An automation system for elderberry post-harvest processing

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Content

- Elderberry introduction
- Process for elderberry production
- Post-harvest processing
- Automation systems

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Elderberry products

Syrups, juices, jams, jelly, gummies, craft beer …

Dietary supplements

Elderberry functions

- **A healthy crop**
  - Simple list of health benefits:
    - Full of antioxidants and rich in Vitamins A, B, & C
    - Natural Source of Iron & Potassium
    - Contains anthocyanidins - boost your immune system
    - Proven antiviral effects to help combat Influenza and cold
    - May aid in reduced nasal congestion, easing allergy symptoms
    - Improve digestive issues, promoting regularity
    - Anti-aging
    - May reduce blood sugar and increase heart health
    - Combat Covid-19??

https://www.webmd.com/diet/elderberry-health-benefits#1

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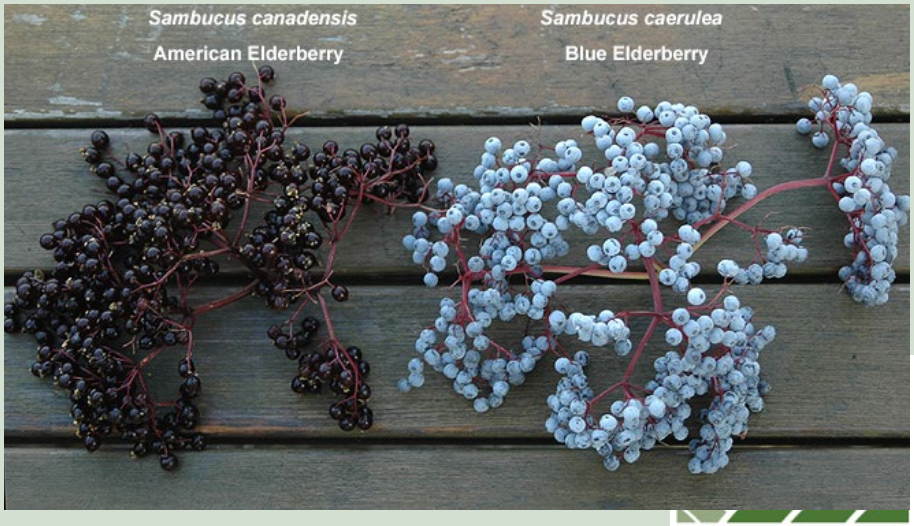
Elderberry crops

- **Species**
  - For commercial production
    - European elderberry
    - **American elderberry**
    - Blue elderberry
    - Red elderberry



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Elderberry market

- **An increasing market**
  - The elderberry market is set to grow by USD 214.88 million from 2020 to 2025

https://www.prnewswire.com/news-releases/elderberry-market-to-grow-at-a-cagr-of-6-52-by-2025health-benefits-of-elderberry-to-boost-growth-17000-technavio-reports-301425689.html

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Elderberry market

- **An increasing market**
  - The #3 best-selling dietary supplements by 2019
  - 95% of the elderberries consumed in the United States are imported from Europe
  - >50% of the remaining amount is cultivated in the Show-Me State
    - Just not enough to the market (according to growers)
  - MU awarded a $5.3M grant from USDA to develop the elderberry system

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American Elderberry

- **A native species**
  - Relatively easy to grow

Elderberry Culture by Patrick Byers: https://www.youtube.com/watch?v=xve_lEc3dKg

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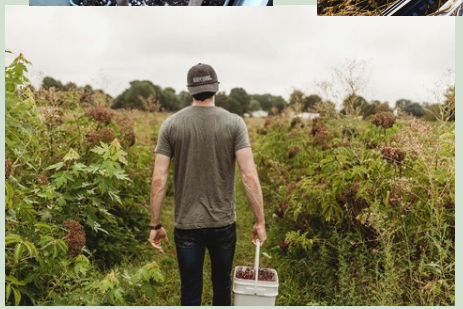
Elderberry production

