



The  
UNIVERSITY  
of VERMONT

# 2021 Online Saffron Workshop Proceedings

*Saffron: From Start to Finish, Planting to Selling*

Thursday, March 11 and Thursday, March 18

University of Vermont ZOOM, Burlington, VT USA

A Workshop for Growers, Marketers & Researchers



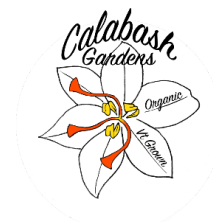
# Supporters of the Fifth Annual Saffron Workshop

Burlington, Vermont USA

March 11 and 18, 2021

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## Toward Paper-based Nanocage Sensors for Saffron Analysis

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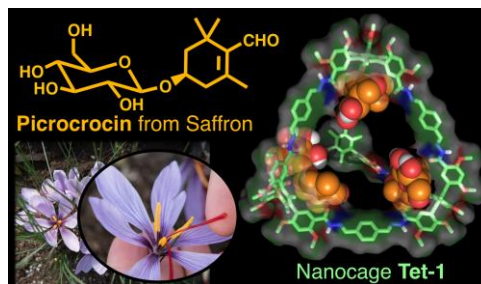
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**Summary.** Despite an excellent reputation of Vermont for producing high-quality food products, new real-time sensing technology is needed to ensure the highest quality of local food products. To address this fundamental challenge, we have invented chemically tunable nanocages (molecular structures with a large cavity to bind guest molecules), which are advancing into accessible chemical sensors to detect components like picrocrocin in Saffron.

Our nanocages are more stable and cost-effective to create than potential alternatives and they are also capable of cooperatively binding multiple analytes (**Fig. 1**) at the same time (which enhances sensitivity).

For these reasons, our nanocage-based sensing technology has numerous potential agricultural and environmental applications. Proof-of-principle has been established by sensing an herbal glycoside (picrocrocin) from saffron.

Overall, our nanocages represent (see: Sharafi *et al.* “Size-selective Catalytic Polymer Acylation with a Molecular Tetrahedron” *Chem (Cell Press)* **2020**, *6*, 1469–1494. Highlighted in Science Daily and >20 other News Channels) a new type of porous material with many potential, future applications. A typical nanocage is



**Fig. 1. Picrocrocin molecule** (responsible for saffron flavor) binding inside of our nanocage **Tet-1**. A computer-simulated binding model is shown in element style with **picrocrocin** (organic carbon, space-filling representation). Saffron flower (lower left): stigma (red threads); stamen (yellow structure).

assembled by mixing a universal corner piece with a readily available linker piece. By simply changing the linker pieces, the nanocages can be tuned to recognize specific natural compounds (like picrocrocine in saffron) with relatively high selectivity. Linkage of the corner pieces is based on a unique technology from the Schneebeli lab to create hydrazone bonds, rendering the first hydrozone nanocage with  $T_d$  symmetry. Due to their distinctive chemical structures, these nanocages are stable in aqueous solvents, even at 80 °C. The excellent stability of the cages in water, which is significantly enhanced for our systems compared to related imine-linked cages, is important to generate the proposed sensors. We will discuss selective recognition by the nanocage, as well as an outlook on real-time sensor production for saffron quality assessment.

**Biographical Information.** Severin T. Schneebeli completed his B.S. degree at the University of Zurich in 2006 and received his Ph.D. in 2011 from Columbia University, working jointly with Prof. Ronald Breslow and Prof. Richard Friesner. As an International Institute for Nanotechnology (IIN) Postdoctoral Fellow at Northwestern University with Prof. Sir Fraser Stoddart (2016 Chemistry Nobel Laureate) from 2011 to 2014, Severin's research transitioned to the synthesis and computer-aided design of hierarchical functional nanomaterials. Since summer 2014, Severin has been serving as the PI of the Mesosynthesis Laboratory at the University of Vermont as an Assistant Professor of Chemistry. In 2020, Severin was promoted to Associate Professor. His current research aims to advance the field of soft materials, by investigating how traditional concepts of organic chemistry — like selective recognition and catalysis — can be extended to larger length scales for precision polymer synthesis. Severin is the recipient of a 2018 ARO Young Investigator Award, a 2019 NSF CAREER Award, and a 2020 Thieme Chemistry Journals Award.

## Saffron Product Safety for Medicinal Applications



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**Summary.** In addition to being a widely used culinary spice, saffron (*Crocus sativus* L.) has a long history of use as a medicinal herb. In Ayurveda, the traditional medicine system of the Indian subcontinent, saffron is called kumkuma or kesar and is used as a digestive aid and anti-inflammatory, and to treat skin conditions. In Traditional Chinese Medicine, saffron is called *fan hong hua* and is used to treat high fevers and increase contractions in pregnant women. Like most traditional medicine uses of plants, a lack of contemporary scientific research and clinical trials prevents the use of herbs like saffron from being recognized as safe for use in the treatment of specific medical conditions. The last few years has seen an abundance of new scientific information about the use of saffron and its constituents for a range of diverse medical applications, much of it generated by Iranian researchers.

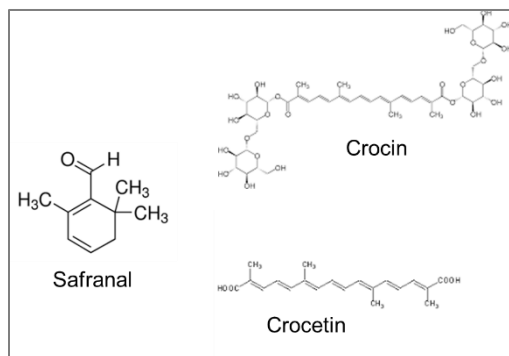
The determination of the safety of a botanical for ingestion by humans considers numerous factors. One of the key factors is the chemical constituents produced naturally by the plants and their pharmacological effects, and whether any of them are toxic to humans. Sometimes the presence of toxic constituents is associated only with specific parts of a plant, so that careful plant collection and processing allow for safe use of the botanical. Another aspect is whether the plant's constituents interact with other substances, such as foods, dietary supplements, or medications that an individual may also consume. Such interactions may either slow or increase the metabolism of other medications and be potentially harmful to the individual.

