UC Berkeley Archaeobotany Laboratory Report #85: Tuber Identification
Venicia Slotten, Katherine Chiou, and Christine A. Hastorf
Fall 2016
Date: December 16, 2016

**Tuber Reference Collection Methodology**

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Family</th>
<th>Common Name</th>
<th>Stained</th>
<th>Fresh</th>
<th>Charred</th>
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<td><em>Daucus carota</em></td>
<td>Apiaceae</td>
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<td><em>Ipomoea batatas</em></td>
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<td>Manioc</td>
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</table>

All stained samples were prepared by Katherine Chiou.

**Fresh Samples** Total= 45 samples

Fresh samples were cut into small sections displaying the transverse, tangential, and radial cross-sections, with attention given to both the edge of the specimen and the center of the specimen. Pieces were about 1.0 cm in length, 1.0 cm in width, and between .2 and .4 cm in thickness, in order to fit the Scanning Electron Microscope (SEM) mounting stubs.

All fresh samples underwent the generic processing protocol provided by the Electron Microscope Laboratory at UC Berkeley, which included:

1) Fixation (1 hour) - 2% glutaraldehyde in 0.1M Sodium cacodylate buffer, pH 7.2
2) Rinse (3 X 10 min) - 0.1M sodium cacodylate buffer, pH 7.2
3) Post-Fix (1 hour) - 1% Osmium tetroxide in 0.1M sodium cacodylate buffer, pH 7.2
4) Rinse (3 X 5 min) - 0.1M sodium cacodylate buffer, pH 7.2
5) Dehydrate in a series of ETOH (35%, 50%, 70%, 80%, 95%, 100%, and 100%) for 10 min each (70 min total).

6) Critical Point Dry (4 samples at a time) using the Tousimis AutoSamdri 815 Critical Point Dryer (45 min)

All specimens were then stored in sample vials labeled with their sample number (See complete list of sample numbers).
Charred Samples

Sections of the remaining tubers were cut into larger pieces designated for carbonization. These pieces were approximately 4-5 cm in length, width, and depth (varying based on size of tuber’s actual width). When possible, two samples were created for each cross-section (transverse, tangential, and radial) to allow for two different lengths of time within the furnace. All specimens were wrapped in aluminum foil, labeled, buried in sand, and then placed in a furnace for either 2.5 or 3.5 hours at 250 °F. See complete sample list for exact times for each sample.

Once cooled, one of each cross-section for each species was fractured in order to view anatomical features using the SEM. Many samples were quite brittle, so clean fractures were not always possible. Additionally, a section showing the exterior surface after charring was obtained for each species.

Total= 48 samples

Scanning Electron Microscopy (SEM)

Both the processed fresh samples and fractured carbonized samples were imaged using a TM-1000 Scanning Electron Microscope at the Electron Microscope Laboratory at UC Berkeley. Specimen were mounted onto 0.5” aluminum holders temporarily using carbon tape. The cross-sections were cleaned using compressed air to remove any broken fragments that could obstruct the identifiable features during future analysis.

Initially, specimens were coated with a thin layer of conductive material (gold) using the Tousimis Sputter Coater before SEM analysis. This step was then stopped since the material was not over-powering in charging on its own and the TM-1000 does not require this step. Below are those samples which were sputter coated. All others were not.

| 01-Lm-TransC | 03-Lm-TangC | 05-Lm-Rad | 07-Ot-TransE | 09-Ot-TangE | 11-Pe-TransC | 13-Pe-TangC |
| 02-Lm-TransE | 04-Lm-TangE | 06-Ot-TransC | 08-Ot-TangC | 10-Ot-Rad | 12-Pe-TransE |