- **Labor intensive crop**
  - Typical production practices
    - Propagation
    - Planting
    - Pruning
    - Fertilization and irrigation
    - Pest control
    - Harvest – blossom and fruit
    - Destemming
    - Processing






  - Need mechanical solutions for scale-up production

Elderberry post-harvest processing

- **Post-harvest processing**
  - Destemming → Sanitizing → Rinsing → Weighing

Elderberry post-harvest processing

- **Terry Durham - River Hills Harvest**

Elderberry post-harvest processing

- **Destemming – destemmers**

https://youtu.be/xve_lEc3dKg?t=1468

Elder Farms

https://youtu.be/6nX8WStpmDk?t=6

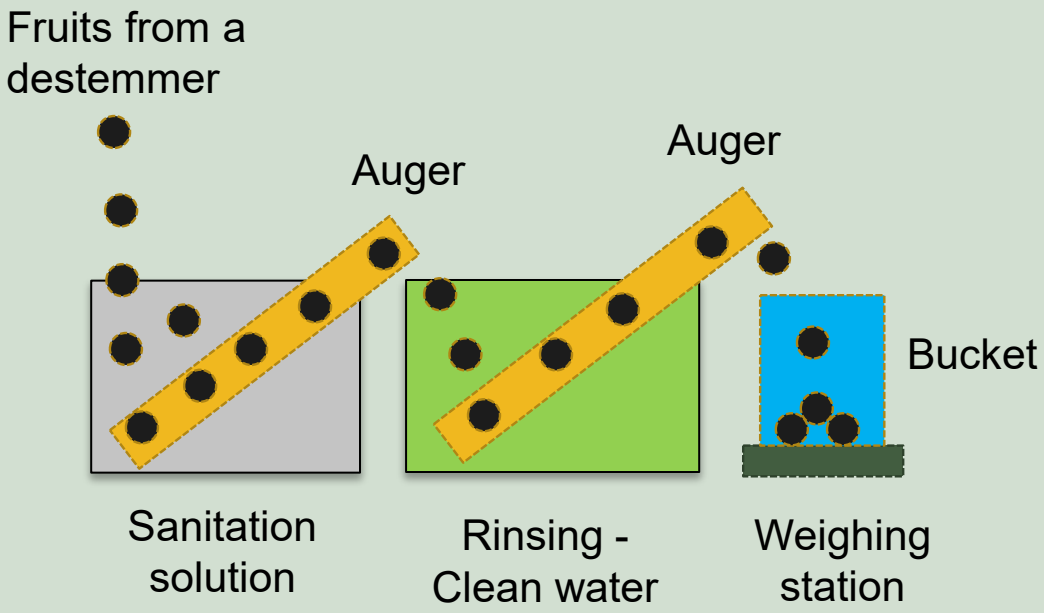
Elderberry post-harvest processing

- **Hand sanitizing/washing**

by Patrick Byers, MU
https://youtu.be/xve_lEc3dKg?t=1579

Elderberry post-harvest processing

- **Automation processing**
  - **Our solutions**



Weight: 25 lbs

4:25 pm
01/07/2022

Farm: xxx
Process: xxx
Bucket #: 12
Total: 450 lbs

Control center

Elderberry post-harvest processing

- **Automation for sanitizing/washing**
  - **Prototype was built**
  - **Auger system**
  - **Conveyer system**

Elderberry post-harvest processing

- **Automated system for sanitizing washing**
  - **Conveyer system**

Elderberry post-harvest processing

- **Automated system for sanitizing washing**
  - **Conveyer system**

Introduction of Joe

- Joe Baratta
- PHD Candidate - Food Science
- Joined project in September
- Design experience handling seeds
  - Degree in Mechanical Engineering
  - Emphasis in prototyping and equipment
- Thesis in Extraction Chemistry – Aging Spirits

