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92. Andean Parenchyma Reference Collection

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Andean Parenchyma Reference Collection
Laboratory Report #92

Venicia Slotten, Christine A. Hastorf, and Katherine Chiou
University of California, Berkeley
July 2025

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STUDY SUMMARY

A select collection of Andean roots and stems were systematically analyzed and imaged in order to form a reference collection that could aid in the identification of preserved parenchymatous tissue recovered in a macrobotanical form through archaeological investigations. This experimental study looked at various roots and stems that were likely significant in ancient Latin American diets in order to try to identify any diagnostic morphological features that may exist.

This collection specifically aided in the identification of macrobotanical parenchyma recovered from the Chiripa site, which is located on the Taraco Peninsula in the Titicaca Basin altiplano near the border of Peru and Bolivia. This is a high elevation setting situated at approximately 3,800 masl. Reference material was collected from local markets in this region.

The reference material was prepared in a variety of ways to demonstrate differential preservation conditions that could be encountered archaeologically and to allow for multiple views of the various anatomical features. Preparation of the specimens included charring at various temperatures and various lengths of time as well as dessication, freezing, and boiling techniques. All preparation was conducted at the University of California Berkeley in the McCown Archaeobotany Laboratory and the Archaeological Research facility.

LIST OF TAXA INCLUDED IN THE STUDY

The reference images in this document are organized alphabetically based on the scientific name (genus and species). Images are then organized based on the order of anatomical features detailed above.

Genus and Species	**Family**	**Common Name**	**Type**	**Geographical Setting**
Ipomoea batatas (L.)Lam.	Convulvulaceae	sweet potato	root	lowland
Lepidium meyenii Walp.	Brassicaceae	maca	root	local to Titicaca Basin
Manihot esculenta Crantz	Euphorbiaceae	manioc	stem	lowland
Oxalis tuberosa Molina	Oxalidaceae	oca	stem	local to Titicaca Basin
Oxalis tuberosa Molina	Oxalidaceae	calla (freeze-dried)	stem	local to Titicaca Basin
Pachyrhizus erosus (L.) Urb.	Fabaceae	jicama	root	lowland
Schoenoplectus californicus subsp tatora (CA Mey.) Steud.	Cyperaceae	totora	rhizome	local to Titicaca Basin
Smallanthus sonchifolius (Poepp.) H. Rob.	Asteraceae	yacón	root	lowland
Solanum tuberosum L.	Solanceae	papa/potato	stem	local to Titicaca Basin
Solanum tuberosum L.	Solanceae	chuño (freeze-dried)	stem	local to Titicaca Basin
Tropaeolum tuberosum Ruiz & Pavon	Tropaolaceae	mashua/isañu	root	local to Titicaca Basin
Ullucus tuberosus Caldas	Basellaceae	ulluco/papalisa	root	local to Titicaca Basin

CATEGORIES OF DIAGNOSTIC ATTRIBUTES

Each taxon's individual section within this reference document includes images of a) the exterior surface texture, b) periderm thickness, c) vascular tissue patterning in a transversal view, and d) xylem perforation structure. All of these anatomical features were not necessarily viewed with every single form of preparation. While each of these anatomical features can help to identify preserved parenchyma fragments, it is critical for the archaeological material to have at minimum the vascular tissue preserved and viewed in the transverse section in order to have a confident identification. All other features can further confirm an identification, but cannot be relied upon on their own for identification purposes.

Exterior Surface Texture	Periderm Thickness	Vascular Bundle Arrangement	Xylem Wall Perforation
Undifferentiated	Thin (0 to 2 cells)	Ovoid/Concentric	Pitted
Reticulate	Medium (3 to 6 cells)	Irregular	Scalariform
Smooth/Wrinkled	Thick (7+ cells)	Linear	Helical/Spiral

Genus and Species	Common Name	Exterior Surface Texture	Periderm Thickness	Vascular Bundle Arrangement	Xylem Wall Perforation
Ipomoea batatas	sweet potato	Undifferentiated	Medium	Irregular	Pitted (alternate)
Lepidium meyenii	maca	Smooth/ Wrinkled	Medium	Ovoid/ Concentric	Helical/ Spiral
Manihot esculenta	manioc	Smooth/ Reticulate	Thick	Linear	Helical/ Spiral
Oxalis tuberosa	oca	Reticulate/ Wrinkled	Medium	Ovoid/ Concentric	Helical/ Spiral
Oxalis tuberosa	calla (freeze-dried)	Smooth/ Wrinkled	Medium	Ovoid/ Concentric	Helical/ Spiral
Pachyrhizus erosus	jicama	Reticulate/ Wrinkled	Thick	Ovoid/ Irregular	Scalariform
Schoenoplectus *californicus subsp tatora*	totora	Reticulate/ Striated	Thick	Ovoid/ Concentric	Scalariform
Smallanthus sonchifolius	yacón	Smooth	Thick	Irregular	Scalariform
Solanum tuberosum	papa/potato	Undifferentiated	Medium	Ovoid/ Irregular	Helical/Spiral & Scalariform
Solanum tuberosum	chuño (freeze-dried)	Undifferentiated	Medium	Ovoid/ Irregular	Helical/Spiral & Scalariform
Tropaeolum tuberosum	mashua/isañu	Wrinkled/ Reticulate	Medium	Irregular	Helical/Spiral & Scalariform
Ullucus tuberosus	ulluco/papalisa	Smooth/ Wrinkled	Thin	Irregular	Helical/Spiral & Scalariform

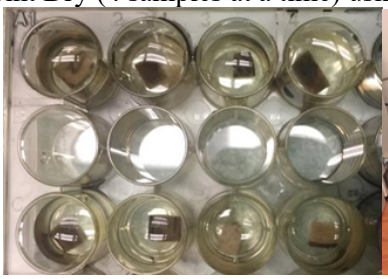
PREPARATION PROCEDURES

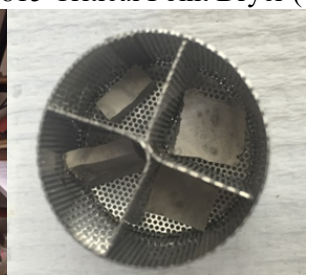
DEHYDRATED SAMPLES

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)





CHARRED SAMPLES

All specimens were wrapped in aluminum foil (unless noted otherwise), labeled with a permanent marker, buried in sand, and then placed in a muffle furnace within a metal container for the specified temperatures and lengths of time detailed in this document. Once cooled, samples were fractured while under the view of stereomicroscope in order to view fresh surfaces of the transverse and tangential views. Successful fractures were mounted and the various anatomical features under consideration were imaged using a Hitachi TM-1000 (Environmental Scanning Electron Microscope). 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. Images of the various cross-sections were taken at multiple magnifications, usually 50x, 100x, 200x, 500x. The micrographs were focused on vascular bundle arrangement, xylem wall pitting, periderm thickness, and exterior surface texture.





Muffle Furnace Stereoscope Hitachi TM-1000 (E-SEM)

STAINED SAMPLES

The staining methodology followed Hather (2000:81-84).

*Hather, J.G. 2000. *Archaeological Parenchyma*. London: Archetype Publications

Part 1: Sample Preparation

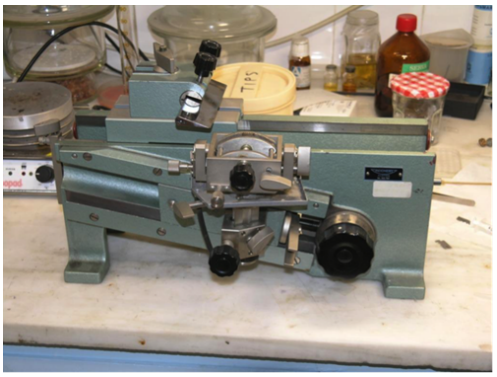
1. Soak fresh tubers with thick/tough periderms in water overnight.
2. Section tubers into two halves across the transverse plane with a sharp knife (try to make as "flat" a cut as possible).
3. Section one of the halves across the same plane to make a ~2-cm-thick round.
4. If needed, cut the round into pieces along the longitudinal plane that can fit on a slide.

Part 2: Using the Microtome

1. Clamp prepared tuber piece into vise
2. Slice manually with fresh blade
3. Brush water regularly with a small brush onto the specimen to lubricate and facilitate slicing
4. Use the brush to remove sections from the clamped specimen
5. Keep the sections hydrated by placing them in a petri dish filled with water

Part 3: Staining and Mounting

1. Stain slides with a 40/40 mix of alcian blue and safranin
2. Alcian blue stains cellulose (e.g., parenchyma) blue
3. Safarnin (e.g., sclerenchyma, xylem vessels) stains lignin red
4. Mount stained sections under water on 2"x3" slides (prevent air bubbles)
5. Cover with 2"x3" glass coverslip and viewed under a BX51 microscope.