After the specimen chamber was vented, the aluminum mounts were secured on the microscope’s stage one at a time, the chamber was closed, and a vacuum pump removed air from the chamber. Images of the various cross-sections were taken at multiple magnifications, usually 50x, 100x, 200x, 500x, and 1000x. The micrographs were focused on vascular bundle arrangement, xylem wall pitting, periderm thickness, and exterior surface texture.
<table>
<thead>
<tr>
<th>Specimen ID</th>
<th>Common name</th>
<th>Sample type</th>
<th>Stem/Root</th>
<th>Orientation</th>
<th>Box #/Stub #</th>
<th>Date Prepped</th>
<th>Date Processed in ELM</th>
<th>Date Imaged on SEM</th>
<th>Temp (Deg.)</th>
<th>Furnace Time (Hours)</th>
<th>Sputter Coated</th>
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<td>Sputter Coated</td>
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<td>Date Processed in ELM</td>
<td>Date Imaged on SEM</td>
<td>Temp (Deg.)</td>
<td>Furnace Time (Hours)</td>
<td>Sputter Coated</td>
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<td>83-Ip-TransCenter</td>
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Ip=Ipomoea batatas (CONVULVULACEAE)  
Ot=Oxalis tuberosa (OXALIDACEAE)  
Lm=Lepidium meyenii (BRASSICACEAE)  
Me=Manihot esculenta (EUPHORBIACEAE)  
Pp=Pachyrzus erosus (FABACEAE)  
Ss=Smallanthus sonchifolius (ASTERACEAE)  
Sa=Solanum (SOLANACEAE)  
Tt=Tropaeolum tuberosum (TROPAEOLACEAE)  
C=Center of specimen  
E=Edge of specimen (contains periderm)
Fresh Specimen
Ipomoea batatas
CONVULVULACEAE
Common Name: Sweet Potato
Sample Type: Wet/Fresh
Transverse Center
Ipomoea batatas
CONVULVULACEAE

Common Name: Sweet Potato
Sample Type: Wet/Fresh

Transverse Center (continued)
Ipomoea batatas
CONVULVULACEAE
Common Name: Sweet Potato
Sample Type: Wet/Fresh
Transverse Edge
Ipomoea batatas
CONVULVULACEAE

Common Name: Sweet Potato
Sample Type: Wet/Fresh

Tangential Edge
Ipomoea batatas
CONVULVULACEAE
Common Name: Sweet Potato
Sample Type: Wet/Fresh
Radial
*Lepidium meyenii*
BRASSICACEAE

Common Name: Maca
Sample Type: Wet/Fresh

Transverse Center
Lepidium meyenii
BRASSICACEAE

Common Name: Maca
Sample Type: Wet/Fresh

Transverse Edge
**Lepidium meyenii**
**BRASSICACEAE**

Common Name: Maca
Sample Type: Wet/Fresh

Transverse Edge (Continued 2)
Lepidium meyenii
BRASSICACEAE
Common Name: Maca
Sample Type: Wet/Fresh
Tangential Center
Lepidium meyenii
BRASSICACEAE

Common Name: Maca
Sample Type: Wet/Fresh

Tangential Edge
Lepidium meyenii
BRASSICACEAE

Common Name: Maca
Sample Type: Wet/Fresh

Tangential Edge (cont.)
Lepidium meyenii
BRASSICACEAE
Common Name: Maca
Sample Type: Wet/Fresh
Radial Center
**Lepidium meyenii**

**Common Name:** Maca

**BRASSICACEAE**

**Sample Type:** Wet/Fresh

**Radial Edge**
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Wet/Fresh
Transverse Center
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Wet/Fresh
Transverse Edge
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Wet/Fresh
Transverse Edge (Continued)
Manihot esculenta
EUPHORBIACEAE

Common Name: Manioc
Sample Type: Wet/Fresh

Tangential Center
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Wet/Fresh
Tangential Edge
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Wet/Fresh
Radial
Oxalis tuberosa
OXALIDACEAE

Common Name: Oca
Sample Type: Wet/Fresh
Transverse Edge
Oxalis tuberosa
OXALIDACEAE

