

The Future of Fashion and Functionality: Transforming Produce Waste and Lignocellulosic Fibers into Sustainable Vegan Leather

Research Background



Research Contribution

- Develop an innovative process that utilizes 100% natural materials and reduces produce waste
- Discover the ideal wasted produce and fiber ratio (virgin:recycled) to create vegan leather
- Develop a procedure with added fibers
- Create a working and usable prototype (bags, wallets, etc.)

Main Criteria:

- Microscopic Fiber Structure
- Strength/Stretch
- Thickness
- Hydrophobicity

Variables

Independent Variables:

- Type of wasted produce
 - Mango, Pineapple ← Reported
 - Celery, Avocado ← Not Reported
- Ratio of the fibers
 - Medium: 7:3, 3:7 - 14g:6g
 - Close: 4:3, 3:4 - 8g:6g
 - Far: 3:1, 1:3 - 9g:3g

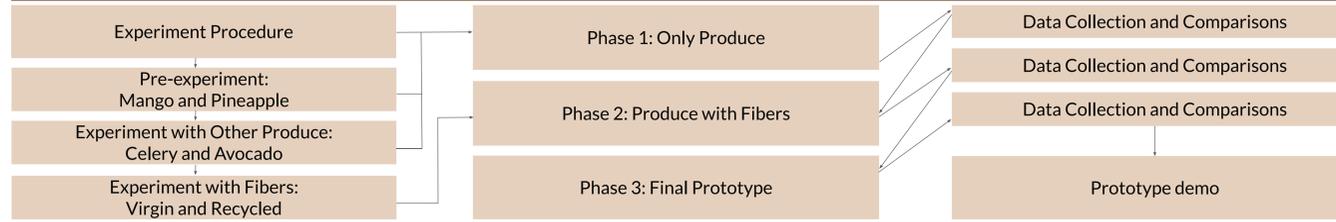


| Reason of Fibers Choice: | Reason of Produce Choice: |
|--|--|
| <ul style="list-style-type: none"> Recycled Fibers (already processed) <ul style="list-style-type: none"> Low cost, commonly found: shredded paper Virgin Fibers: <ul style="list-style-type: none"> Higher cost, higher strength: pet bedding | <ul style="list-style-type: none"> Strength <ul style="list-style-type: none"> More fibers (mango, celery) Accessibility <ul style="list-style-type: none"> Fruits that are frequently imported to US: pineapples and avocados |