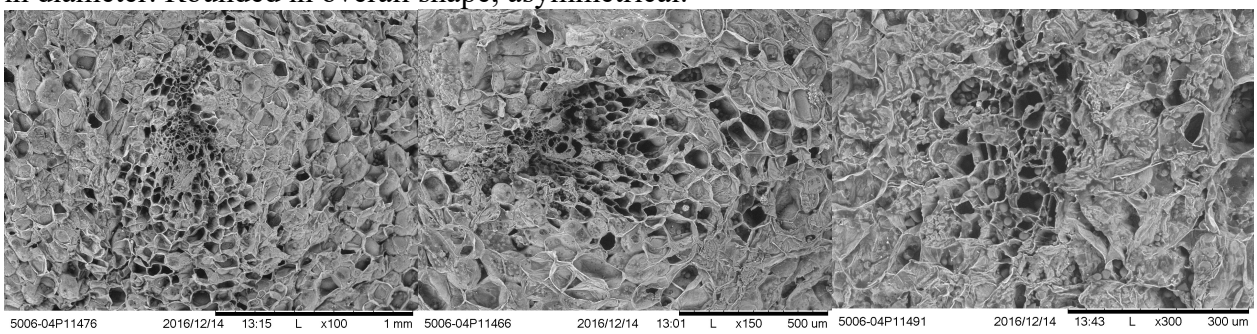
Reichert Jung Om E sledge microtome



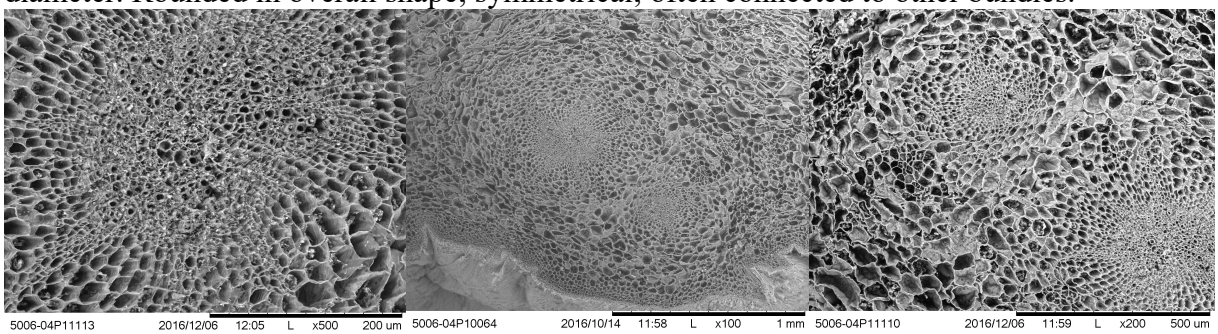
BX51 microscope

Overview of Vascular Tissue Patterning

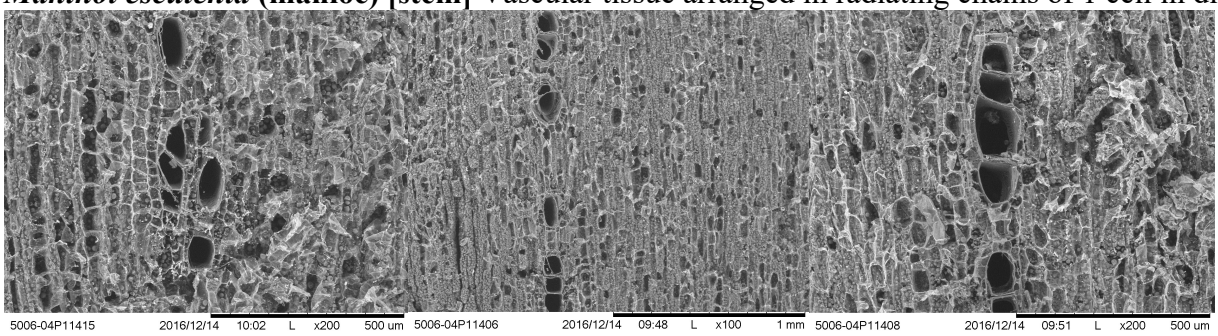
Ipomoea batatas **(sweet potato) [root]** Vascular tissue is loosely concentrated in bundles of 12+ cells in diameter. Rounded in overall shape; asymmetrical.



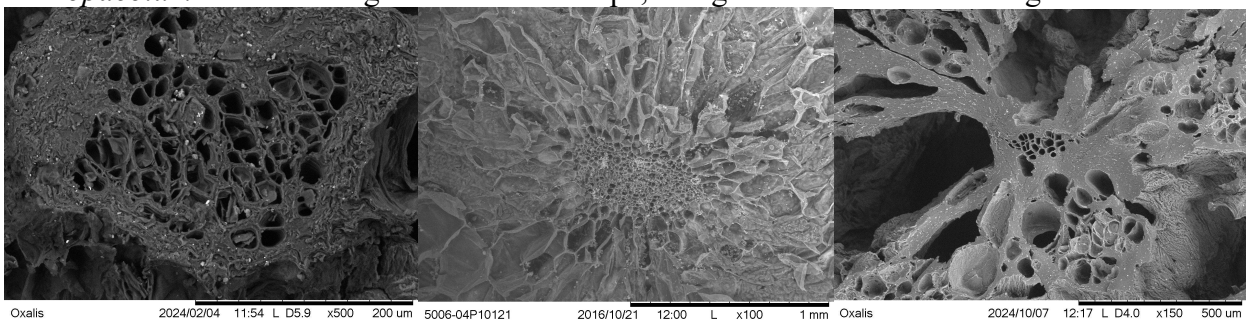
Lepidium meyenii **(maca) [root]** Vascular tissue in distinct concentrated bundles of 20+ cells in diameter. Rounded in overall shape; symmetrical; often connected to other bundles.



Manihot esculenta **(manioc) [stem]** Vascular tissue arranged in radiating chains of 1 cell in diameter.

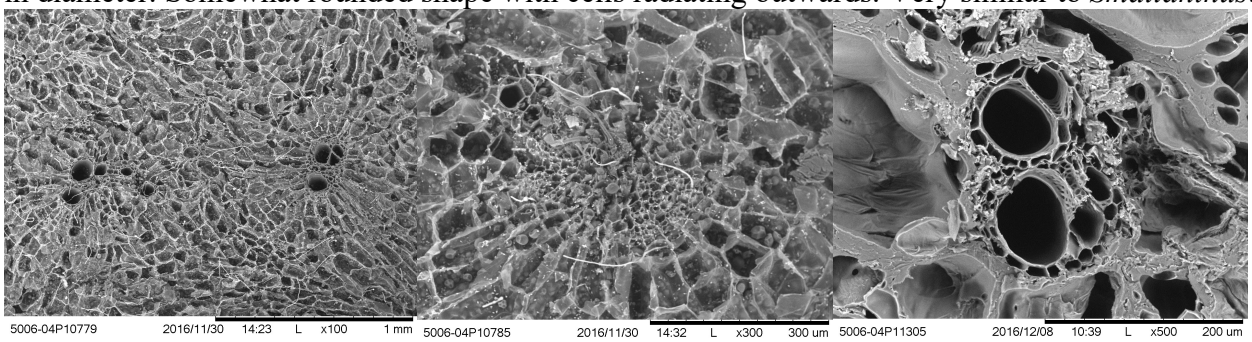


Oxalis tuberosa **(oca) [stem]** Vascular tissue concentrated in a bundle of 10+ cells in diameter. Similar to *Tropaeolum*. Rounded/angular in overall shape, elongated on one side. Arranged in a transverse ring.

