LOCALLY GROWN FRUIT RETAINS ITS SOIL SIGNATURE USING THE SCANNING ELECTRON MICROSCOPE TO BRIDGE SOIL SCIENCE TO FRUIT SPREADS

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OVERVIEW

The need to transform the undergraduate laboratory experience has been well documented in the literature. One proposed method is through the use of Course-based Undergraduate Research Experiences (CURE's). Incorporating CURE's has been linked to fostering interest in the natural sciences, improving the retention of students in STEM disciplines, and providing students an opportunity to improve their understanding of the nature of science (Figure 1). At Delta State University, students enrolled in Materials/Methods of Environmental Science (BIO 415) and Instrumental Analysis (CHE 460) have explored if the nutritional value of food is a measure of soil fertility and the availability of nutrients. While recognizing that soil is essential for life, students were curious to determine if elements found in noncommercial jams/jellies from different areas of the United States would correlate with soils in which the plants were grown. From 2017-2021, 27 different fruit spreads (jams/jellies/preserves/marmalades) were acquired from known areas throughout the United States (Figure 2; Table 1) and cooked down to an ash (Figure 3). Each ash sample was analyzed with an energy-dispersive x-ray Fluorescence Spectroscopy unit associated with the JEOL scanning electron microscope (SEM) to determine elemental composition (Figure 5). Textures of the ash were photographed with the SEM (Figure 4) and the ash color was compared to color chips associated with the Munsell Soil Color Chart. Local soil-based information published in the National Resouce Conservation Service (NRCS) soil website and on geological maps was compared to the chemical elements acquired from the ash samples. Students discovered that they could corelate the fruit spread samples to the local geologic setting in many situations. These laboratory experiences have been successful in that students could explain and interpret data generated by the SEM. Students also built strong collaborations and were able to conduct that research that is of interest to the broader scientific community. They have given scientific posters at national and state meetings, authored an international paper, and given a PowerPoint for a Perm University/Delta State University teleconference that pertain to this project. This research may be extended to other local products throughout the United States such as salsa and maple syrup that would enhance the CURE experience.

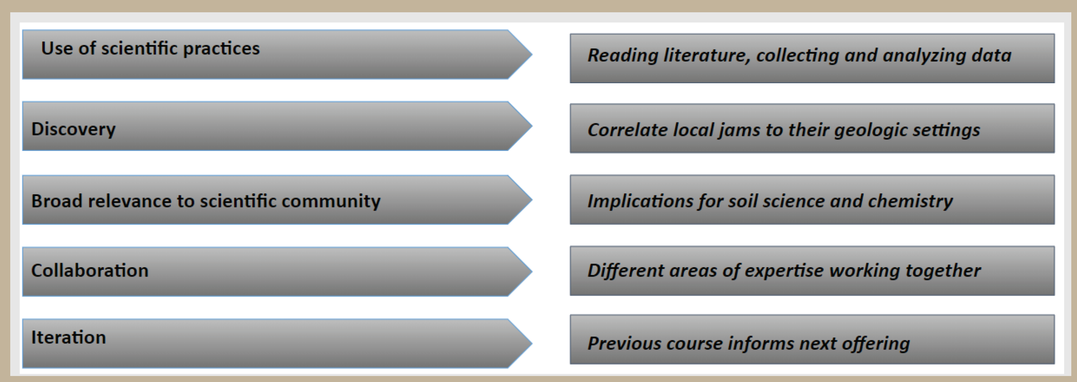

Figure 1. Key features of a CURE lab experience adapted from Auchincloss et al. 2014.

CONCLUSIONS

- Processing the fruit spreads, prior to putting them in the furnace, often took 2 -3 weeks.
- Twenty-two different elements were found in total. The greatest number of elements were from floodplain sediments from Mississippi Delta.
- Similar fruit spreads from different sites did not possess the same chemical elements: i.e. peach jam from Laurel, VA compared to peach jam from Nampa, ID.
- Fruit spreads from the same region often contained a different composition of elements.
- Calcium spikes were noted from fruits are reflective of limestone and/or calcium rich soils: Brigham, UT, Lincoln Co., NV, Montague, MA and Bear Lake, ID.
- Nickel found in Nampa, ID may be associated with mineral tailings when the area mined ores.
- A large spike of magnesium, noted in the raspberry lavender sample from Corrales, NM, may reflect the presence of wind-blown dust or sedimentary deposits that are high in magnesium.
- Anthropogenic factors may have influenced soil composition. Spikes of potassium and phosphorus may be from fertilizer applications to enhance soil suitability: raspberry rhubarb from Mariposa, CA and blueberry rhubarb from Brookfield, MA.
- In general the chemistry of the soils was reflected in the jams/jellies/preserves. Root uptake in plants is complex and even small traces of soil elements may be found in edible fleshy fruits.
- Students were able to gain a stronger understanding of the social aspects of science including collaboration and presenting scientific data.
- This project has resulted in several peer reviewed conference presentations and publications offering new knowledge to the scientific community.