Common Name: Oca
Sample Type: Wet/Fresh

(Continued)
**Oxalis tuberosa**  
**OXALIDACEAE**

**Common Name:** Oca  
**Sample Type:** Wet/Fresh

**Tangential Center**

[Images of microscopic sections]
Oxalis tuberosa
OXALIDACEAE

Common Name: Oca
Sample Type: Wet/Fresh

Tangential Edge
**Oxalis tuberosa**

**Common Name:** Oca

**Sample Type:** Wet/Fresh

**Radial**
*Oxalis tuberosa*

**Common Name:** Oca

**Sample Type:** Wet/Fresh

**Radial Edge**
**Pachyrhizus erosus**

**Common Name:** Jicama

**Sample Type:** Wet/Fresh

**Tangential Edge**
*Pachyrhizus erosus*

Common Name: Jicama

Sample Type: Wet/Fresh

**Radial**
Smallanthus sonchifolius
ASTERACEAE
Common Name: Yacon
Sample Type: Wet/Fresh
Transverse Center
Smallanthus sonchifolius
ASTERACEAE
Common Name: Yacon
Sample Type: Wet/Fresh
Tangential Edge
Smallanthus sonchifolius
ASTERACEAE
Common Name: Yacon
Sample Type: Wet/Fresh
Radial
**Solanum**
**SOLANACEAE**

Common Name: Papa
Sample Type: Wet/Fresh

Transverse Center

---

**Images:**
- 5006-04P10873 2016/12/02 11:11 L x50 2 mm
- 5006-04P10874 2016/12/02 11:13 L x100 1 mm
- 5006-04P10875 2016/12/02 11:14 L x300 300 um
- 5006-04P10876 2016/12/02 11:15 L x200 500 um
- 5006-04P10877 2016/12/02 11:17 L x150 500 um
- 5006-04P10878 2016/12/02 11:19 L x500 100 um
**Solanum**
**Solanaceae**

**Common Name:** Papa

**Sample Type:** Wet/Fresh

**Tangential Center**
Solanum
Solanaceae

Common Name: Papa
Sample Type: Wet/Fresh
**Tropaeolum tuberosum**
**TROPAEOLACEAE**

Common Name: Mashua
Sample Type: Wet/Fresh

Transverse Edge
Tropaeolum tuberosum
TROPAAEOLACEAE
Common Name: Mashua
Sample Type: Wet/Fresh
Tangential Center
*Tropaeolum tuberosum*

**Common Name:** Mashua

**Sample Type:** Wet/Fresh

**Tangential Edge**
**Tropaeolum tuberosum**
**TROPAEOLACEAE**

Common Name: Mashua
Sample Type: Wet/Fresh
*Ullucus tuberosus*

**BASELLACEAE**

**Common Name:** Papalisa/Ollucu

**Sample Type:** Wet/Fresh

**Transverse Center**
**Ullucus tuberosus**
BASELLACEAE

Common Name: Papalisa/Ollucu
Sample Type: Wet/Fresh

Transverse Edge
**Ullucus tuberosus**

**BASELLACEAE**

Common Name: Papalisa/Ollucu

Sample Type: Wet/Fresh

Transverse Edge (continued)
**Ullucus tuberosus**  
**BASELLACEAE**  
**Common Name:** Papalisa/Ollucu  
**Sample Type:** Wet/Fresh  
**Tangential Center**
**Ullucus tuberosus**  
**BASELLACEAE**  
Common Name: Papalisa/Ollucu  
Sample Type: Wet/Fresh  
Tangential Edge
**Ullucus tuberosus**

**BASELLACEAE**

**Common Name:** Papalisa/Ollucu

**Sample Type:** Wet/Fresh

**Tangential Edge (Continued)**
Ullucus tuberosus

BASELLACEAE

Common Name: Papalisa/Ollucu

Sample Type: Wet/Fresh

Radial
Ullucus tuberosus
BASELLACEAE
Common Name: Papalisa/Ollucu
Sample Type: Wet/Fresh
Radial Edge
Charred Specimen
Ipomoea batatas
Common Name: Sweet Potato
Sample Type: Charred
Lepidium meyenii
BRASSICACEAE
Common Name: Maca
Sample Type: Charred – 2.5 hours
Lepidium meyenii
BRASSICACEAE

Common Name: Maca
Sample Type: Charred – 2.5 hours
Lepidium meyenii
Common Name: Maca
Sample Type: Charred
Stem End
Lepidium meyenii
BRASSICACEAE

Common Name: Maca
Sample Type: Charred

Stem End (Continued)
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Charred

Tangential
**Manihot esculenta**

*EUPHORBIACEAE*

Common Name: Manioc

Sample Type: Charred

Tangential (Continued)
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Charred

Transverse
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Charred

Transverse (Continued)
Pachyrhizus erosus
FABACEAE
Common Name: Jicama
Sample Type: Charred