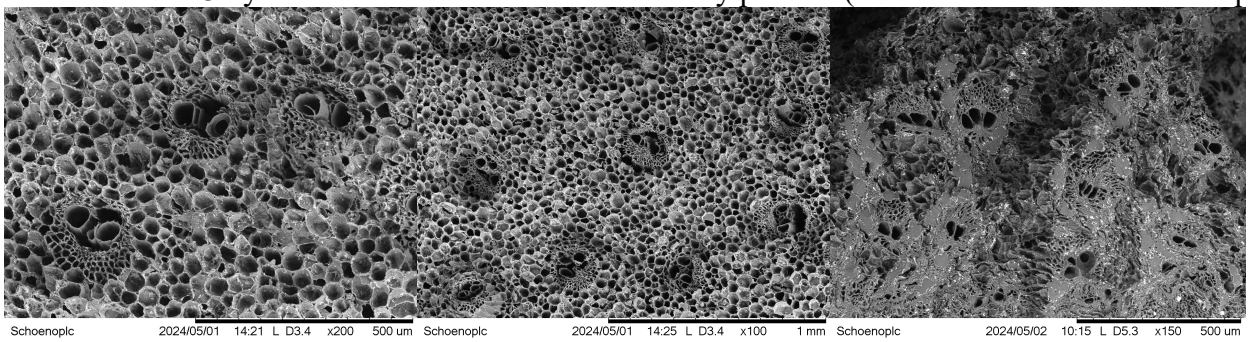


Overview of Vascular Tissue Patterning

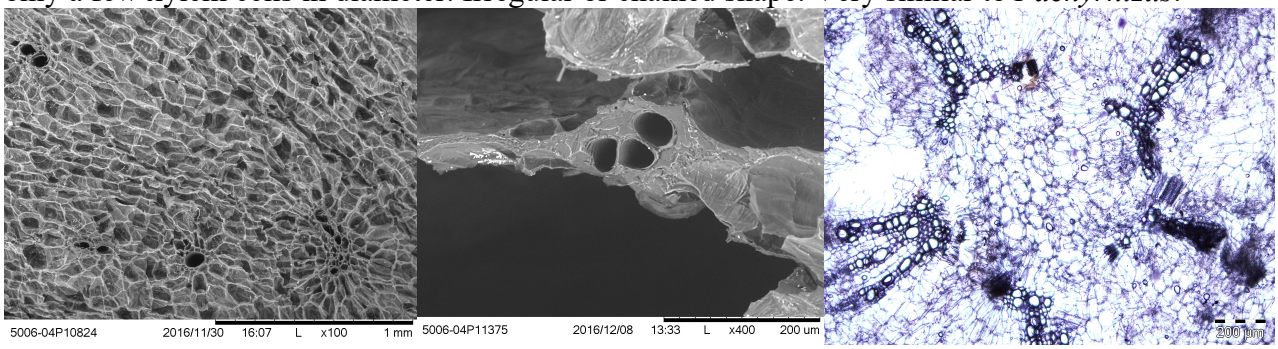
***Pachyrhizus erosus* (jicama) [root]** Vascular tissue concentrated in small bundles of 3 to 5 xylem cells in diameter. Somewhat rounded shape with cells radiating outwards. Very similar to *Smallanthus*.



***Schoenoplectus californicus subsp tatora* [rhizome]** Vascular tissue concentrated in numerous small bundles with 2-3 xylem cells in diameter. Surrounded by phloem (rounded in overall bundle shape).

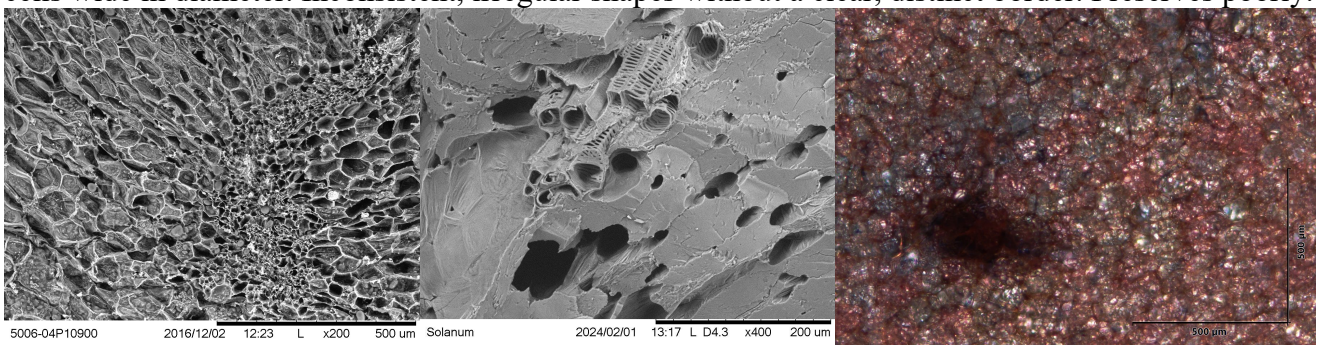


***Smallanthus sonchifolius* (yacón) [root]** Vascular tissue in very small, isolated bundles or chains with only a few xylem cells in diameter. Irregular or chained shape. Very similar to *Pachyrhizus*.

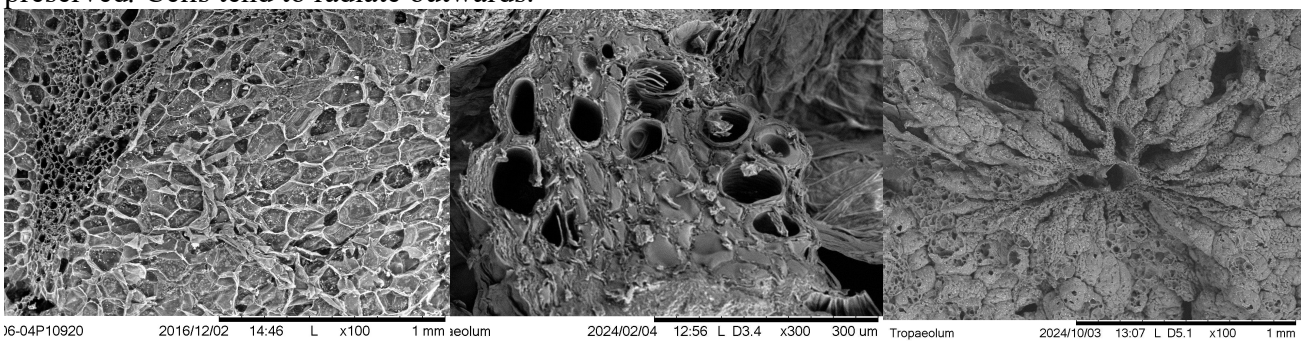


Overview of Vascular Tissue Patterning

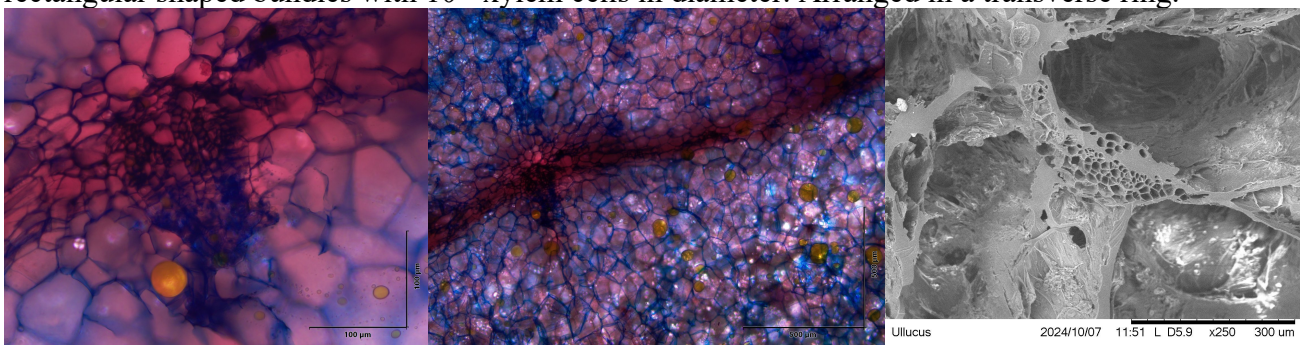
Solanum tuberosum **(papa) [stem]** Vascular tissue concentrated in indistinct bundles that can be 10+ cells wide in diameter. Inconsistent, irregular shapes without a clear, distinct border. Preserves poorly.



Tropaeolum tuberosum **(mashua) [root]** Vascular tissue concentrated in irregular and angular shaped bundles with 6+ xylem cells in diameter. Can appear similar to *Oxalis*, but tends to be less well preserved. Cells tend to radiate outwards.



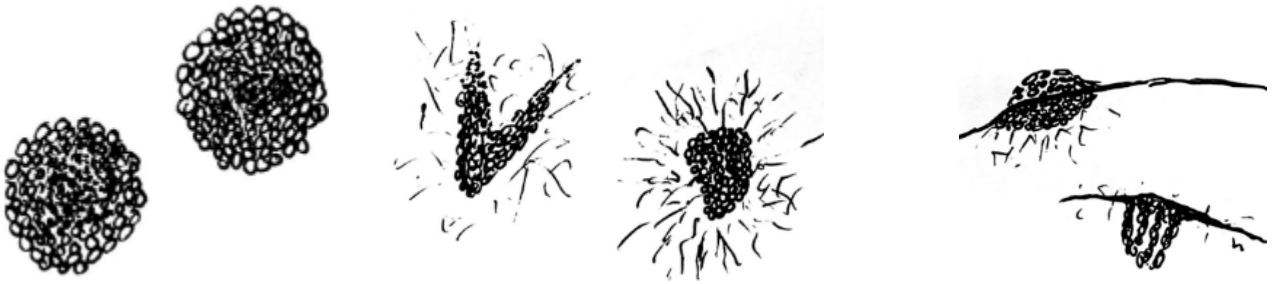
Ullucus tuberosus **(ulluco/papalisa) [root]** Vascular tissue concentrated in irregular and semi-rectangular shaped bundles with 10+ xylem cells in diameter. Arranged in a transverse ring.