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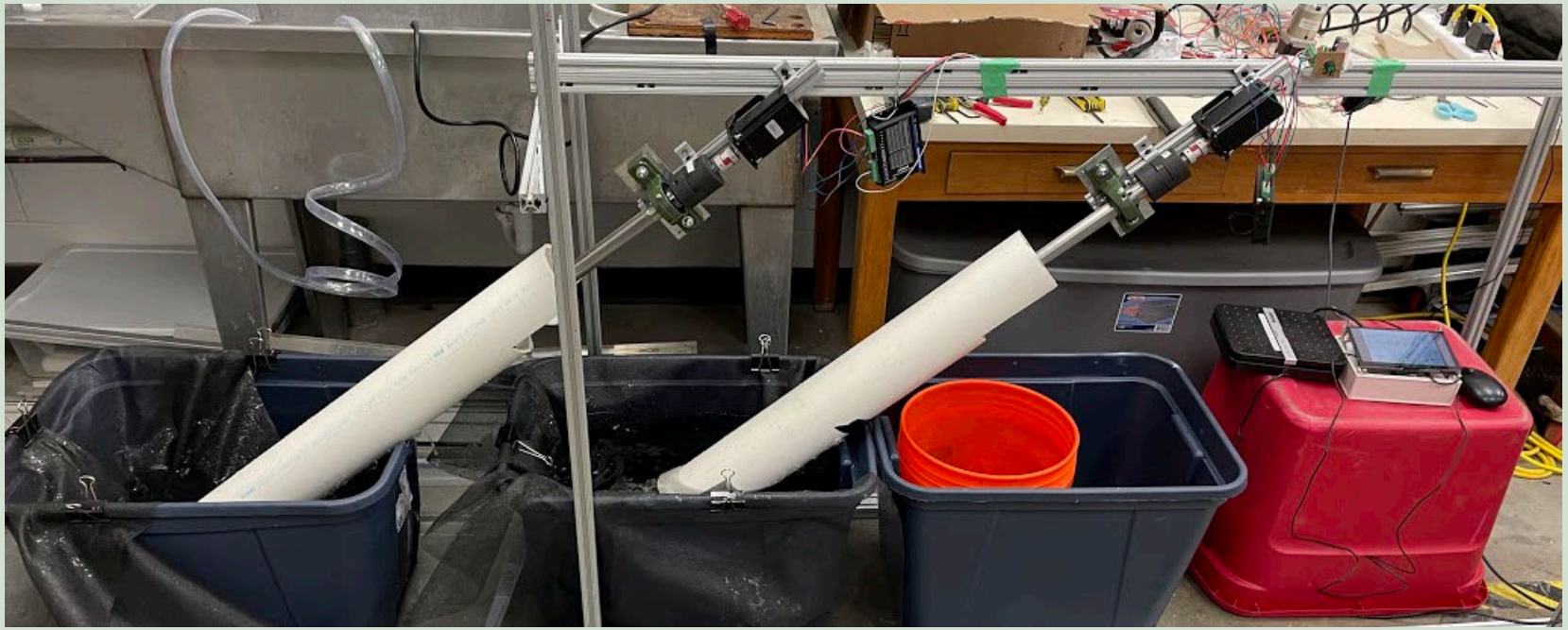
Elderberry post-harvest processing