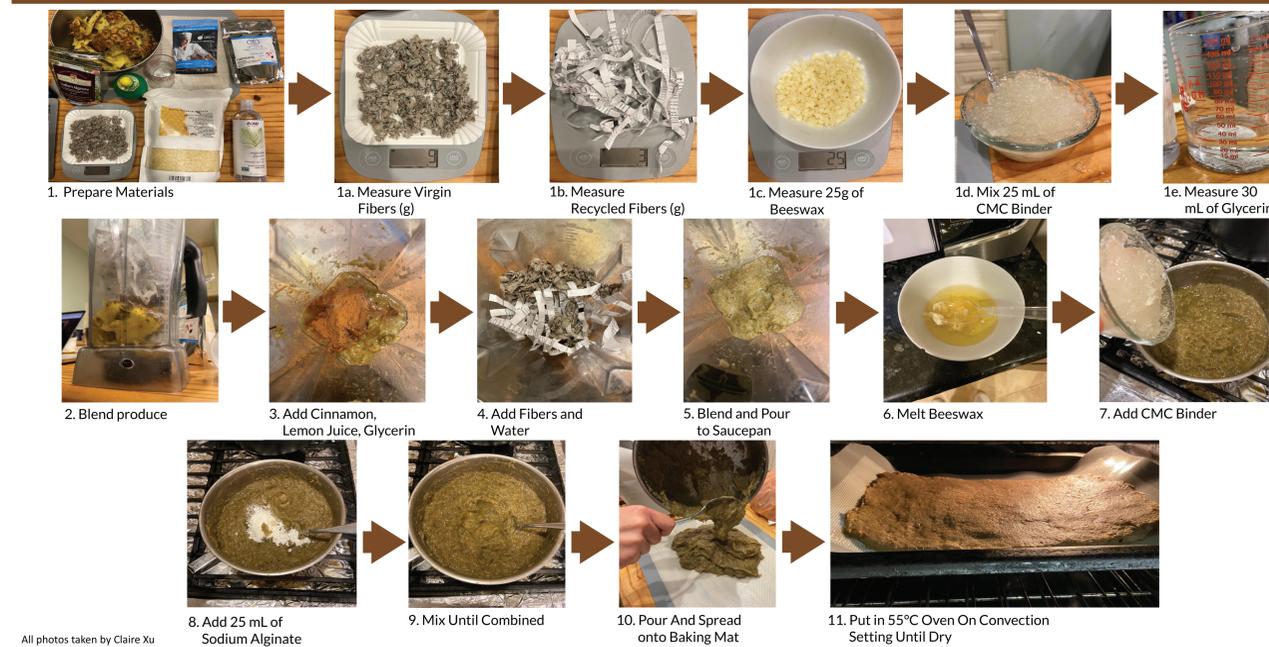
Summary of Previous Research

| Organization | Raw Materials | Method | Cost | Strength | Limitations |
|--------------|---|--|---|--|---|
| FruitLeather | Mangoes, additives, trays, dehydrator, compressor | Turn mangoes into pulp, add additives, pour into tray, leave in dehydrator overnight, coat in protective glaze, compress layers together (~2 days) | Mangoes = free from Netherland | Durable, utilize different mangoes for diff. colors, eco-friendly | - Only produce 80 square meters/month - doesn't last as long as traditional leather - more expensive |
| Desserto | Cactus, non-toxic chemicals, machines | Mash leaves, dry for 3 days, mix with chemicals, shape into any texture (~4 days) | Nopal cactus seed = \$5-20 from Mexico | recycled, biodegradable, durable, breathable, doesn't stain, lasts to 10 years | - same price as animal leather - includes five restricted substances - 65% plastic polyurethane - cactus only makes up 30% |
| Sohotree | Apples, biological plastic substitute, grinding machine | Collect residues, dry, grind to powder, mix with plastic substitute, shape into texture (~1-3 weeks) | 3 apples = wallet, \$300 for a backpack | sustainable, power material, lasts forever, durable | - expensive - uses plastic substitute |