Sketches of the vascular bundle patterning of the Andean taxa under consideration:

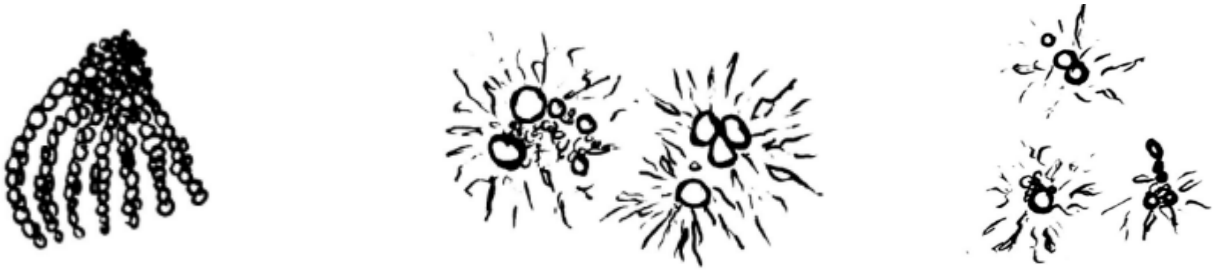
Local Roots

Lepidium meyenii (maca) *Tropaeolum tuberosum* (mashua) *Ullucus tuberosus* (ulluco)



Lowland Roots

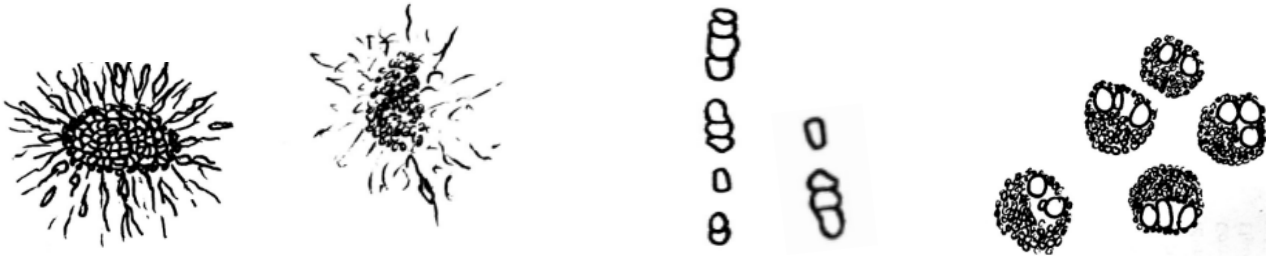
Ipomoea batatas (sweet potato) *Pachyrhizus erosus* (jicama) *Smallanthus sonchifolius* (yacon)



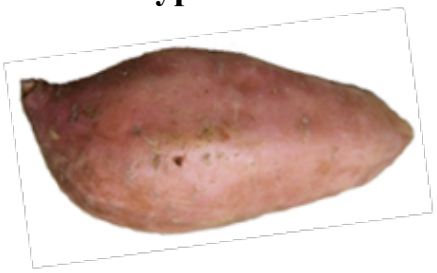
Local Stems **Lowland Stem** **Rhizome**

Oxalis tuberosa *Solanum tuberosum* *Manihot esculenta* *Schoenoplectus californicus subsp tatora*

(oca) (papa) (manioc) (totora)



Scientific Name: *Ipomoea batatas*
Common Name: sweet potato
Type: Root

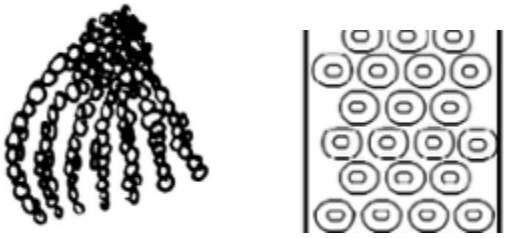


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Undifferentiated: Poorly defined surface texture. Flaked and rippled.

Periderm: Medium: Thin and defined, approximately 4 cells thick, regular rectangular cell structure.

Vascular Tissue: Irregular: Bundles irregularly shaped, dense, xylem cells radiating in strands from a core center, 8-12 cells wide. Xylem Perforation Structure: Pitted, alternate pattern.



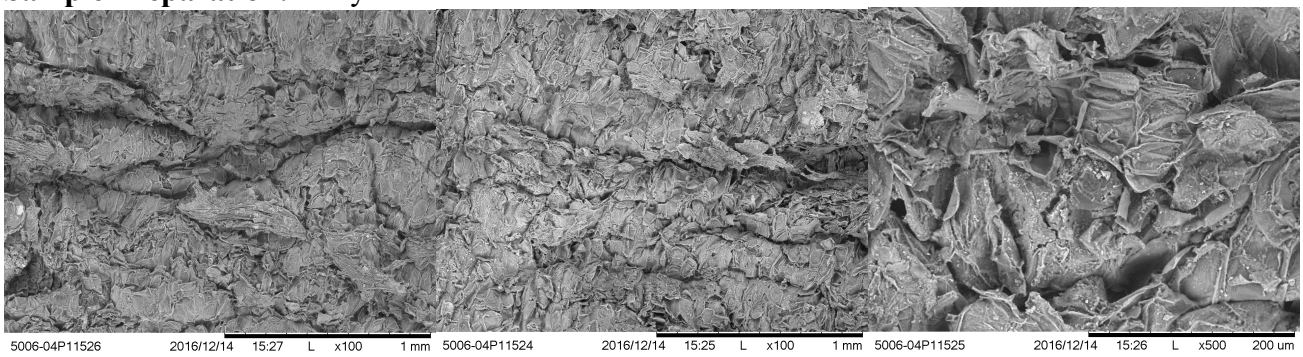
Forms of Preparation:

- Charred 'fresh' (not dried or boiled) at 250℃ for 2.5hrs in foil buried in sand
- Stained
- Dehydrated

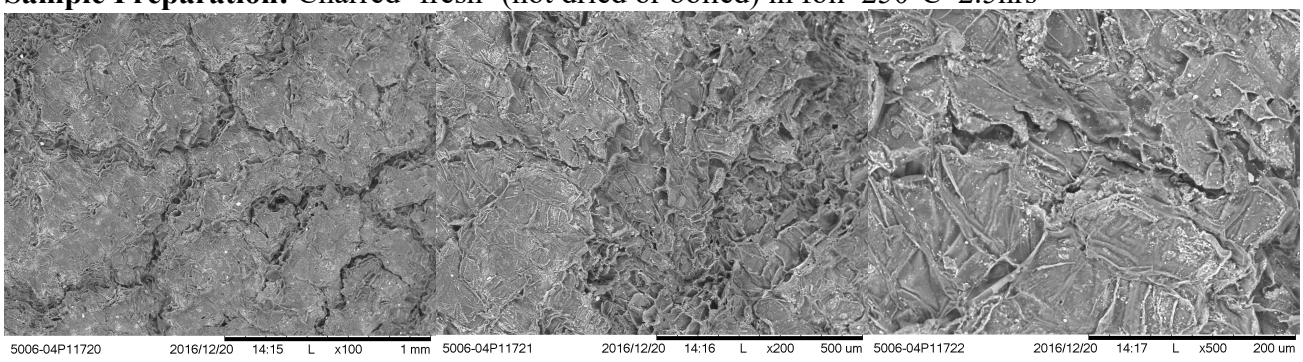
Scientific Name: *Ipomoea batatas* **Common Name:** sweet potato **Type:** Root