- **Automated system for sanitizing/washing**
  - **Auger system**

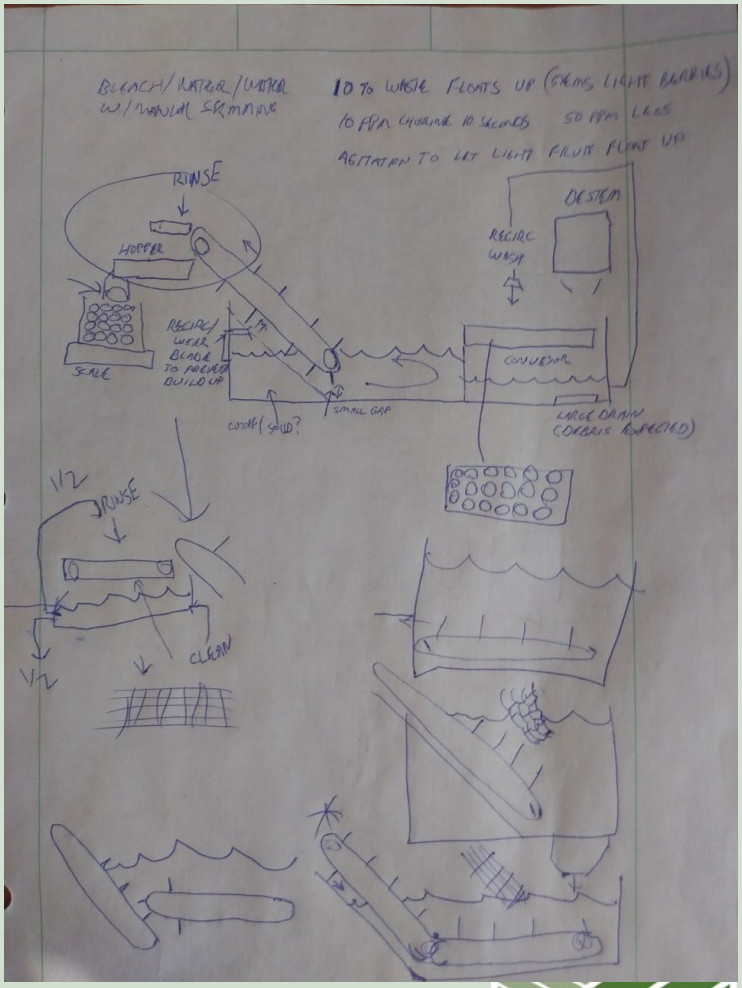


Elderberry post-harvest processing

- **Hand sanitizing/washing**
  - **Auger system :** https://vimeo.com/663144693/30c3745a8e

First draft design

- Conveyors were originally to be utilized to move fruit through sanitization
- Manufacturers of conveyors were adamant they couldn't be driven from underwater long-term
- Their solutions were abandoned after several failed discussions with their design engineers
- Unlike other fruit that is conveyed, elderberries need to sink to allow density separation of ripe and unripe fruit



