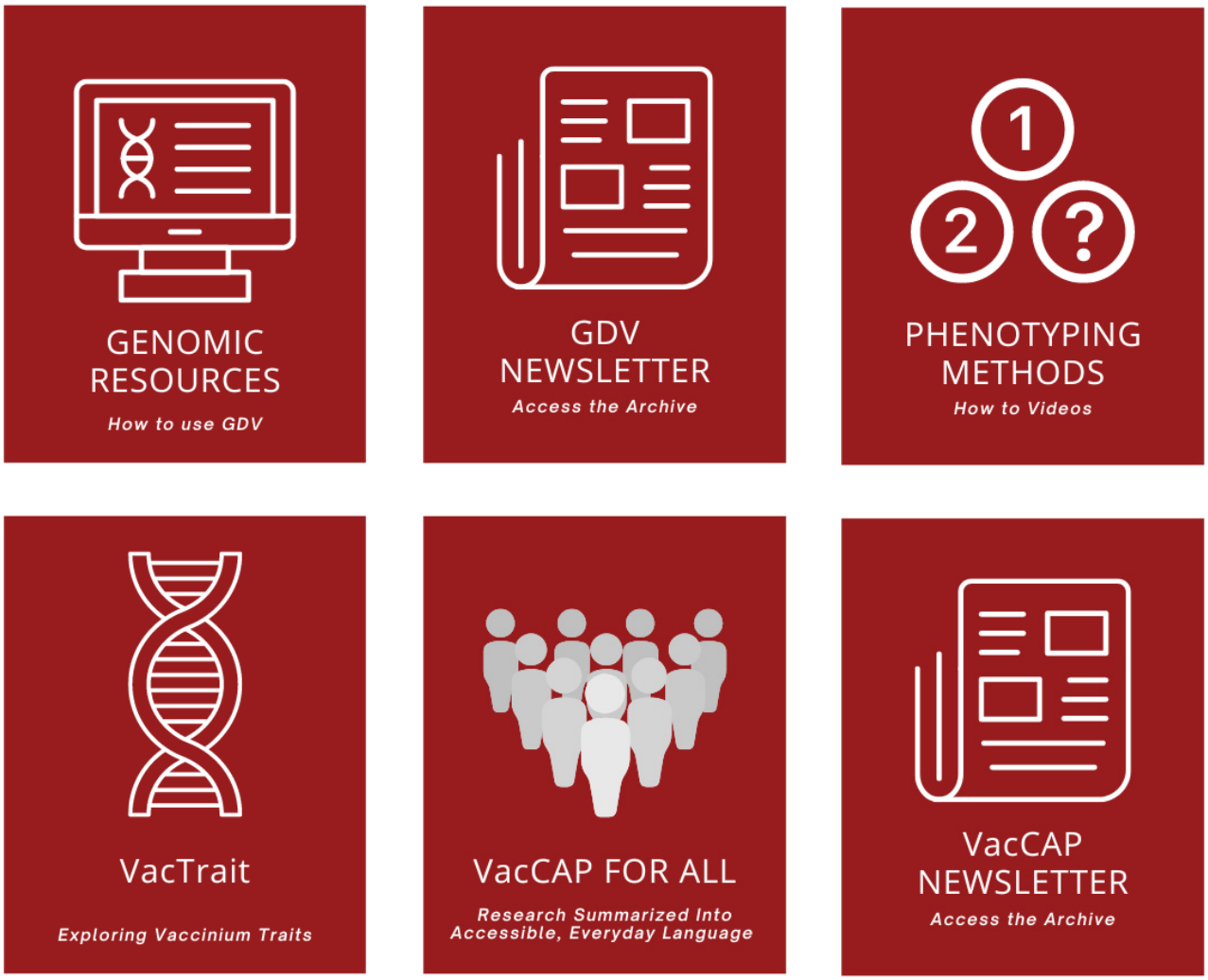
Where do you see the future of* Vaccinium *breeding going in the next 20 years?

In my humble opinion, it is critical to develop blueberry cultivars enduring various abiotic and biotic stresses to make production less costly and more sustainable in the changing climate.

In what way have you used resources from VacCAP to facilitate your work?

My program and I have benefited a lot from VacCAP publications, conference talks, newsletters, and the community of VacCAP scientists. I used the genotyping platform developed as part of the project to genotype additional cultivars and breeding materials. I also used phenotyping protocols recommended by VacCAP team for postharvest trait evaluation. It is amazing to see how much have been achieved through this collaborative effort.

Check Out These VacCAP Resources



Newsletter Staff & Contributors

Editors

- Massimo Iorizzo, Project Director, *North Carolina State University*
- Amaya Atucha, Co-PD, *University of Wisconsin-Madison*
- Lisa Wasko DeVetter, Co-PI, *Washington State University*
- Josie Russo, Communications Specialist, *University of Wisconsin-Madison*

Design

- Josie Russo, *University of Wisconsin-Madison*

Feature Article Authors

- "Survey Says: How the Zalapa Team Is Identifying the Best Methods for Measuring Texture Traits in Cranberry" by Josie Russo[1], Hector Lopez-Moreno[1], Juan Zalapa[2], Amaya Atucha[1], and Lisa Wasko DeVetter[3]
- "A Tribute to Bernadine Strik – Berry Goddess" by Lisa Wasko DeVetter[3]

1. Department of Horticulture, University of Wisconsin-Madison
2. USDA-ARS, Vegetable Crops Research Unit, Department of Horticulture, University of Wisconsin-Madison
3. Department of Horticulture, Washington State University

Join Us on Social Media

VacCAP
@VacciniumCAP

VacCAP
Project

Do you want to stay up to date on all the latest news and resources? Follow us on Twitter @VacciniumCAP. You will be able to:

- Get the latest articles and resources
- Find webinar announcements and registration links
- Check out photos from the field
- And so much more!

Also check out our new website www.vacciniumcap.org and YouTube channel to see articles and videos as they go live.

Partners: Do You Want to Contribute to the VacCAP Newsletter?

If you are interested in contributing or have announcements for events, publications, or another other initiative that you want to share, contact Josie Russo at jrusso2@wisc.edu with the subject line "VacCAP Newsletter Contribution"

VacCAP
IMPROVING FRUIT QUALITY

USDA
United States Department of Agriculture
National Institue of Food and Agriculture
Award #: 2019-51181-30015

www.vacciniumcap.org
vaccapsocial@gmail.com | @VacciniumCAP