View: Exterior Surface

Sample Preparation: Dehydrated

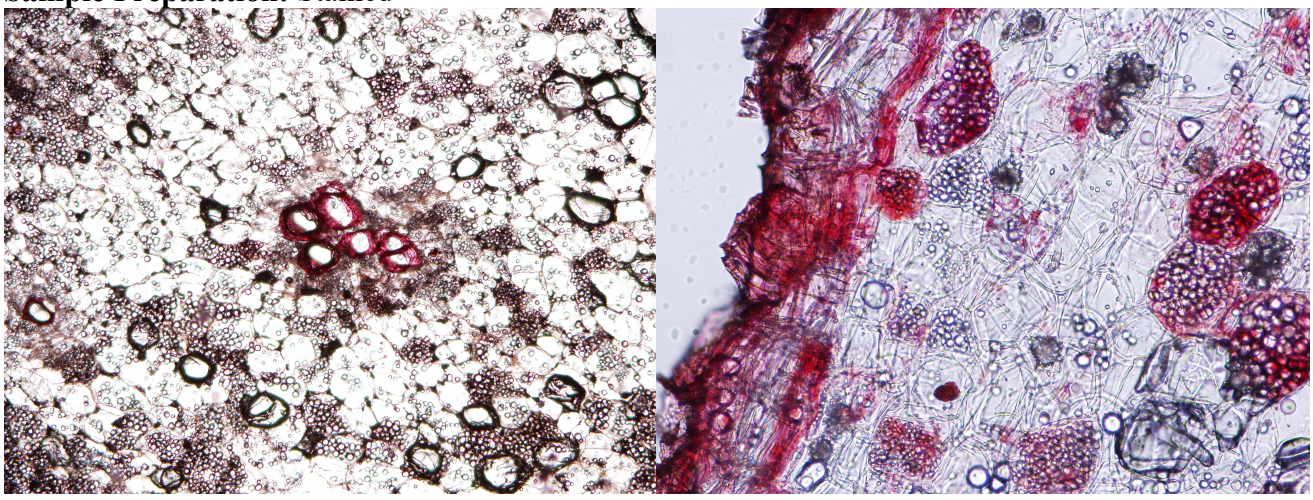


Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



View: Vascular Tissue

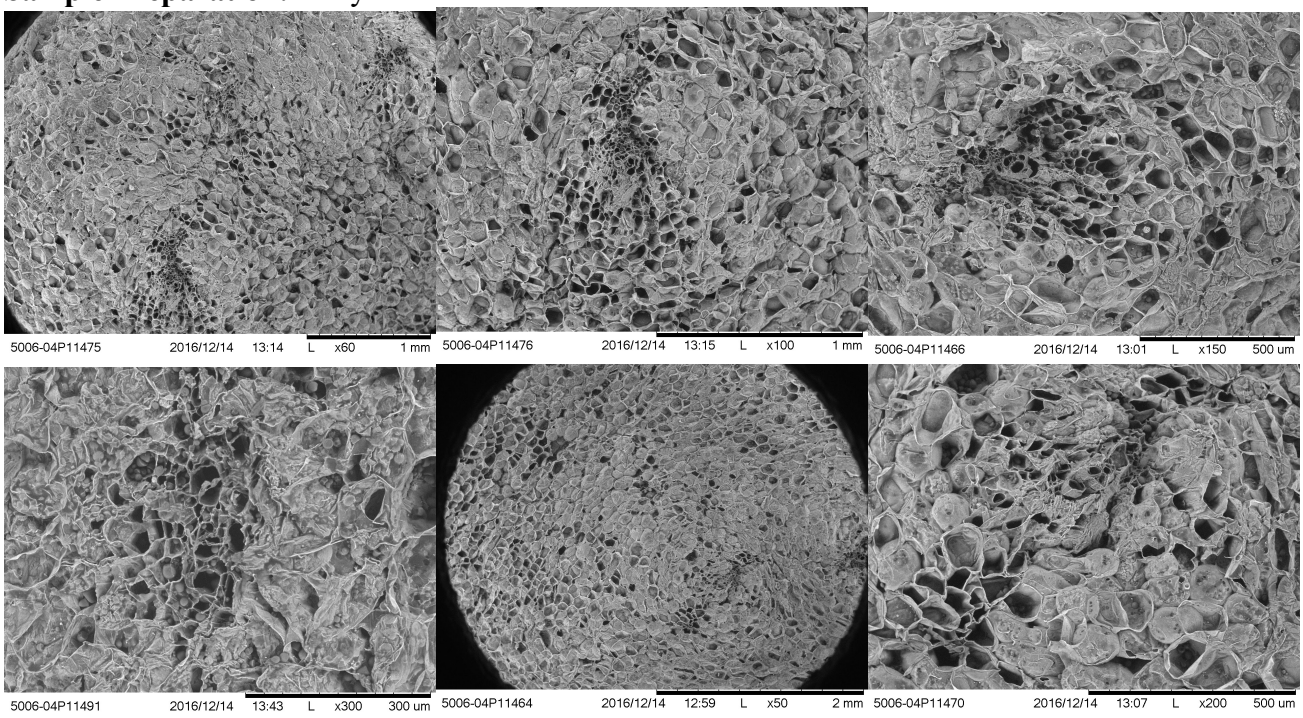
Sample Preparation: Stained



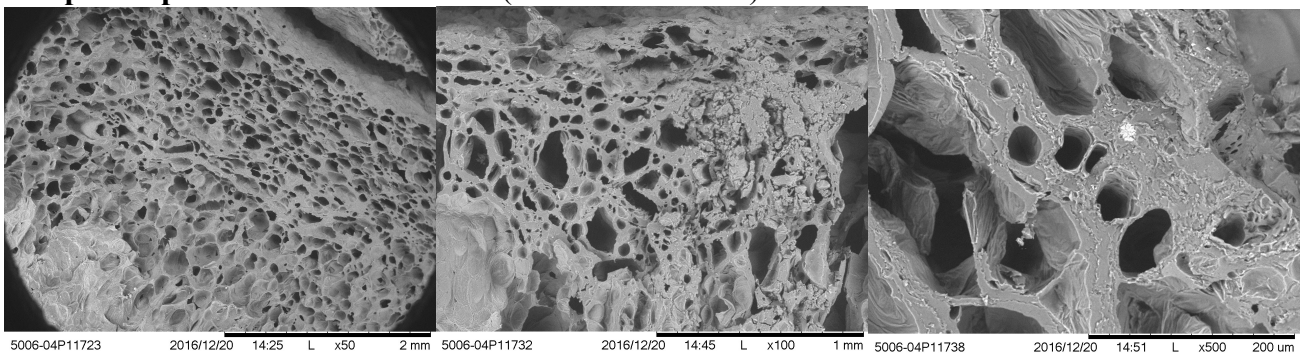
Scientific Name: *Ipomoea batatas* **Common Name:** sweet potato **Type:** Root

View: Vascular Tissue

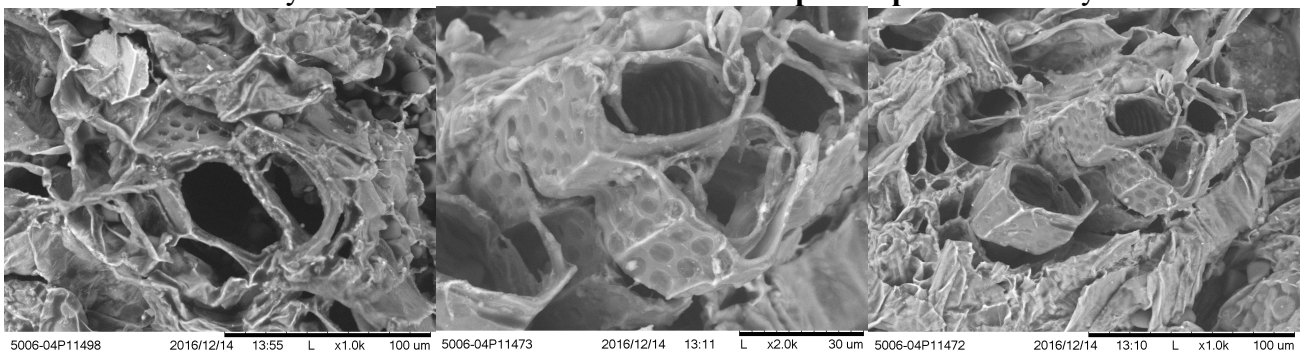
Sample Preparation: Dehydrated



Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



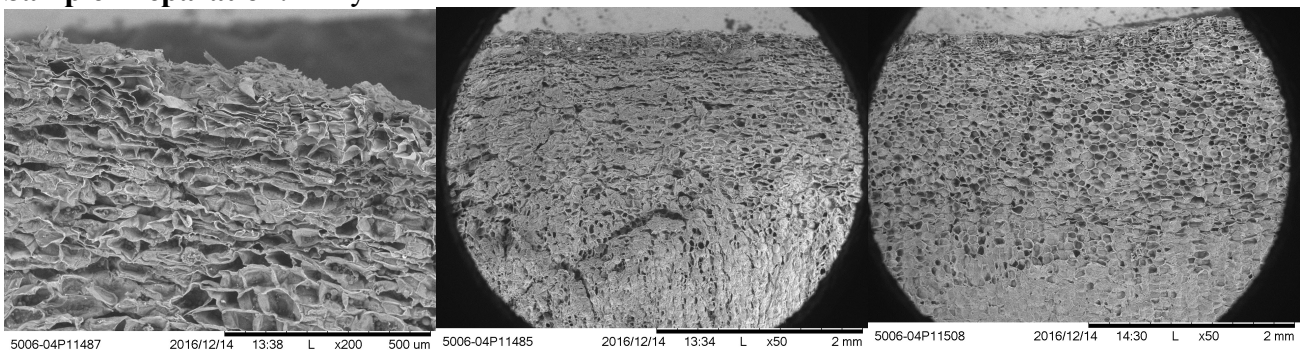
View: Xylem Perforation Structure: Pitted **Sample Preparation:** Dehydrated