Consideration is also given to whether specific sensitive sub-populations should not consume an herb in therapeutic amounts, such as pregnant women or children.

Individual countries determine the regulatory process for recognizing substances as medicinal products. In the United States, the Food and Drug Administration (FDA) has provided guidance on the development of drugs from botanical sources. In addition to the applicable regulations for conventional drug development, sponsors and investigators for botanical drugs must be able to produce an article that is exactly the same from batch-to-batch, so that therapeutic consistency can be assured using Chemistry, Manufacturing, and Controls (CMC) for drugs generally. Few botanical drugs have been registered in the U.S., but herbal products and extracts are widely available in the dietary supplement product category, which has its own unique regulatory framework.

The American Herbal Products Association (AHPA) published the Botanical Safety Handbook 2<sup>ed.</sup> in 2013. This reference book of safety information for more than 500 herbs is available in both hard copy and on-line formats. AHPA is presently updating individual botanical entries for the on-line version, and recently completed a revision of the saffron entry after review of clinical trials and other scientific studies published after 2013. Saffron was classified as an herb that should not be taken by pregnant women at therapeutic doses unless under the supervision of a qualified health practitioner, and was noted as having no known concerns for interactions with other substances.

To summarize the new safety data available for saffron, AHPA identified more than 30 human clinical trials that have been performed using saffron, saffron extracts, or purified constituents from saffron, including safranal and crocin (Fig 1). Clinical studies were performed for a myriad of medical conditions, including depression, anxiety, and other mental health conditions; Alzheimer's disease; weight loss; macular degeneration; and rheumatoid arthritis. Most of these studies indicated some encouraging potential medical benefits from the use of the saffron or saffron derivatives. From a safety perspective, no serious adverse events were attributed to the treatment of trial subjects with articles derived from saffron.



**Fig 1.** Chemical structure of safranal, crocin and crocetin.

Case reports of individual adverse events associated with ingestion of saffron indicated two events in which individuals had allergic reactions after consuming foods containing saffron. Isolated incidents such as these do not impact the overall safety profile for saffron, particularly given its wide use as a culinary spice worldwide.

Other new scientific data include pharmacology studies which indicate that saffron may impact fasting blood glucose levels, which is relevant to diabetic individuals. Another study examined the use of saffron in the induction of labor in full-term pregnancy. New toxicity studies ranged from measurements of acute toxicity after single exposures to assessments of sub-chronic toxicity after exposures of three months duration in experimental animals. Data from genotoxicity and mutagenicity studies indicate that saffron does not cause damage to genetic material.

In summary, review of new scientific data did not change the current AHPA Botanical Safety Handbook classifications for saffron in terms of its cumulative safety and potential interactions, but the recent studies serve to elaborate on the established safety parameters for human use of saffron. The new data contribute to a very robust profile of safety data in which traditional herbal practitioners, medical professionals, researchers, and consumers can have confidence.

**Biographical Information.** Jane M. Wilson is the Director of Program Development for the American Herbal Products Association, a position she has held for eight years. Her duties include working with the AHPA management team to develop, implement, and manage AHPA programs and services, and performing outreach activities in support of the AHPA membership and other herbal products industry organizational collaborators. She holds a Master of Public Health degree in Toxicology and a Bachelor of Science degree in Medical Technology, both earned at the University of Michigan.



## Weed Management in Saffron

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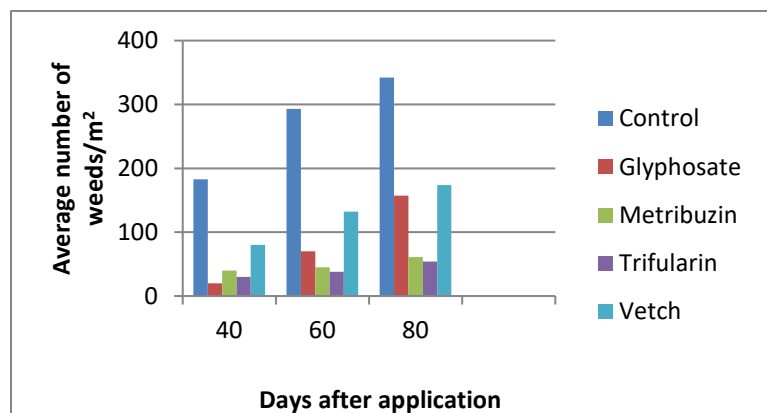
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**Summary.** Management of weeds remains challenging for saffron producers in Lebanon. Saffron is a relatively poor competitor with weeds. Thus, weed control early in the growing season or before saffron emergence is a must. The only tool used against weeds by Lebanese farmers is hand weeding during the growing season, which is labor-intensive and economically unfeasible. Thus, the search for more effective and realistic methods for controlling weeds has become increasingly important. A field trial was performed in the Summer/Fall of 2017 at the American University of Beirut in Lebanon to evaluate the efficacy of various weed control measures in a 5-year old saffron field. Treatments were: metribuzin (0.56 kg ai/ha, Early-POST); trifluralin (1 kg ai/ha, shallow PPI); glyphosate (3.7 kg ai/ha, Early-POST); vetch (300 kg/ha,

cover crop); and check (Fig 1). Except for vetch (Planted in early August), all treatments were applied in early-September, three weeks after irrigating the field but before saffron emergence. Results showed that all treatments significantly reduced the level of weed infestation in saffron 40 and 60 days post-application as compared to the control (Fig. 2). Although vetch reduced weeds, it interfered with harvesting operations since vetch plants were taller than



**Fig 1.** A) Control, B) glyphosate (left) and vetch (right), C) metribuzin, and D) trifluralin field treatments.



the saffron crop, making flower picking difficult. None of the treatments were toxic to saffron plants. The best results considering both long-term weed management and selectivity in saffron were obtained by the application of metribuzin and trifluralin.