Transverse
Pachyrhizus erosus
Common Name: Jicama
FABACEAE
Sample Type: Charred

Transverse (continued)
Smallanthus sonchifolius
ASTERACEAE

Common Name: Yacon
Sample Type: Charred

Transverse
Smallanthus sonchifolius
ASTERACEAE
Common Name: Yacon
Sample Type: Charred

Transverse (Continued)
**Solanum**

**Common Name:** Papa

**Sample Type:** Charred

**Tangential**
Solanum
SOLANACEAE

Common Name: Papa
Sample Type: Charred

Transverse
Solanum
SOLANACEAE

Common Name: Papa
Sample Type: Charred

Transverse (Xylem)
Tropaeolum tuberosum

Common Name: Mashua

Tropaeolaceae

Sample Type: Charred

Tangential
Tropaeolum tuberosum
Common Name: Mashua
Sample Type: Charred

Tangential (Continued)
Tropaeolum tuberosum
TROPAAEOLACEAE
Common Name: Mashua
Sample Type: Charred
Transverse
Tropaeolum tuberosum
TROPAEOLACEAE
Common Name: Mashua
Sample Type: Charred

Transverse (Continued)
Ullucus tuberosus
BASELLACEAE

Common Name: Papalisa/Ollucu
Sample Type: Charred

Tangential (Continued)
Specimen Surfaces
Ipomoea batatas
CONVULVULACEAE
Common Name: Sweet Potato
Sample Type: Charred
Exterior Surface
Ipomoea batatas
CONVULVULACEAE
Common Name: Sweet Potato
Sample Type: Wet/Fresh
Exterior
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Wet/Fresh
Exterior
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Charred

Exterior Surface

Images of charred samples of Manihot esculenta, showing different magnifications and views.
Oxalis tuberosa
OXALIDACEAE

Common Name: Oca
Sample Type: Charred

Exterior
Pachyrhizus erosus
Common Name: Jicama
FABACEAE
Sample Type: Charred
Exterior
Smallanthus sonchifolius
ASTERACEAE
Common Name: Yacon
Sample Type: Charred
Tropaeolum tuberosum  
Common Name: Mashua  
Exterior  
Sample Type: Charred
**Ullucus tuberosus**

**BASELLACEAE**

**Common Name:** Papalisa/Ollucu

**Sample Type:** Charred

Exterior
Stained Specimen
*Daucus carota*

**Common Name:** Carrot  
**APIACEAE**  
**Sample Type:** Stained
Ipomoea batatas
CONVULVULACEAE
Common Name: Sweet Potato
Sample Type: Stained
Manihot esculenta
EUPHORBIACEAE

Common Name: Manioc
Sample Type: Stained
Manihot esculenta  
EUPHORBIACEAE  
Common Name: Manioc  
Sample Type: Stained  
(Continued)
Manihot esculenta
EUPHORBIACEAE
Common Name: Manioc
Sample Type: Stained (Continued)
Pachyrhizus erosus
FABACEAE
Common Name: Jicama
Sample Type: Stained
Pachyrhizus erosus
FABACEAE
Common Name: Jicama
Sample Type: Stained
Smallanthus sonchifolius  Common Name: Yacon
ASTERACEAE  Sample Type: Stained
Solanum
SOLANACEAE
Common Name: Papa
Sample Type: Stained
Solanum
Solanaceae

Common Name: Papa (Continued)
Sample Type: Stained
Diagnostic Feature Comparisons:

Exterior Surfaces
Exterior Surface Texture – Charred at 250° (100x and 500x)

*Lepidium meyenii* (Maca)

*Ullucus tuberosus* (Papalisa)
Exterior Surface Texture – Charred at 250° (100x and 500x)

Smallanthus sonchifolius (Yacon)

Solanum (Potato)
Exterior Surface Texture – Charred at 250° (100x and 500x)

*Oxalis tuberosa* (Oca)

*Tropaeolum tuberosum* (Mashua)
Exterior Surface Texture – Charred at 250° (100x and 500x)

Pachyrhizus erosus (Jicama)
Exterior Surface Texture – Fresh Samples (100x and 500x)

*Ipomoea batatas* (Sweet Potato)