ACKNOWLEDGEMENTS

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REFERENCE CITED

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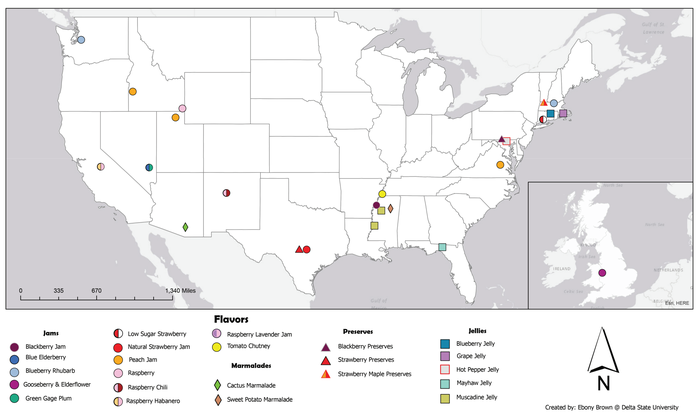

Figure 2. Generalized map that depicts the location of 27 fruit spread samples.

Figure 3. Sequence of steps in preparing the fruit spread samples prior to being analyzed with the SEM: A. fruit spreads being heated on a hot plate, B. placing fruit spreads into crucibles, C. filled crucibles ready to be fired in the furnace, D. crucibles inside the Fisher Isotemp Model 650-58 Muffle Furnace. E. students removing ash from the crucibles, F. ash samples stored in scintillation vials.

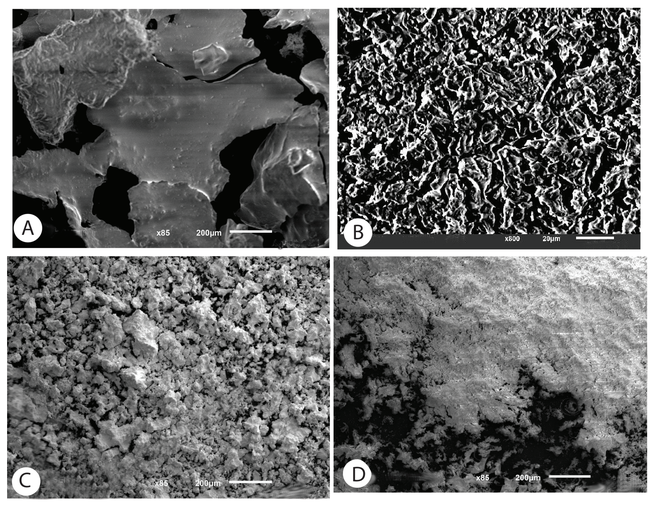

Figure 4. Scanning electron images of the ash from four fruit spread samples A Vicksburg, MS muscadine ash, B. East Lyme, CT blueberry ash, C. Maple Valley, WA blueberry rhubarb, and D. Tucson, Arizona, cactus marmalade

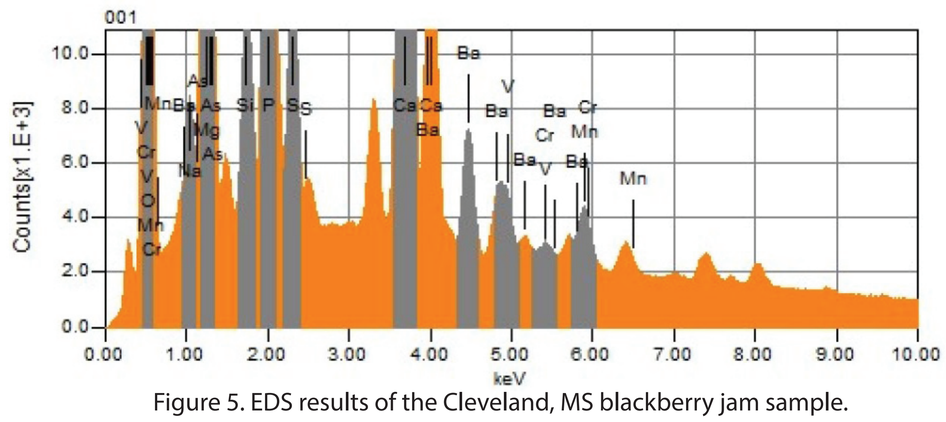

Figure 5. EDS results of the Cleveland, MS blackberry jam sample.

Table 1. Elements found in 22 noncommercialized fruit spreads.

Jam/ Jelly State	Elements																			
	Na	Mg	Al	P	Si	K	Ti	S	Ca	Cr	Fe	Ba	Mn	Cu	Ni	V	Zn	Mo	Cl	As
Raspberry habanero, CA	x	x	x	x	x	x	x		x		x	x								
Peach, ID	x			x	x	x			x	x	x		x		x					
Peach, VA			x	x	x					x	x				x					
Peach, UT	x	x		x	x		x		x					x						
Blueberry rhubarb, MA	x	x		x		x			x			x								
Grape, MA	x		x	x	x	x				x	x	x		x						
Strawberry maple, MA	x	x		x	x		x	x	x		x									
Blackberry, MS	x	x		x	x			x	x	x		x	x			x				
Muscadine, MS		x	x	x	x		x	x	x	x		x	x			x	x	x		
Sweet potato, MS	x	x	x	x	x	x		x	x	x	x	x								
Raspberry lavender, NM		x	x	x	x	x		x	x			x								
Blue elderberry, NV	x	x		x	x	x		x	x	x	x			x						
Strawberry, TX	x	x	x	x	x	x	x		x		x									
Natural strawberry, TX	x	x	x	x	x	x	x													
Raspberry, ID	x	x		x	x		x	x	x		x			x						
Hot pepper MD	x	x	x	x	x	x			x			x								
Blueberry, CT	x	x	x	x	x	x		x	x				x							x
Tomato chutney, TN	x	x		x	x	x		x	x										x	x
Blackberry, PA		x		x	x	x	x	x	x											
Mayhaw, FL		x		x	x			x	x											
Raspberry, red chile, NM			x		x		x				x									