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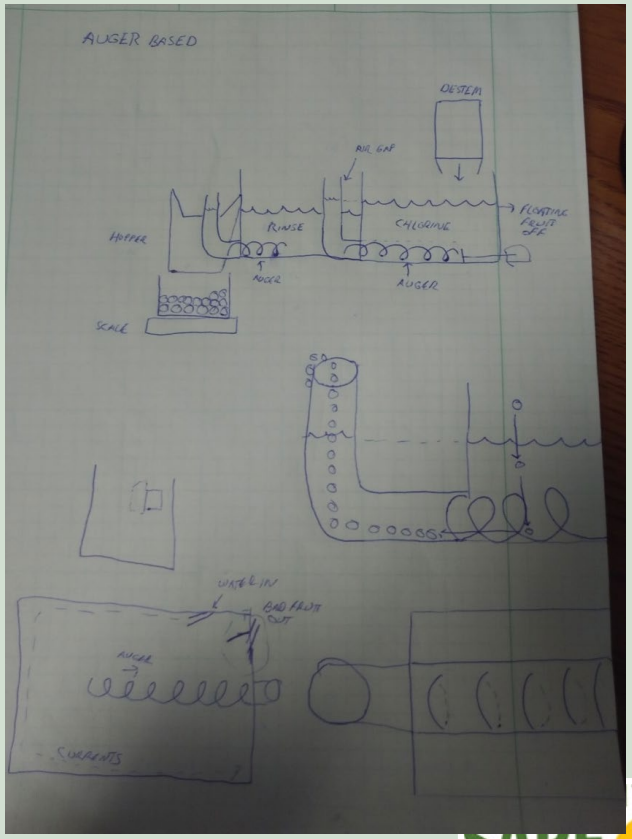
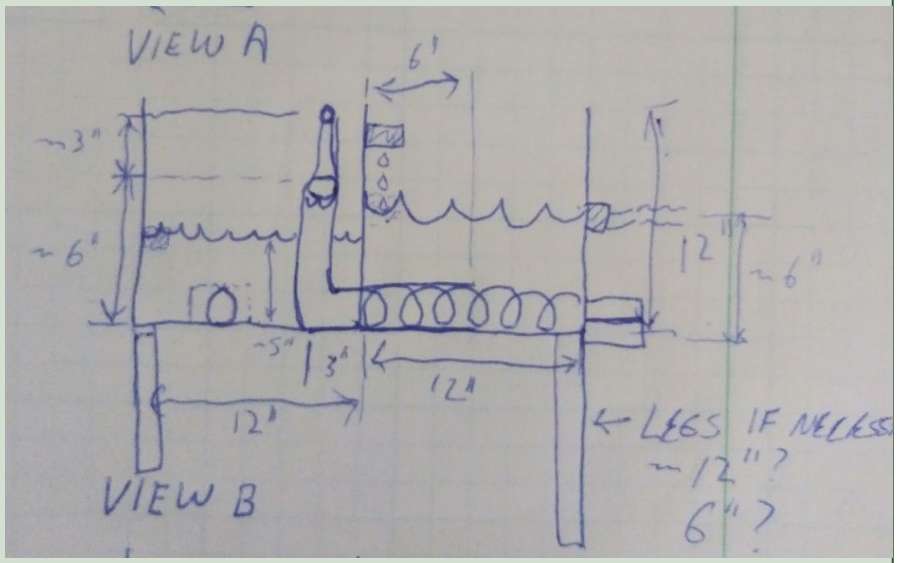
Original auger proposal

- Was linear in container sequencing to integrate with harvesting
- Used a pipe elbow to prevent chlorine solution from moving between tanks
- Relied on berries pushing each other up a column
- Testing revealed this would likely crush fruit
- Angling the out-feed while the auger remained in XY plane was not sufficient



Side cut of original auger

- AA shows the orientation of the proposed water recirculation/replenishment
- This allows unripe berries to be removed and tank to be agitated
  - Freeing debris to float up
- This also allows control of chlorine levels in tank
  - Clean water in can contain chlorine at necessary levels
  - Prevents need to stop and refresh tank chlorine to meet proper levels for sanitation



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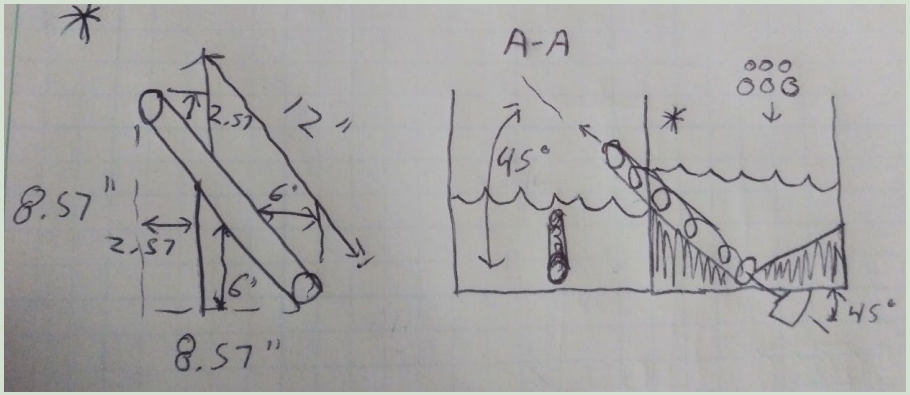
Angling auger to prevent fruit damage