*Manihot esculenta* (Manioc)
Diagnostic Feature Comparisons:

Xylem Wall Pitting
Xylem Wall Pitting

Lepidium meyenii (Maca)

Tangential Edge

Tangential Center

Transverse Edge

Oxalis tuberosa (Oca)

Radial

Transverse Edge

Fresh Specimen 1000x
Xylem Wall Pitting

Fresh Specimen 1000x

*Pachyrhizus erosus* (Jicama)

Transverse Center

Transverse Edge

Tangential Center

Radial
**Xylem Wall Pitting**

**Smallanthus sonchifolius (Yacon)**

Transverse Center

Transverse Edge

Tangential Center

**Solanum (Potato)**

Transverse Edge

Tangential Center

Tangential Center
Xylem Wall Pitting

Fresh Specimen

*Tropaeolum tuberosum* (Mashua)

Transverse Edge

Radial

1000x – 1500x
Xylem Wall Pitting

**Ullucus tuberosus** (Papalis)

Transverse Edge

Radial

Fresh Specimen 1000x
Xylem Wall Pitting

**Ipomoea batatas** (Sweet Potato)

- Transverse Center
- Tansverse Center

**Manihot esculenta** (Manioc)

- Transverse Center
- Radial
- Tangential Center

Fresh Specimen

1000x – 2000x
Diagnostic Feature Comparisons:

Periderm Thickness
Periderm Thickness

Ipomoea batatas (Sweet Potato)

Transverse Edge

Manihot esculenta (Manioc)

Transverse Edge

Tangential Edge

Tangential Edge

Tangential Edge
Periderm Thickness

**Lepidium meyenii (Maca)**

Transverse Edge

Tangential Edge

Radial

**Oxalis tuberosa (Oca)**

Transverse Edge

Tangential Edge

Radial
Periderm Thickness

**Fresh Specimen**

*Pachyrhizus erosus* (Jicama)

<table>
<thead>
<tr>
<th>Transverse Edge</th>
<th>Tangential Edge</th>
<th>Radial</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="5006-04P10800_20161130_1501_L_x200_500um.png" alt="Image" /></td>
<td><img src="5006-04P10804_20161130_1517_L_x80_1mm.png" alt="Image" /></td>
<td><img src="5006-04P10810_20161130_1534_L_x200_500um.png" alt="Image" /></td>
</tr>
</tbody>
</table>

*Smallanthus sonchifolius* (Yacon)

<table>
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<th>Radial</th>
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<tbody>
<tr>
<td><img src="5006-04P10828_20161130_1621_L_x100_1mm.png" alt="Image" /></td>
<td><img src="5006-04P10861_20161202_1029_L_x150_500um.png" alt="Image" /></td>
<td><img src="5006-04P10869_20161202_1050_L_x600_100um.png" alt="Image" /></td>
</tr>
</tbody>
</table>
**Periderm Thickness**

**Solanum** *(Potato)*

- Transverse Edge
- Tangential Edge
- Radial

**Tropaeolum tuberosum** *(Mashua)*

- Transverse Edge
- Tangential Edge
- Radial
Periderm Thickness

*Ullucus tuberosus* (Papalisa)

- Transverse Edge
- Tangential Edge
- Radial
Diagnostic Feature Comparisons:

Xylem/Phloem Arrangement
Xylem/Phloem Arrangement  

**Ipomoea batatas** (Sweet Potato)  
Transverse Edge

Transverse Center
Xylem/Phloem Arrangement

Fresh Specimen

*Lepidium meyenii* (Maca)
**Xylem/Phloem Arrangement**

*Manihot esculenta* (Manioc)

**Transverse Center**

**Transverse Edge**
Xylem/Phloem Arrangement

*Oxalis tuberosa* (Oca)
Xylem/Phloem Arrangement

Fresh Specimen

*Pachyrhizus erosus* (Jicama)
Xylem/Phloem Arrangement

*Smallanthus sonchifolius* (Yacon)

**Fresh Specimen**
Xylem/Phloem Arrangement

*Solanum* (Potato)
Xylem/Phloem Arrangement

*Tropaeolum tuberosum* (Mashua)

[Images of Tropaeolum tuberosum (Mashua) xylem and phloem arrangements]