**Fig 2.** Effect of glyphosate, metribuzin, trifluralin and vetch on weed population (n=4).

**Biographical information.** Dr. Mustapha Haidar is a Weed Science Professor and Director of the Advanced Research Enabling Communities at the American University of Beirut (AUB). He obtained his B.Sc degree in plant protection from Baghdad University, M.Sc from AUB in plant protection, and Ph.D in Weed Science from Colorado State University, USA. He served throughout the years as a Chairman of the Agriculture Department and as a Member and Chairman of several committees at AUB and at the national level. Dr. Haidar has more than 35 years of experience in weed management, crop production and outreach activities in Lebanon and the MENA region and is the author of various scholarly publications

## Altenburger Safran

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**Summary.** At our project Altenburger Safran we make it possible to combine research and community- it is a research project, but it is a communication bridge between cultures, generations and countries too. Currently, 128 plots (8m<sup>2</sup> each) with different test conditions are being tested in and around Altenburg on four different areas (Fig 1). The test series take about three years with four repetitions each, for example with the use of fungicides and herbicides or cultivation with combination fruits.



**Fig. 1.** Test site for saffron cultivation trials in Altenburg.

Thirty, forty, even forty-six pounds of highly expensive saffron are mentioned on the chef's annual grocery list. These orders were placed by the Altenburg castle of the Prince Elector of Saxony-Altenburg. Why had so much saffron ordered? We especially ask ourselves: who ordered and bought it

and for what purpose? These questions lead to an interdisciplinary research project which connects to the cultural and agricultural history of the central German states of Saxony, Thuringia and Saxony-Anhalt. Until today, in the scientific literature there is hardly any evidence of research on saffron for these regions. Yet, the issue appears to be worthwhile of further investigation. From previous research, which is based exclusively on the study of original files in the historical city and state archives in Altenburg, Weimar and Dresden, it becomes clear that saffron was part of the exotic spices used in the kitchens of the nobility at

the beginning of the 15th century. Saffron had even found its way into the bourgeois kitchens of some cities. Apparently the large quantities of the spice bought by the chef were imported into Central Germany. The traders and the routes they used are, so far, unknown. However, by the late 15th and early 16th century at, saffron was cultivated locally in specially designed gardens in the Thuringian cities of Jena and Altenburg and sold by local saffron traders and spice dealers.

Even the kitchen lists of the infamous Landsknecht mercenaries explicitly mention saffron in addition to ginger and pepper. In a cookbook from a Dominican monastery in Leipzig 80 out of 130 recipes include saffron as an important ingredient. Many of these recipes would even match today's culinary habits. In the search for answers to the questions asked at the beginning, not only commercial and culinary aspects are of interest. Even geographical names still in use today, such as Safranberg (Saffron Hill) or Safrangarten (Saffron Garden), point to this highly interesting chapter in late medieval cultural history.

**Biographical Information.** Dr. Frank Spieth was born in 1962 in Kahla, Thuringia. He studied agriculture at the University of Leipzig before receiving a doctorate in economics in 1993. From this time through 2015, he worked as an advisor on fundraising for several non-profit organizations. In 2015, he co-founded the non-profit company “Wandel-Werte-Wege – W<sup>3</sup>”. He has served as project manager for research on the re-cultivation of saffron in Germany since 2016, with a focus on planting, harvest and economy.

Andrea Wagner was born in 1969 in Erfurt, Thuringia. She studied German, Slavic and educational sciences in Erfurt, Jena, Berlin and Kaluga from 1987 to 1995. For the next 20 years, she worked as an auditor for certification of companies with a focus on employment of women and work-life balance. In 2015, she co-founded the non-profit company “Wandel-Werte-Wege – W<sup>3</sup>” and has served as the owner and CEO since. Her main focus is saffron in history, literature and daily life.



## Winter Injury of Saffron at Cobble Creek Nursery

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**Summary.** Cobble Creek Nursery is a wholesale grower of trees and shrubs in Monkton, VT, established in 1986. We are located in USDA hardiness zone 4 (average winter lows of -15 to -30 F). We decided to try saffron in 2017 and planted 2500 corms from ROCO in Holland in late August, 2017. We planted two slightly raised beds about 120 feet long. The beds were 3 feet wide with the corms planted 6 inches deep and 6 inches apart in staggered rows (Fig. 1). The first fall our harvest only yielded a disappointing 150 flowers.

The second harvest in the fall of 2018 was a bountiful 65 grams (10,000+ flowers). Our fall 2019 harvest was even better at about 80 grams even though the season was shortened in November with a below normal cold snap. November 8<sup>th</sup> saw 3 inches of snow, November 11 and 12 a few more inches. Then we had a low of 3 degrees Fahrenheit on the morning of the 13<sup>th</sup> and similar lows on the 14<sup>th</sup>. At this time there was still 3-5 inches of snow covering the saffron beds that insulated the ground, corms and lower saffron foliage. However, the top halves of the leaves were exposed to the cold. We then experienced even colder temperatures on November 16 and 17, slightly above and below zero. The damage was not visible to the eye right away but showed up later. In late winter and early spring the portion of the leaves that were unprotected above the snow had turned a brownish tan color. The foliage below the snow was green. I remember from a previous conference that saffron is cold



**Fig. 1.** One of two 120' saffron beds at Cobble Creek Nursery displaying senescence of the leaves.

hardy to around -15 F. However, most plants reach their peak winter hardiness in mid-winter. It's a gradual hardening off that takes place in the cells of plants as the weather turns colder in fall and early winter. I know this from my 40+ years of nursery growing and from research that Dr. Norman Pellett did at UVM. I also contacted Dr. Leonard Perry from UVM who did similar research on herbaceous perennials. He confirmed that cold hardiness in plants increases and peaks by mid-winter.