- Angles were tested for pressure accumulation
  - 60 degrees was determined to crush fruit in the bottom of the tube
  - 45 degrees was determined acceptable
  - Any shallower than 45 would also be sufficient
  - Testing was conducted with water, and plastic BBs dense enough to sink



First Prototype

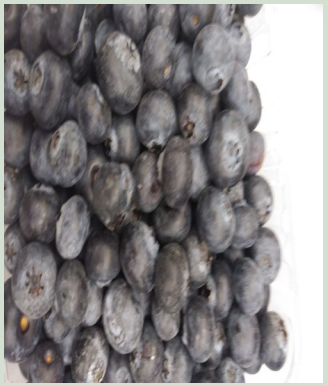
- Testing was conducted with the first design
  - Using plastic BBs the size of elderberry
  - Using Blueberries the same toughness as elderberry to predict fruit damage
- Auger could run at slow speeds of ~50 RPM up to 115 RPM
  - 4” Auger with standard pitch (= dia)
  - Free flowing berries (comparable to seeds in water)
  - Correction of 0.5 for 45 degree angle
  - Q_calc = 250 kg/h at 50 RPM and 580 kg/h at 115 RPM

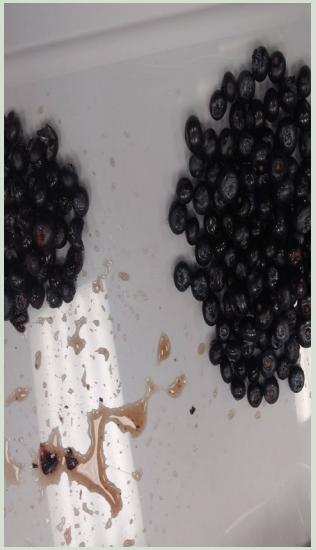
$$Q = 60 \times \left(\frac{\pi}{4}\right) \times D^2 \times S \times N \times \alpha \times \rho \times C$$

https://powderprocess.net/Equipments%20html/Screw_Conveyor_Design.html

Berry Damage

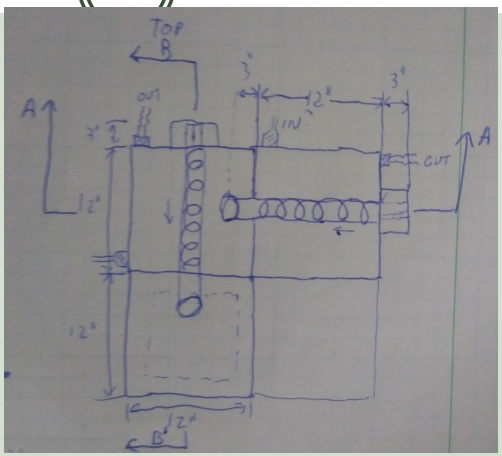
- Significant fruit damage occurred
  - At both low and high conveyance rates (50 and 115)
  - Characterized as bruising or visible skin rupture
  - 25% of fruit by mass was damaged in “worst” trials





Improving Design to minimize damage

- Reducing travel distance for berry
- Smoothing auger to prevent tearing skin
- Fixing angle
- Increasing open section
- Increasing fraction of travel in water



3D Printer connections

- Connections between stepper and auger shafts have been prepared for prototype
- Loads experienced and measured are in the range of polyacrylate polymers
- Material is compatible with cleaning and sanitation

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Interface with other equipment

- Visited during harvest: River Hills Harvest Farms
- Observed this destemming machine operate
  - Reasonably reliable, with throughput in the #00s / hour
  - Requires manual loading of bunches
- Separates berries via X axis agitation of a perforated metal sheet berries fall through
- Other designs have similar output shoots and destem via rotary separation

Berry Outfeed to interface with separation equipment

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Questions?

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"DEVELOP AN EFFICIENT FRUIT HANDLING SYSTEM FOR ELDERBERRIES"