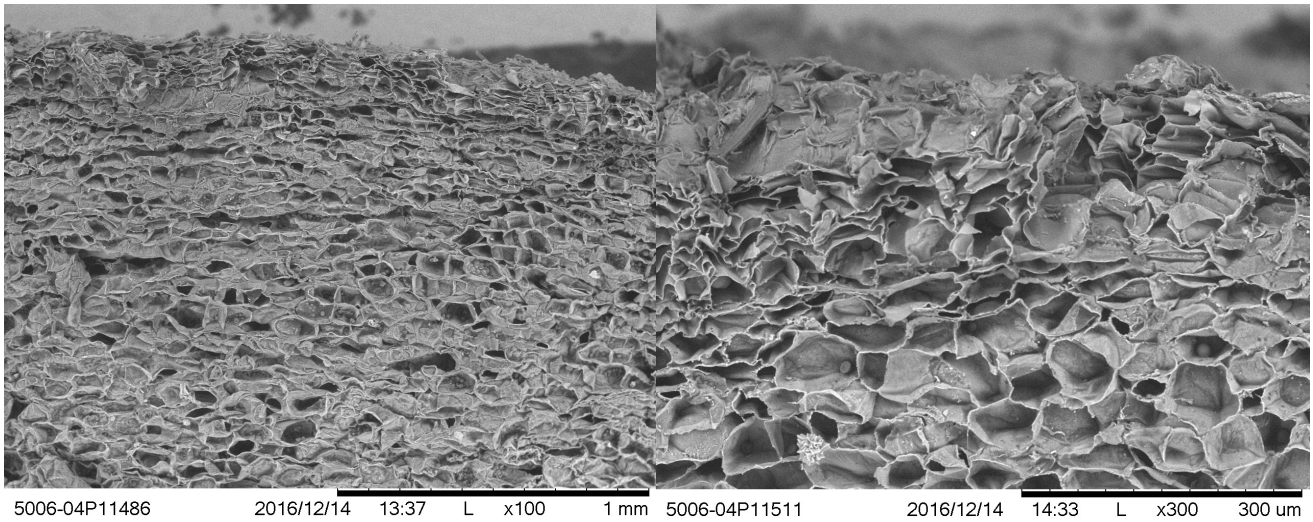


Scientific Name: *Ipomoea batatas* **Common Name:** sweet potato **Type:** Root

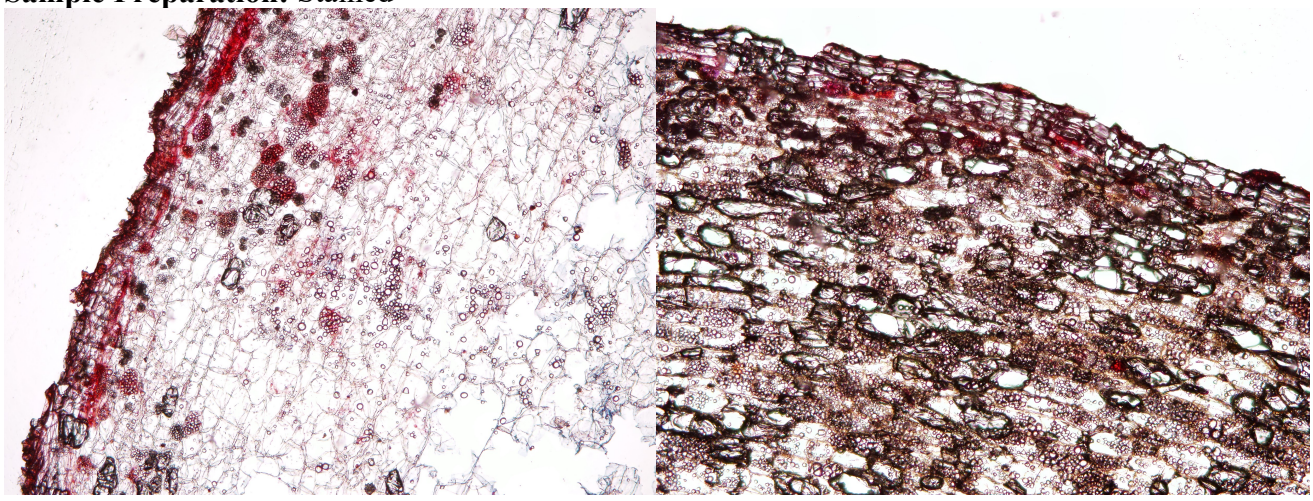
View: Periderm

Sample Preparation: Dehydrated





Sample Preparation: Stained



Scientific Name: *Lepidium meyenii*
Common Name: maca
Type: Root

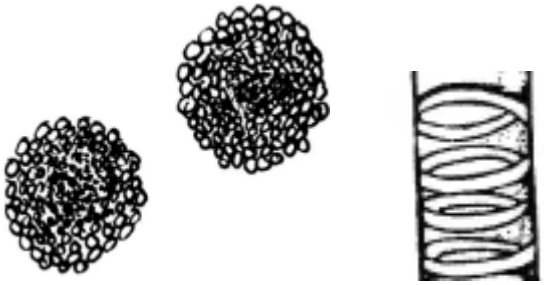


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Smooth/Wrinkled: Smooth exterior surface with large wrinkles and bulges.

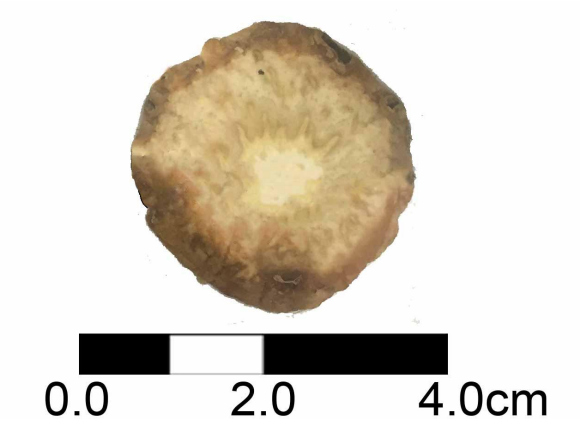
Periderm: Medium: Discretely defined, 4-7 cells thick, irregular cell structure. Can solidify when carbonized.

Vascular Tissue: Ovoid/Concentric: Distinct dense, circular bundles that are symmetrical, up to 20 cells wide.
Xylem Perforation Structure: Helical/Spiral



Forms of Preparation:

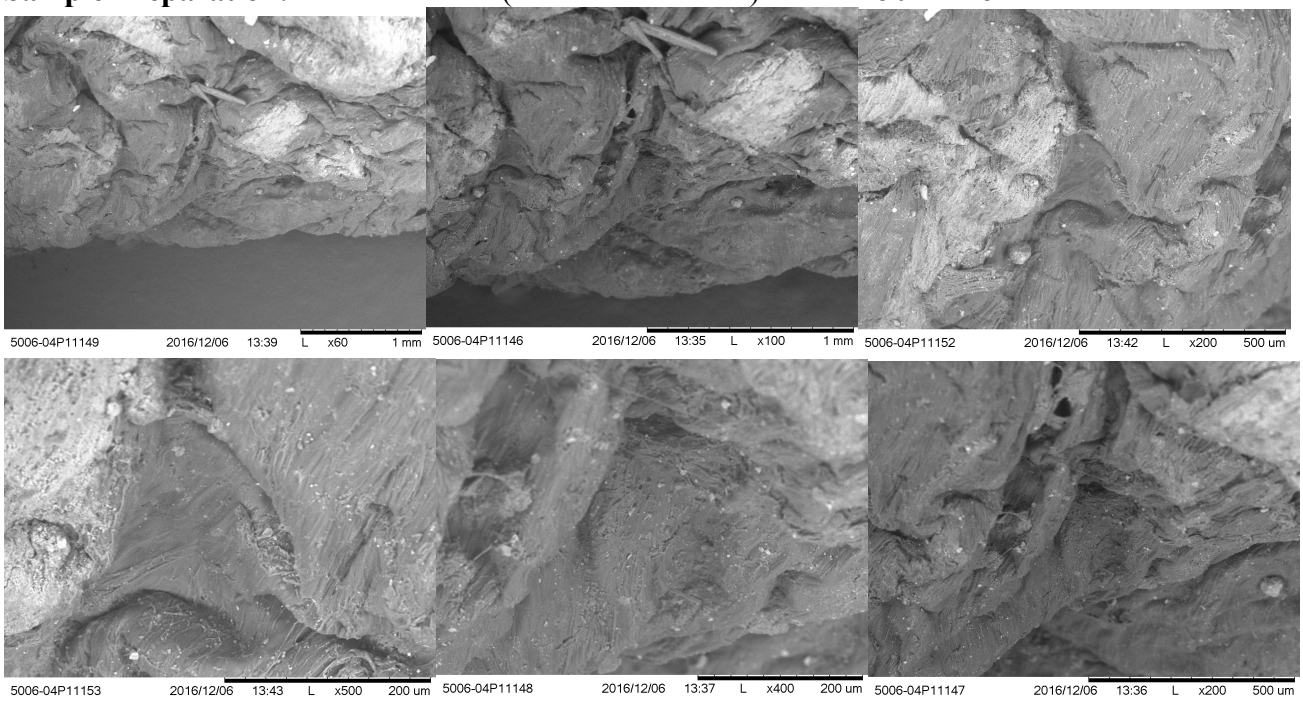
- Charred 'fresh' (not dried or boiled) in foil 250℃ 2.5hrs buried in sand
- Dehydrated