Research Plan



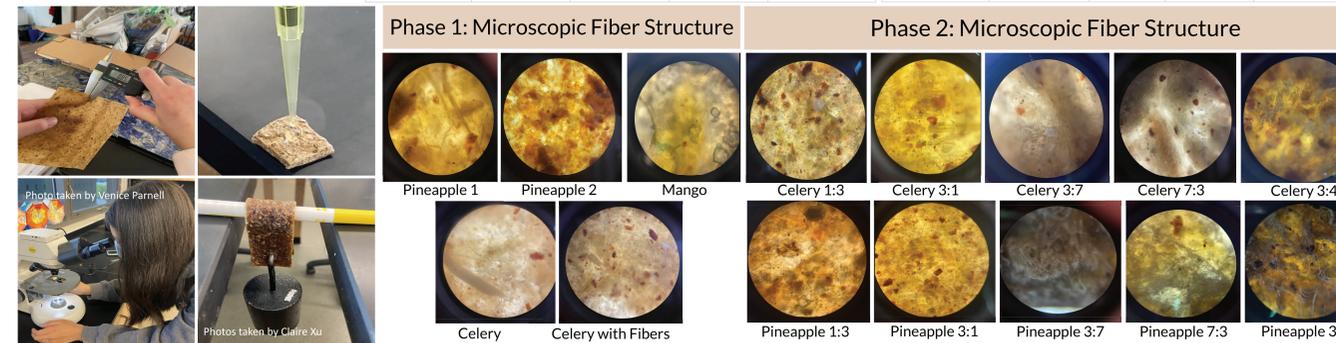
Experiment Procedure



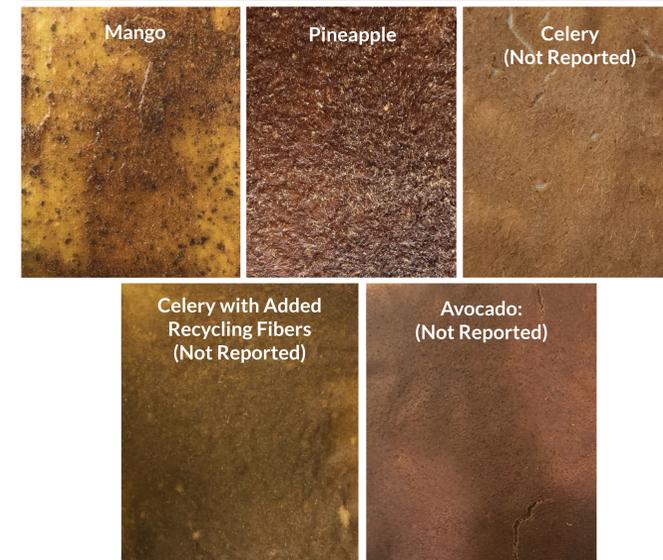
All photos taken by Claire Xu

Data Collection

| Strength/Stretch | | | | Thickness | | | | Water Contact Angle | | | | | |
|------------------------------------|----------|-------|-----------|------------------------------------|--------------|--------------|--------------|---------------------|------------------------------------|-----------|-----------|-------------|----------------|
| Leather Type | Strength | Level | Status | Leather Type | Point 1 (mm) | Point 2 (mm) | Point 3 (mm) | Average (mm) | Leather Type | WCA 1 (°) | WCA 2 (°) | Average (°) | Hydrophobicity |
| PHASE 1: | | | | | | | | | | | | | |
| Real Leather | ~6000g | H | | Real Leather | 1.93 | 1.72 | 1.68 | 1.78 | Real Leather | 63 | 86 | 74.5 | L/M |
| Pineapple 1 | ~2000g | H | keep | Pineapple 1 | 2.5 | 2 | 2.3 | 2.27 | Pineapple 1 | 83 | 53 | 68 | L |
| Pineapple 2 | ~120g | L | eliminate | Pineapple 2 | 1.34 | 1.75 | 2.07 | 1.72 | Pineapple 2 | 34 | 46 | 40 | L |
| Mango | ~150g | L | eliminate | Mango | 1.08 | 0.68 | 0.99 | 0.92 | Mango | 84 | 64 | 74 | L/M |
| Celery | ~190g | L | eliminate | Celery | 0.97 | 1.64 | 0.77 | 1.13 | Celery | 75 | 21 | 48 | L |
| Celery with Recycling Fibers (10g) | ~1500g | M/H | keep | Celery with Recycling Fibers (10g) | 0.82 | 1.03 | 0.99 | 0.95 | Celery with Recycling Fibers (10g) | 89 | 70 | 79.5 | M |
| Avocado | ~200g | L | eliminate | Avocado | 0.64 | 0.63 | 0.99 | 0.75 | Avocado | 85 | 84 | 84.5 | M/H |
| PHASE 2: | | | | | | | | | | | | | |
| Celery 1:3 | ~1180g | M | eliminate | Celery 1:3 | 1.2 | 1.04 | 1.58 | 1.27 | Celery 1:3 | 71 | 83 | 77 | M |
| Celery 3:1 | ~750g | L/M | eliminate | Celery 3:1 | 0.84 | 0.7 | 1.25 | 0.93 | Celery 3:1 | 87 | 86 | 86.5 | M/H |
| Pineapple 1:3 | ~1000g | M | eliminate | Pineapple 1:3 | 4.61 | 2.75 | 4.33 | 3.90 | Pineapple 1:3 | 40 | 33 | 36.5 | L |
| Pineapple 3:1 | ~3200g | H | eliminate | Pineapple 3:1 | 5.44 | 2.36 | 5.75 | 4.52 | Pineapple 3:1 | 70 | 31 | 50.5 | L |
| Celery 3:7 | ~1500g | M/H | eliminate | Celery 3:7 | 1.66 | 2.38 | 2 | 2.0.1 | Celery 3:7 | 91 | 95 | 93 | H |
| Celery 7:3 | ~4200g | H | eliminate | Celery 7:3 | 1.32 | 0.57 | 1.6 | 1.16 | Celery 7:3 | 87 | 88 | 87.5 | M/H |
| Pineapple 3:7 | ~900g | L/M | eliminate | Pineapple 3:7 | 5.49 | 3.92 | 4.72 | 4.71 | Celery 3:7 | 18 | 10 | 14 | L |
| Pineapple 7:3 | ~3000g | H | eliminate | Pineapple 7:3 | 5.49 | 2.77 | 5.82 | 4.69 | Pineapple 7:3 | 95 | 112 | 103.5 | H |
| Celery 3:4 | ~4500g | H | keep | Celery 3:4 | 1.99 | 0.94 | 1.5 | 1.48 | Pineapple 3:7 | 94 | 89 | 91.5 | H |
| Celery 4:3 | ~3000g | H | eliminate | Celery 4:3 | 1.2 | 1.55 | 1.09 | 1.28 | Pineapple 7:3 | 90 | 105 | 97.5 | H |
| Pineapple 3:4 | ~3000g | H | eliminate | Pineapple 3:4 | 2.15 | 2.63 | 1.85 | 2.21 | Celery 3:4 | 60 | 67 | 63.5 | L |
| Pineapple 4:3 | ~3300g | H | eliminate | Pineapple 4:3 | 1.78 | 1.61 | 2.09 | 1.83 | Celery 4:3 | 90 | 105 | 97.5 | H |
| PHASE 3: | | | | | | | | | | | | | |
| Celery 3:4 | ~5000g | | | Phase 3 | 1.11 | 2.53 | 1.72 | 1.79 | Pineapple 3:4 | 60 | 67 | 63.5 | L |
| | | | | Celery 3:4 | | | | | Pineapple 4:3 | 127 | 93 | 110 | H |