The foliage died back normally by early June. In September of 2020 the new foliage began to emerge and by mid-October there was lush, healthy foliage. What followed was a very disappointing harvest of about 12 grams from the beds that had yielded 80 grams the previous year. We expected that maybe our yield would decrease a bit because it was our 4<sup>th</sup> harvest season. That may have been a small part of the reduction but I suspect the major cause was the foliage damage and the resulting reduced photosynthesis in the winter and spring. Consequently there were far fewer flower buds that were initiated. We are hoping that the corms recover and give us a better yield in the fall of 2021.

In conclusion, those of us that are growing Saffron in areas where winter temperatures hit -15 F or colder after Jan 1, or get unexpected cold snaps earlier in the winter, should make plans for protection. After our experience from November 2019 we now use heavy grade winter blankets when needed for temporary protection. The blankets are made of spun bonded polypropylene similar to Remay row covers but much thicker. If interested you can contact me for more information and sources.

**Biographical Information.** John Padua has a BS in Plant and Soil Science from the University of Vermont, Burlington VT. He has been a grower and propagator of woody nursery plants in Vermont for 40 years.

## Calabash Gardens

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**Summary.** Calabash Gardens is a saffron farm in Wells River, Vermont. They began a test plot for saffron in 2018 and continued testing for 2 years. Their initial 2,000 corms produced about 10 grams of saffron for them in their first year. The following year, they harvested one ounce (28g) of saffron. Inspired, they expanded to half an acre in 2020, seeking to host 120,000 corms. Intensive rock removal was needed in order to prep the land for planting. Once prepped, the

field was dimpled for a planting template. The density of corms started at 6,000 corms, however they stretched to try and meet their goal of 10,000 corms per row. 70 volunteers were needed to get the work done. With necessary COVID precautions in place, volunteers worked over the course of four



**Fig 1.** Field preparation for saffron planting in Fall 2020.

days. While most were planters, some were kitchen aids and others musicians for entertainment. 70,000 of their 120,000 corms were planted during this volunteer party. The last corm entered the ground September 25<sup>th</sup>. At least one volunteer assisted Jette each day following the planting party, for a few hours at a time. Overall, the experience was incredibly labor intensive and time consuming; Jette worked every day for 6-8 hours. Their first flower was seen on October 8<sup>th</sup>, and their last flower on December 6<sup>th</sup>. Overall, they were harvesting every day for nearly two whole months. Their peak harvest lasted one week. Luckily, about ten family members had come to visit during this time. They typically had six people in the field harvesting

from 9am to 3pm, and another 4 people inside processing. It took about twice as many hours to process as it did to harvest, and most nights they finished between midnight and 1am.

This year, they will be expanding to a full acre, half of which will be in its 2<sup>nd</sup> season. Four to six new full-time employees will be added to ensure the work is completed. Zaka notes that you need to expect a lot of hard work. Both labor force and proper preparation are incredibly important. Jette notes that while flowers could be held overnight, the crop will be lost on the second day. Processing needs to be done immediately to ensure the highest quality.

**Biographical Information.** Jette Mandl-Abramson, born in New Mexico, raised in the South coast of New Hampshire, is primarily a ceramist, herbalist and organic regenerative farmer. She has also worked in the restaurant industry for fifteen years. Her passions are great food, horticulture, animals and wild edible plants. She wants every initiative she takes to be ecofriendly and regenerative as well as giving something back to the community. She started work on a horse farm when she was 11 years old. At 26 she started her first organic farmstead in Lee, NH and moved the whole farm north shortly thereafter.

Claudel Zaka Chery, a Haitian poet and film director, moved to Newbury from Jacmel-Haiti in 2011. He was the assistant to the director of FOSAJ, Flo McGarrell. Both Mr McGarrell and Zaka ran the Jacmel art center with great energy and taste. It's while there in Newbury he honed his interest in peculiar taste, spices, such as saffron and cuisines. Jaka and Jetta bought a farm in Wells, VT where they specialize in saffron production.





## Garlic Company of Vermont: VT Grown Saffron

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**Summary.** The Garlic Company of Vermont is a small family farm in Barre, VT. In 2019, they purchased 1,000 non-organic saffron corms from Roco Saffron. After minimal ground preparation and planting, they saw their first flower on October 11 and last flower on November 3. Their first year harvest was just over 3 grams with a 70-75% bloom rate (Fig 1).



**Fig 1.** 2019 saffron blooming season.

	First Flower	Last Flower	Harvest (grams)
1000 corms (1 <sup>st</sup> season)	10/11	11/3	3 g
Total (2019)			3 g
1000 corms (2 <sup>nd</sup> season)	10/9	10/30	30 g
10,000 corms (1 <sup>st</sup> season)	10/23	12/4	35 g
Total (2020)			65 g

**Table 1.** Blooming timeline and total harvest for the 2020 and 2021 seasons.

The second year, about 12,000 ft<sup>2</sup> was prepped for the second planting. 10,000 Roco Saffron non-organic corms were ordered. Soil amendments consisted of compost, 1200 lbs of lime, 300 lbs Pro-Grow fertilizer, and 40+ hours of rock-picking. Their first flower was seen on October 23 and the last flower not until December 4. These newly planted corms produced about 35 grams in 2020, while corms planted in 2019 produced about 30 grams in their second season. (Table 1).

**Biographical Information.** We're a small family farm that is located in Central Vermont, in the beautiful Town of Barre. Growing garlic began as a hobby, and over decades, has turned into a passionate mission to share our garlic with everyone. We specialize in growing the highest quality, most flavorful, hardneck garlic. Our farm family believes that healthy plants come from healthy soil, and we use only naturally occurring fertilizers and amendments in this process.