Scientific Name: *Lepidium meyenii* **Common Name:** maca **Type:** Root

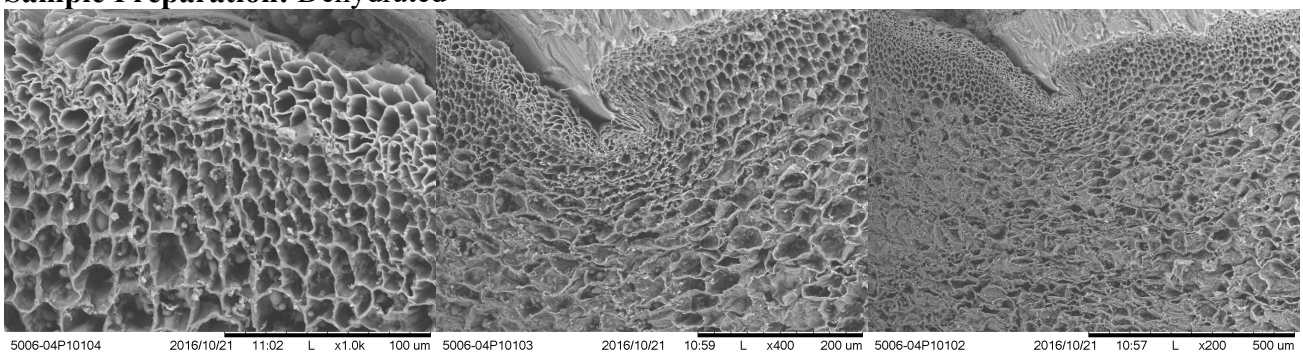
View: Exterior Surface

Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs

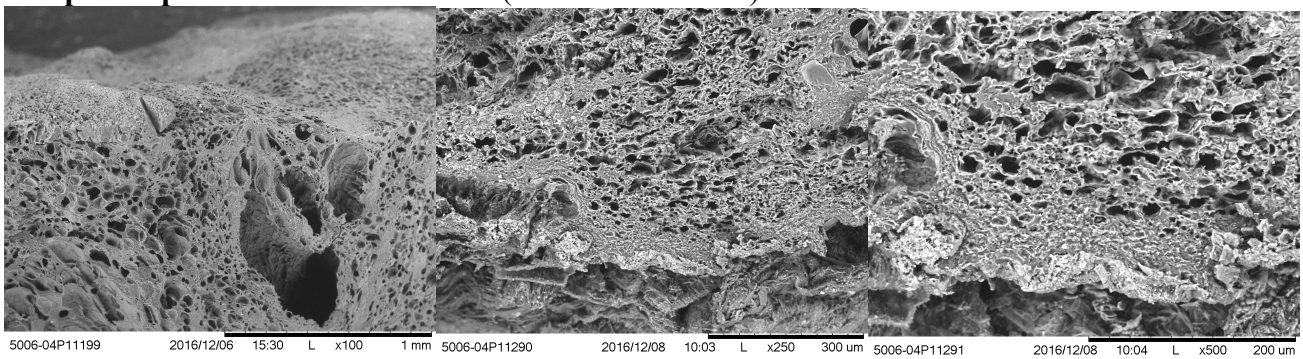


View: Periderm

Sample Preparation: Dehydrated



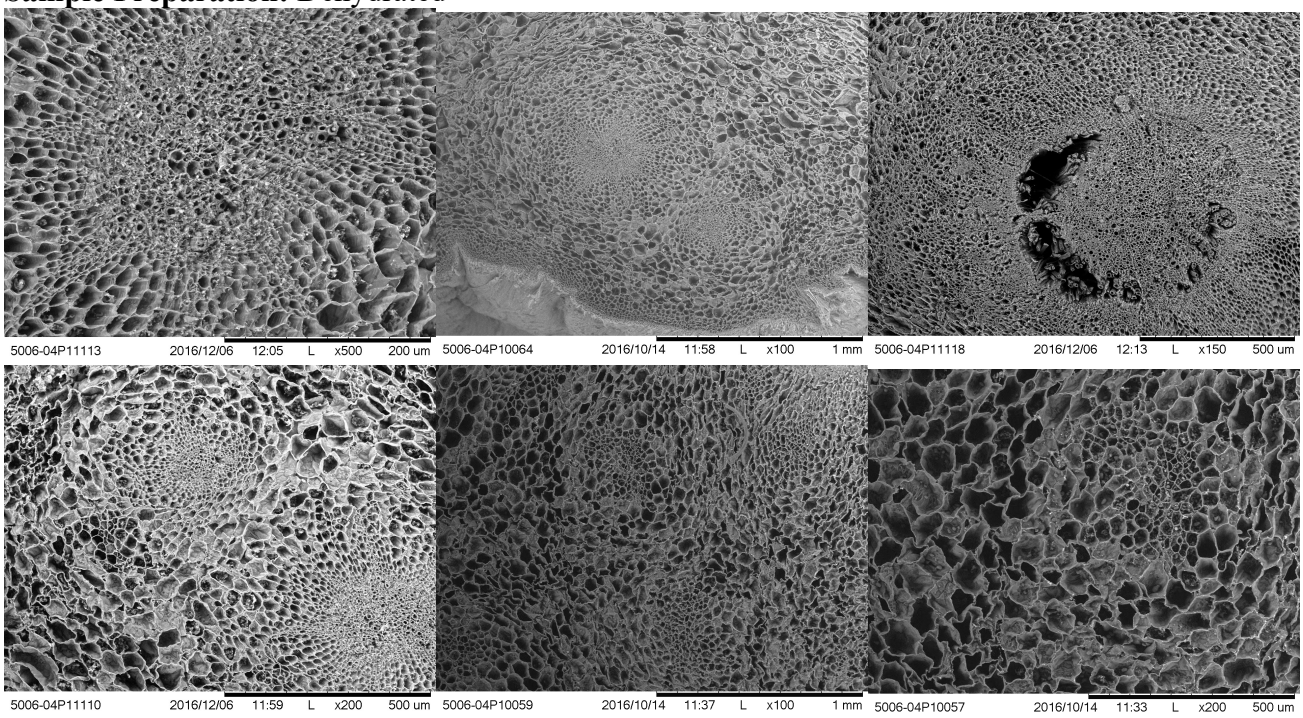
Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



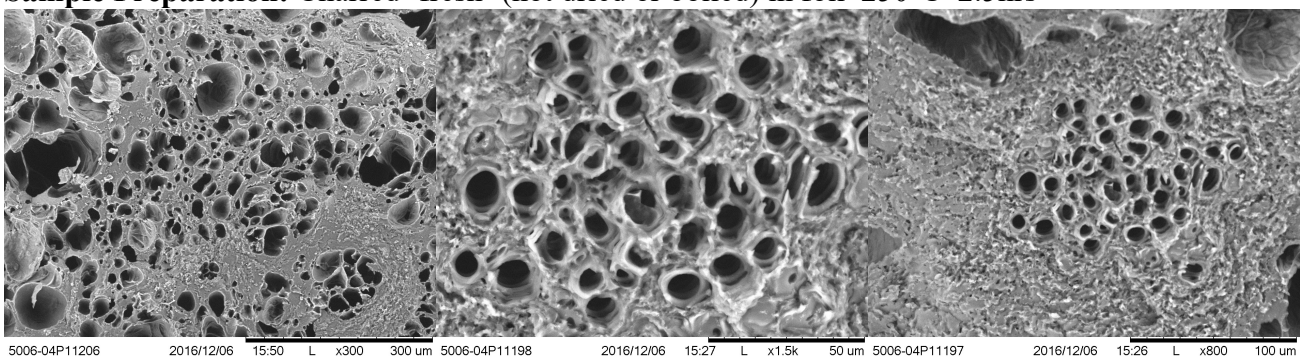
Scientific Name: *Lepidium meyenii* **Common Name:** maca **Type:** Root

View: Vascular Tissue

Sample Preparation: Dehydrated

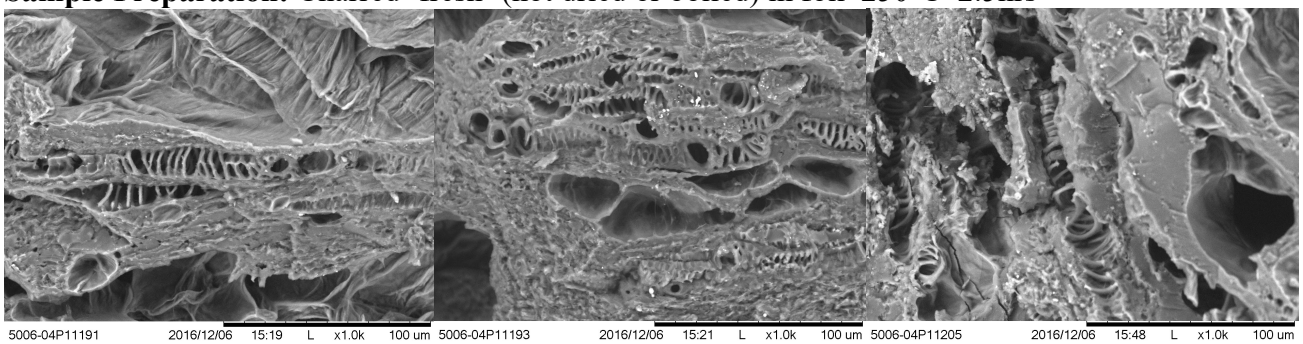


Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



View: Xylem Perforation Structure Helical/Spiral

Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



Scientific Name: *Manihot esculenta*

Common Name: manioc
Type: Stem



SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Smooth and Reticulate: Either smooth or reticulate surface; variable.

Periderm: Thick: Extremely thick (20+ cells), dense rectangular cells.