Produce Comparison

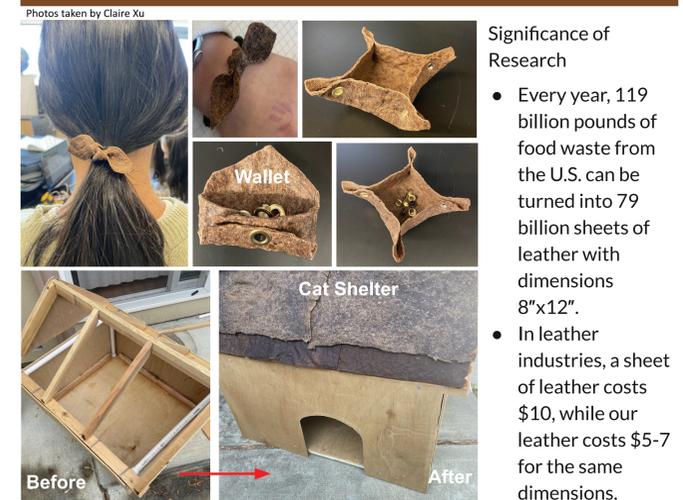


Photos taken by Claire Xu

Conclusion

- Celery, with a 3:4 ratio of lignocellulosic fibers (6 grams of virgin fibers to 8 grams of recycled fibers), is our most optimal leather. With similar thickness and texture, the celery leather withstands 5,000 grams, compared to 6,000 grams traditional leather can withstand
- Costs about \$5-7, making it cheaper than cow leather which costs about \$10 for the same size
- Hydrophobic: water contact angle is 92°
- Ideal for making bags and wallets; creases are not visible when leather is folded unlike real leather

Product Creations



Future Work

- Large-scale research to find results of leather created with different produce and ratios
- Identify how long-lasting the product is
- Smoothen the texture of our leather
- Further improve our product by making it more hydrophobic by adding sealants
- Discover methods to allow our product to be manufactured for wholesale
- Collaborate with various organizations to test our product