## Roco Saffron

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**Summary.** Roco Saffron is a family company supplying the industry with premium quality of Saffron bulbs directly from the farms in the Netherlands since 1882. It was originally founded by the Rotteveel family four generations ago distributing flower bulbs such as tulip and hyacinth bulbs to Europe and U.S.A. markets. With specific expertise in saffron corms, they've developed contracts with a number of Dutch growers for saffron corm production. They are able to guarantee corm sizes, starting at 7 cm to 11+ cm circumference. Corms are kept at a constant temperature from harvest until delivery with temperature-controlled reefer containers. This is necessary for Northern hemisphere shipments as sailing time from



**Fig 1.** Harvesting saffron corms with partnered Dutch growers.

Rotterdam to New York is approximately 14 days. North American growers can expect corm delivery between the end of August and early September. Southern hemisphere markets receive special temperature treated corms in climate controlled cells between February and March.

Corms can be purchased online through the official Roco Saffron online shop.

**Biographical Information.** Hans Rotteveel has been involved in the Flower Bulb business since a child. Hans has traveled throughout Europe & the U.S.A. visiting customers and supplying the finest quality of flower bulbs from Holland. Hans decided to fully dedicate working with professional Saffron growers from all over the world supplying not only his expertise about Saffron but also premium quality Saffron Bulbs. Roco Saffron is a Rotteveel company with a focus and specialization in Saffron Bulbs only.

## Peace and Plenty Farm

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**Summary.** Peace and Plenty are an organic, 7-acre market garden and saffron farm based in Northern California. They also serve as an Airbnb and event space for others to enjoy. Their organic saffron fields were first established in 2017, where they planted 7000 corms in 6000 sq. ft. Their yield that first year was about 25 grams. They lost an estimated 30% of their corms to gophers and voles, leading them to dig up all remaining corms in 2018, which amounted to around 50,000+ corms. These corms were then planted in approximately 10,000 sq. ft. of raised beds made of hardware cloth. Their yield from the raised beds that year amounted to 325 grams. They have not seen any apparent losses to rodents since the switch to raised beds. In 2019, they decided to add an additional 10,000 sq. ft. of new beds and 22,000 corms. This decision led to a yield of 1.2 kg. The following year, with no new additions, the yield nearly doubled, increasing to 2.2 kg. As their three full-time workers were not enough to tackle this job, 11 intern WWOOFers assisted them in their 2020 harvest (Fig 1). As daily harvest were immense, they started at 3 A.M., picking the saffron flowers when they were still closed and easier to pick. A walk-in cooler was used to store flowers until they were ready for processing. Tiring as the intensity of harvest season may be, they managed these struggles



**Fig 1.** WWOOF interns finishing up the daily flower harvest around sunrise.

with cheerful snacks and family dinners before their nightly retire to the tenting areas. By the end of the season, they had picked more than half a million flowers.



**Fig 2.** Disease symptoms among saffron plants, including yellowed leaves, sunken areas (left) and rotting corms (right).

While bountiful, this 2020 harvest did not come without its fair share of problems. In preparation for the season, Peace and Plenty decided to irrigate early in an effort to cool down the soil amidst a severe drought. They then noticed widespread disease symptoms among their saffron crop (Fig 2).

This included yellowing leaves which were easily detached, frequent sunken areas around the plants, and rotting corms. This disease was diagnosed by two plant pathologists as *Fusarium sp.* After mapping the presence of disease in the field, they found that shaded areas were disease-free, while unshaded areas had provided an optimal environment for *Fusarium sp.* following September irrigation in very high temperatures. Extremely high temperatures had again been seen in October. In these conditions, two secondary issues presented themselves: bulb mites and nematodes. The bulb mites, about one mm long, were thought to likely be *Rhizoglyphus robini*. These mites feed on the corms of saffron plants. Nematodes, though also present, were diagnosed as non-parasitic to the plants.

Despite the challenges they have faced, Peace and Plenty have found success in their projects. They host a popular farm stand which draws both many customers seeking to purchase their fruits and veggies, cut flowers, nuts, saffron and value-added products. They thank a number of marketing methods for this success, including Facebook, flyers around town, word-of-mouth, and event hosting. Informational tours and Farm-to-Table dinners (in which saffron is the star) are among their popular events. Instagram is a social media platform which has allowed them to connect with customers far and wide. By telling their story on social media, they have helped folks understand why their saffron is worth more than imported saffron by showing them how much work it takes. Strategies such as using and following relevant hashtags,

quality photography, and connection with chefs and lifestyle influencers to stay abreast trends have all contributed to their growth as a company. Just as important, however, is creating your brand. They suggest the following: get professionally-made graphics, use high-quality eco-packaging, maintain the same aesthetic throughout your product offerings, and use your packaging to show why you are different (Fig 3). Combined, all of these things will keep your project connected and moving forward. Peace and Plenty's efforts have since seen industry reward, with features in Martha Stewart Living, The San Francisco Chronicle, The Press Democrat, and more.



**Fig 3.** Saffron packaging and branding for Peace and Plenty farm.

**Biographical Information.** Simon and Melinda Price established Peace & Plenty Farm, a diversified farm and agritourism destination in 2017. Their goal is for their farm is to promote the local community, improve the health of the land, and minimize the environmental impact of farming. They are building a thriving organic farm that creates a place for community to gather for weddings and events; a place for school children to learn; and to help contribute to an economy of sustainable agriculture

Melinda is a community organizer and entrepreneur, and has worked in education, technology, catering, and as a farm apprentice. She learned perseverance and resilience as a single mom. Simon, a former wildlife biologist, has worked most of his life outdoors, in land management and protecting wildlife and the environment. They started growing saffron in 2017 after hearing about UVM's work on the radio. They now have one of the largest saffron farms in North America.



## Vermont Produce Program

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**Summary.** The Vermont Produce Program aims to help Vermont’s produce industry by aiding farms of all sizes and stages of development to meet food safety requirements, access markets, and promote public health as sustainable agricultural businesses. In January 2011, the Food Safety Modernization Act (FSMA) was enacted, representing the largest update to the Food, Drug & Cosmetic Act since 1938. The purpose of FSMA is to move toward a national food safety system focused on the prevention of foodborne illness. The FSMA Produce Safety Rule (PSR) covers farms that meet certain criteria under the FSMA Produce Safety Rule (PSR). These covered farms must meet science-based standards for the safe growing, harvesting, packing, and holding of fruits and vegetables grown for human consumption. The Vermont Produce Program implements this federal regulation in Vermont.

The production of saffron is subject to regulation under the FSMA PSR to ensure food safety best practices are followed that minimize risks of foodborne illness to consumers. Some saffron farms may be regulated by the Vermont Produce Program and undergo regulatory inspections. There are exemptions for very small farms and partial exemptions for certain farms selling primarily direct-to-consumer and to local restaurants and retailers. Growers that conduct additional processing, in addition to plucking and dehydrating stigmas—such as chopping or grinding—will need to follow Good Manufacturing Practices for Food Products and connect with the Vermont Department of Health. While there is currently no license or registration requirement for selling produce in Vermont, we encourage all farms that grow and sell produce

to enroll in the Vermont Produce Portal ([agriculture.vermont.gov/produceprogram](http://agriculture.vermont.gov/produceprogram)). These regulations are new and sometimes complicated – we are here to help!

If you grow and sell saffron in Vermont, please reach out to the Vermont Produce Program. We can help you understand if your farm is exempt from the FSMA Produce Safety Rule. If your farm is subject to the FSMA Produce Safety Rule and an inspection is required, the Vermont Produce Program can help you prepare for a regulatory inspection. We also offer educational and technical assistance services to all farms that grow produce, regardless of their size and regulatory coverage. Resources to learn more about food safety best practices, access technical or financial assistance, or discuss food safety accreditation and certification options are only a phone call or email away!

**Biographical Information.** Gina Clithero is an Agriculture Development Specialist at the Vermont Agency of Agriculture, Food and Markets. Clithero supports outreach and education activities for the Vermont Produce Program. This work supports fruit and vegetable growers to improve food safety practices on Vermont farms. Clithero also manages grant programs that invest in produce and specialty crops industries. Clithero currently manages the Vermont Produce Safety Improvement Grant program and the Vermont Specialty Crop Block Grant Program.



## Made in Wherever

Brian Leven

Golden Thread Farm, Stowe VT

Website: [goldenthreadfarm.com](http://goldenthreadfarm.com)

**Summary.** Established in 2017, Golden Thread Farm is a saffron farm located in Stowe, Vermont. They host two hoop houses with raised beds, where their organic saffron is currently grown (Fig 1). With a background in law practice, Brian Leven is versed on more than the farming side of things. He service as an attorney for the Vermont State Legislature, as Deputy Secretary of State for Vermont, and as Executive Director of the Vermont State Ethics Commission has familiarized him with the changes in Vermont Legislature surrounding food and consumer law.

In 2006, Rule CP 120 “Representations of Vermont Origin” was brought into action. This serves as a consumer protection authority and applies to the use of the name “Vermont” in connection with sale of goods or services. This protects against the misappropriation of the name “Vermont” in marketing schemes. This applied to a number of transgressions, such as maple syrup from Quebec being sold in Vermont as “Vermont Maple Syrup”, or Mackenzie Meats selling their meats from their Massachusetts base as “Mackenzie Meats of



**Fig 1.** Hoop house with raised saffron beds at Golden Thread Farm.

Vermont”. This rule was intended to have a blanket approach to all goods from Vermont, including processed foods, whole foods, wood and forestry products, etc. As a result this caused confusion, and some changes came to order last July through Act No. 129. “Local” Is now synonymous with “Vermont” and replaces the 30 mile radius rule previously in action. The new definition also differentiates food by category and clarifies how various types of food qualify as “local” or “Vermont” food. Furthermore, food is



categorized into the following three areas: Raw Agricultural Products, Processed Food, or Unique Food Products.

A Raw Agricultural Product is any food in its raw or natural state without added ingredients, and includes pasteurized or homogenized milk, maple sap or syrup, honey, meat, eggs, apple cider, and fruits or vegetables that may be washed, colored, or otherwise treated in their unpeeled natural form prior to marketing. These products are “local” or Vermont” food if they are: exclusively grown or tapped in Vermont; not milk, and was derived from an animal that was raised for a substantial period of its life in Vermont; is milk, where a majority of the milk was produced from Vermont animals; is honey produced by Vermont colonies located exclusively in Vermont when all nectar was collected. Other states employ a variety of labeling restrictions, both general and specific. California is one state which has general labeling restrictions such as seen here in Vermont. The following are examples of specific labeling restrictions seen in other states: wine in CA, citrus in FL, strawberries in LA, maple syrup and honey in NH, honey in NC, honey in RI, wine in WA, cheese in WI. Maine and Georgia are two states which restrict their state logo usage on labels.

It is worthwhile to think of what labeling technique one might wish to use for their saffron. Restaurants which use Golden Thread Farm saffron have reportedly enjoyed being able to tell their customers that the saffron is Vermont-grown. Which labelling will suit your needs best? Vermont saffron? American saffron? North American saffron? As the industry expands and growers define their markets, these techniques will become more important to both the grower and consumer.

**Biographical Information.** Brian Leven is a practicing attorney and property manager. He received a B.A. in Philosophy, Asian Studies, Biology, English, and Physics from the University of Vermont before going on to receive his J.D. in Law from the University of Denver Sturm College of Law in 1996. After serving on the Vermont Legislature Council for 12 years, he went on to serve as the Deputy Secretary of State from 2011 to 2015. He then served as an attorney at Stackpole and French for one year before turning to independent practice in 2016.



## Lemonfair Saffron Co.

Parker Shorey  
Ferrisburgh VT

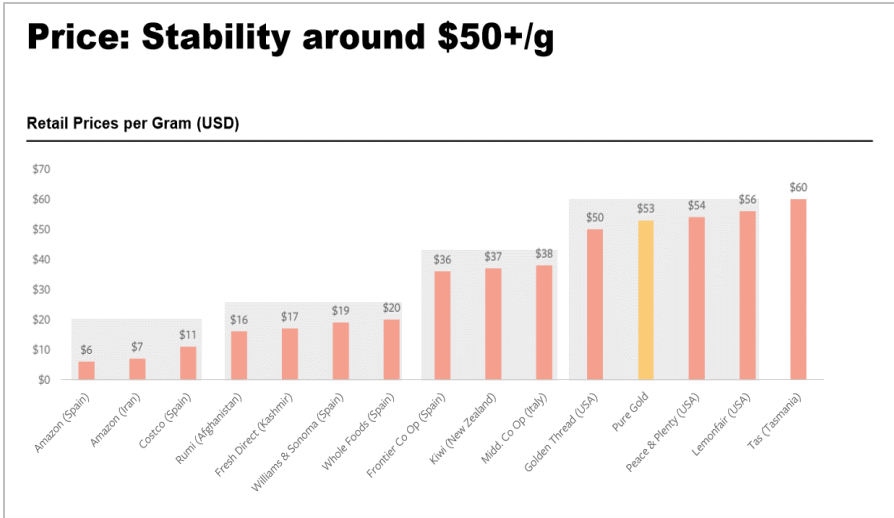


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**Summary.** Lemonfair Saffron Co. is a partnership which Parker Shorey and Hannah Marks started in 2017. Parker built a greenhouse and some raised beds and learned how to grow and dry saffron in cooperation with UVM. Their next focus was building the saffron market down in New York City. They realized that the best way to expand was through partnerships. They found other like-minded family farms with both land and desire to enter a partnership agreement on the methods and ethics of growing saffron, the drying techniques, and finally the sale of their saffron. This created two sides of the project: generation of supply and generation of demand. With the newly formed partnerships, Parker and Hannah was able to focus on the demand side of things. This includes details such as drying, packaging, merchandising, shipping, customer care, incorporation, marketing, partnerships, and research and development. This approach allowed their growers to focus on specialization in saffron production while still growing the business side of the company into what it is today.

Lemonfair emphasizes four elements of their business strategy: product, price, place, and promotion. Not much has changed over the past year for their products, though they have developed a saffron sea salt which they have brought to market and are working on a candle. The price of their saffron has maintained stability surrounding the premium organic or sustainable local saffron pricing of around \$50/gram (Fig 1). Place and promotion, however, have seen the most impact in the last year due to COVID. Restaurants and farmers



**Fig 1.** Retail prices for different suppliers per gram of saffron in USD.

markets, typically a go-to place of sale for saffron, were significantly impacted by the limitations of the pandemic. This shifted focus to online shopping in order to reach consumers, and they expect this trend to continue past the reach of

the pandemic. Another shift was towards new food supply models. BKLYN Larder was a re-seller type model they partnered with, allowing them to sell their product with a smaller cut than you would see taken in places such as a brick and mortar shop. ShopIN.nyc allows sellers to sell things locally, keeping the costs down and giving sellers a larger portion of the profit margin. Specialty shops were also able to keep volume moving throughout the pandemic limitations. New promotion techniques have also seen development during the pandemic, with a notable shift towards home-chef cooking. Increase in experimentation with saffron in cooking and promotion of saffron-centered recipes allowed Lemonfair to pique interest in new customers through their social media pages. Collaboration with influencers, who are active social media figures with a larger number of followers, also helped them to promote their product and recipes to new audiences.

**Biographical Information.** Parker is the founder of Lemonfair Saffron Co., a Vermont-based partnership of family farms committed to sustainable farming and the finest quality saffron. Parker was born and raised in Ferrisburgh, Vermont and now splits time between Vermont and NYC. He has an MBA from the MIT-Sloan School of Management and has worked in food and technology since 2008.

## Saffron Disease Management: Beware What Lies Beneath

Michael Brownbridge

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### **Summary.** Primary pathogens of saffron

While multiple factors influence productivity in saffron, diseases and nematodes are the main biotic constraints, with corm rot being a major limiting factor to successful cultivation of the crop in both traditional and non-traditional areas. Primary fungal pathogens (*Rhizoctonia*, *Fusarium*) are often found associated with secondary pathogens or saprophytes (*Aspergillus*, *Penicillium*) in decaying corms. Bacterial infections occur in corms and foliage, and viruses often cause more chronic symptoms which, over time, lead to poor crop performance. For their part, plant-parasitic nematodes play an important role in plant health as their feeding lesions provide a point of entry for soilborne pathogens such as *Fusarium oxysporum*.

This disease complex causes substantial yield losses in saffron globally, and corm rot is prevalent in moderate to severe form in all saffron growing areas of the world. *Rhizoctonia crocorum* and *F. oxysporum* infect and destroy roots and invade corm tissues. Their occurrence and spread is aided by exchange of infected material and the perennial monocropping of saffron in the same fields. The constant availability of hosts allows inoculum to continually cycle within the crop and levels to build over time, leading to a gradual decline in productivity and ultimately even total crop failure.

### Infection and dispersal of pathogens

Sclerotia formed by *Rhizoctonia* allow the pathogen to survive in the soil. When conditions are favorable, the sclerotia germinate and will infect corms. *Fusarium* survives in diseased corms and soil as mycelium, chlamydospores, macroconidia and microconidia. The thick walled chlamydospores can survive for more

than 20 years. *F. oxysporum* can also grow saprophytically and colonize plant debris, which increases inoculum levels in an infected field. As infected corms decay in the soil, the spores infect newly-sown or daughter corms which further accelerates disease progression.

The primary route by which pathogens disperse into new fields or regions is thought to be through import or exchange of infected corms and associated soil. The dispersal of pathogen propagules occurs rapidly within the field, via contaminated farm implements, tools, labor, clothes, and footwear, and by natural factors, such as water, on animals or in wind-blown soil.

### Disease management

From a disease control standpoint, for minor crops like saffron, there are few registered fungicide options, and even fewer for organic growers. Consequently, other approaches should be prioritized to prevent and manage soilborne diseases:

*Cultural practices.* Crop nutrition, watering, crop rotation, and prior land use practices, are aspects that affect plant health and productivity.

*Exclusion.* The most important step to avoid establishment in pathogen-free areas. Purchase of certified disease-free corms limits introduction and dissemination of disease via infected corms or contaminated soil. In the absence of certified material, consider testing a sample of the new material; quick and reliable DNA-based diagnostic tests can specifically detect pathogens like *F. oxysporum*. Tests can also assess disease levels and risks in soils, and nutrition analyses provide essential feedback on soil fertility to enable more tailored programs to be implemented. There is a cost, but weigh that against the cost of not knowing and either having to deal with disease in the field, and lost revenue through not being able to realize the genetic potential of the crop.

*Management.* Several *Trichoderma* species have shown potential as biocontrol agents for corm rot and have performed well against *F. oxysporum* and *R. solani* when applied to corms as a pre-plant dip. Bacteria such as *Bacillus subtilis* can deliver similar crop protection benefits. In saffron, application of *Trichoderma*

and *Bacillus* spp. as pre-plant dips not only improved plant health but also enhanced growth, which resulted in improved saffron yield and quality.

Initially, diseases may not be prevalent, but in other crops we have learned that they will show up over time. There is no single solution for saffron diseases, and an integrated plant health approach is essential to maintain productivity from initial planting through harvest over several years.

**Biographical Information.** Michael received his Ph.D. from the University of Newcastle Upon Tyne in the UK and has worked in biological control for over 30 years. His work has taken him to positions in Israel, Kenya, the USA (UVM!), New Zealand and Canada. He joined BioWorks at the end of 2019, where he works as a Biological Program Manager providing oversight of BioWorks' portfolio of disease management products, and technical support to customers around use and integration of biological materials for pest and disease management.

## Geographical Classification of Saffron Samples by UV-vis Spectra of Aqueous Extracts Combined with Linear Discriminant Analysis

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**Summary.** Saffron is the most expensive spice in the world not only due to its therapeutic properties, but also due to its ability to provide the combination of taste, aroma and color to foods and beverages. The major biologically active compounds in saffron stigma are crocins, picrocrocin, and safranal that are responsible for saffron color, taste and aroma, respectively. The characterization of saffron samples from many countries indicated that the quality of saffron and its stigma composition is strongly dependant on the production site and its pedoclimatic factors along with local common practices during the pre- and post-harvest processes. In our previous studies, we have developed a novel technique comprising of ISO 3632-2 method combined with supervised statistical approaches to geographically classify The USA (Vermont), Iranian, and Italian saffron samples based on their quality and chemical constituents. Our method consisted of analysing the aqueous extracts of stigma samples using ultraviolet-visible (UV-vis) spectroscopy according to the ISO 3632 standard and analysing the obtained spectra through linear discriminant analysis (LDA) technique, which allowed us to 100% classify Iranian and Italian saffron samples, that was more accurate compared to LDA classification results performed on HPLC peak areas of picrocrocin, safranal and ten different crocins. We are currently expanding the application of our novel technique not only to classify saffron samples from several countries, but also to create a rich date base helping us to categorize any unknown saffron sample and determine their geographical origin with an acceptable accuracy.

## Evaluation of the Effect of Dehydration Methods on the Quality of Vermont Grown Saffron

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**Summary.** Saffron is an emerging high value crop for North American growers. It is the dehydrated stigmas of *Crocus sativus* L., and is thought to have therapeutic properties that can impact several types of cancer cells, digestive inflammatory disorders, Alzheimer disease, diabetes, mellitus and cardiovascular disorders. Crocin (C<sub>44</sub>H<sub>64</sub>O<sub>24</sub>), picrocrocin (C<sub>16</sub>H<sub>26</sub>O<sub>7</sub>) and safranal (C<sub>10</sub>H<sub>14</sub>O) are the main apocarotenoids in stigmas, the concentration of which defines saffron quality. To obtain saffron, *C. sativus* stigmas must lose >80 % of their water content during the drying procedure. Drying can intensively affect the saffron quality.

The goal of this research was to assess the effect of different temperature regimes on the concentration of crocin, picrocrocin and safranal in Vermont-grown saffron. To evaluate the effect of dehydration methods on saffron quality, saffron corms were planted in late September 2019 at the Univ. of Vermont Horticulture Research Center [Lat/Long: 44.43/-73.2; Elevation: 71 m] (USDA plant hardiness zone 5a [-29.9 to -26.1 °C; -20 to -15 °F]). Saffron flowers were harvested in October 2019 and the stigmas were separated and then oven-dried at three different temperatures [a. High (100 °C for 7-10 minutes); b. Medium (77 °C for 25 minutes); c. Low (55 °C for 60 minutes)]. Extracts from the saffron samples from each temperature regime were prepared, and they were tested using nuclear magnetic resonance spectroscopy (NMR) to assess the concentration of safranal, crocin and picrocrocin.



Significantly higher concentrations of safranal and crocin were detected in samples dehydrated at the High regime (100 °C for 7 minutes) compared with other treatments. A significant and positive correlation was found between the amounts of safranal and crocin among the samples. An opposite trend was observed for the concentration of picrocrocin. Samples dried in the Low temperature regime contained slightly more picrocrocin than those from the other treatments, though differences were not statistically significant. Our results suggest drying temperature has a significant effect on the concentration of safranal and crocin, but not on the concentration of picrocrocin. More research is needed to further characterize the impact of drying on saffron quality before specific guidelines can be developed for growers.



**Fig 1.** Saffron extract prepared for NMR testing (L); dried saffron product used for testing.

**Biographical Information.** Arash Ghalehgholabbehbahani is a Research Associate at the University of Vermont. He is an agroecologist with research interests in the field of sustainable agriculture and crop diversification. His professional goal is to promote sustainable agriculture through the implementation of cost-effective changes striving towards holistic and ecologically sound management of crop production. With the establishment of the UVM North America Center for Saffron Research and Development, his research has built a strong foundation from which to launch broad-based research and extension projects on saffron. The projects that he conducts contribute to the development of new high-value crops to encourage product diversification and strengthen financial viability of small family farms