Vascular Tissue: Linear: Isolated linear bundles, 1 to 8 cells in length and one cell wide, parallel arrangement.
Xylem Perforation Structure: helical/spiral or scalariform



Forms of Preparation:

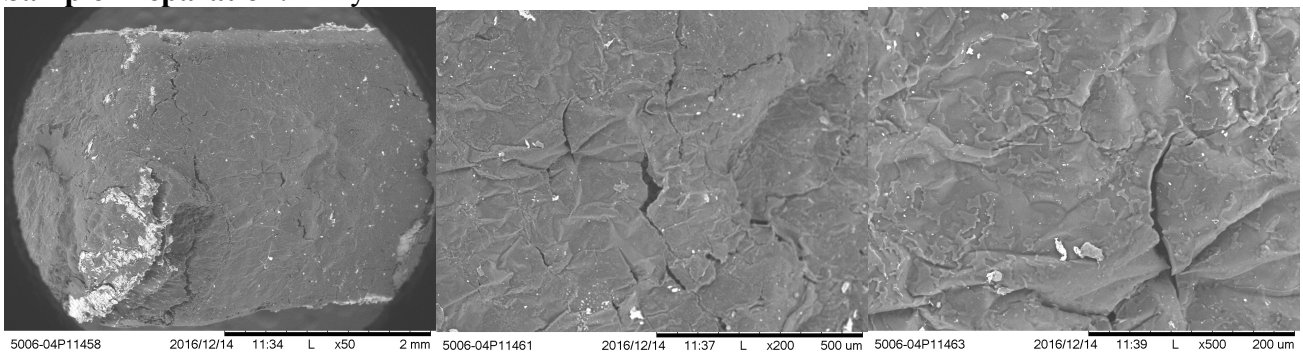
- Charred 'fresh' (not dried or boiled) in foil 250℃ 2.5hrs buried in sand
- Dehydrated
- Stained



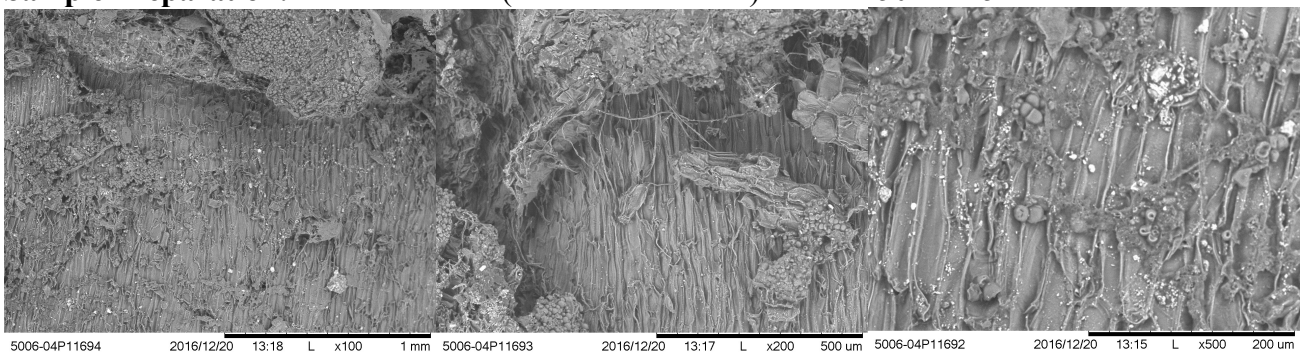
Scientific Name: *Manihot esculenta* **Common Name:** manioc **Type:** Stem

View: Exterior Surface

Sample Preparation: Dehydrated

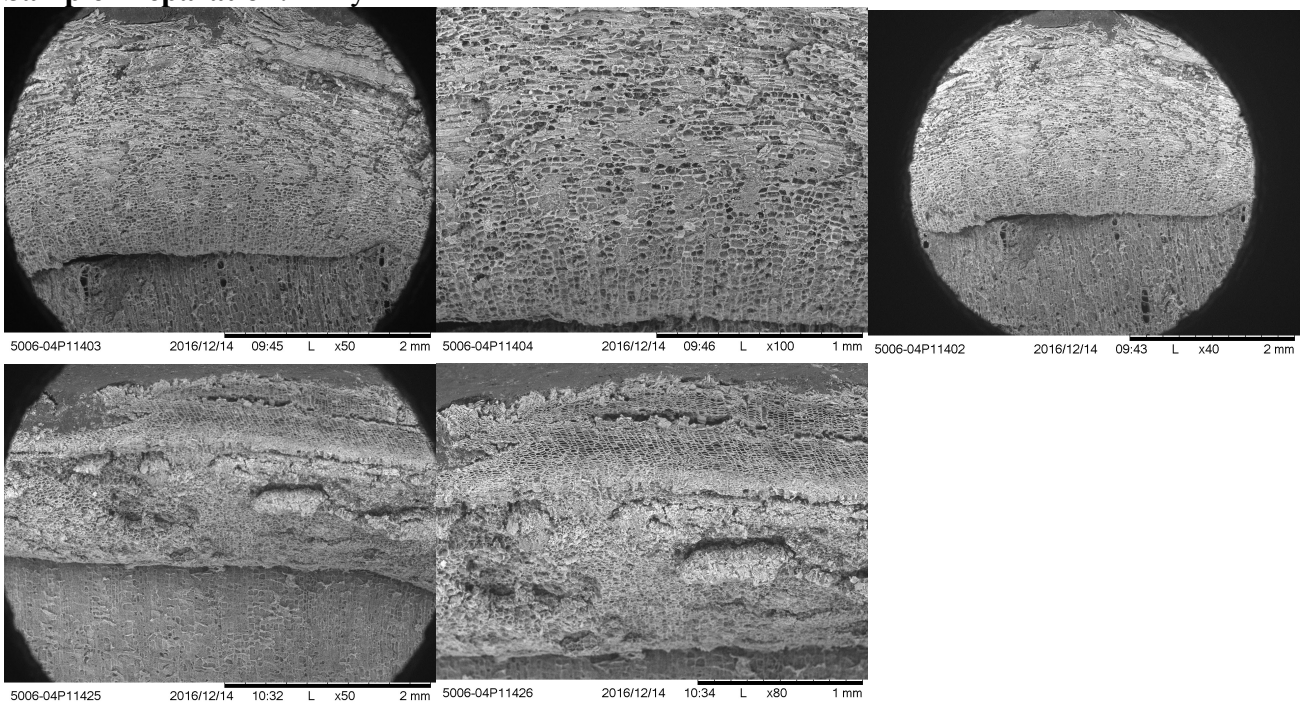


Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



View: Periderm

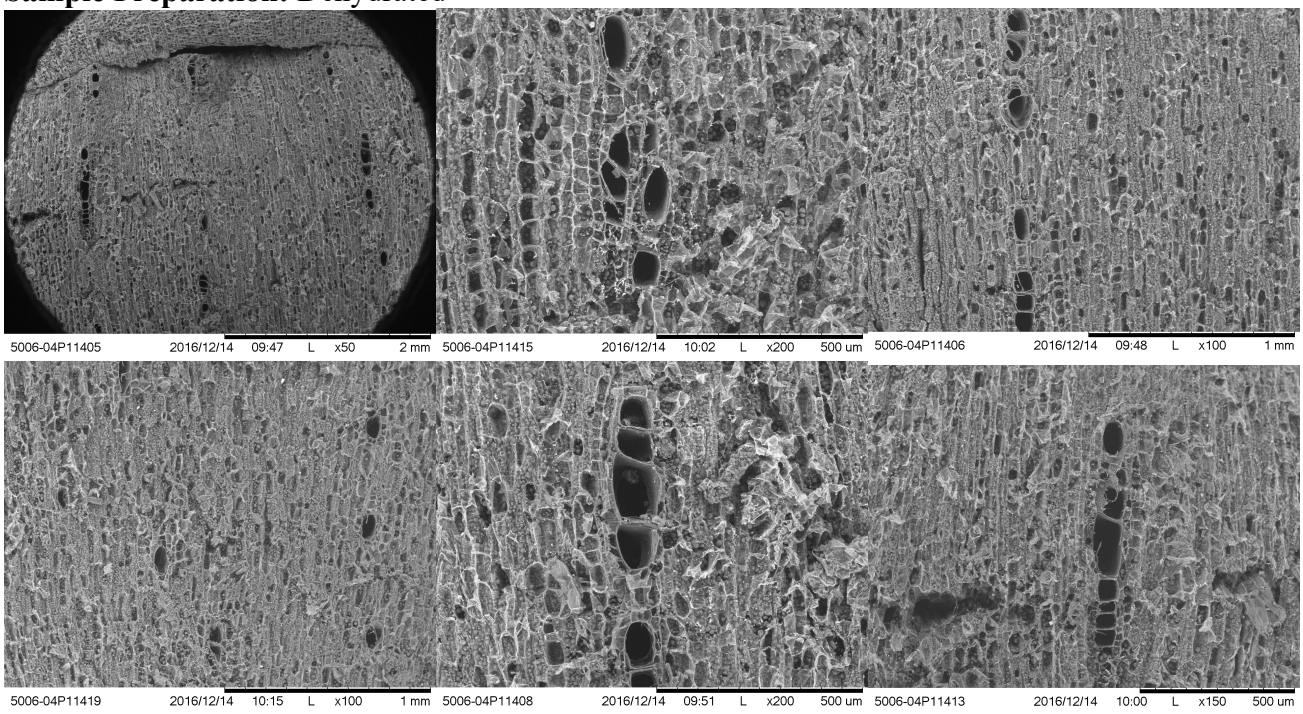
Sample Preparation: Dehydrated



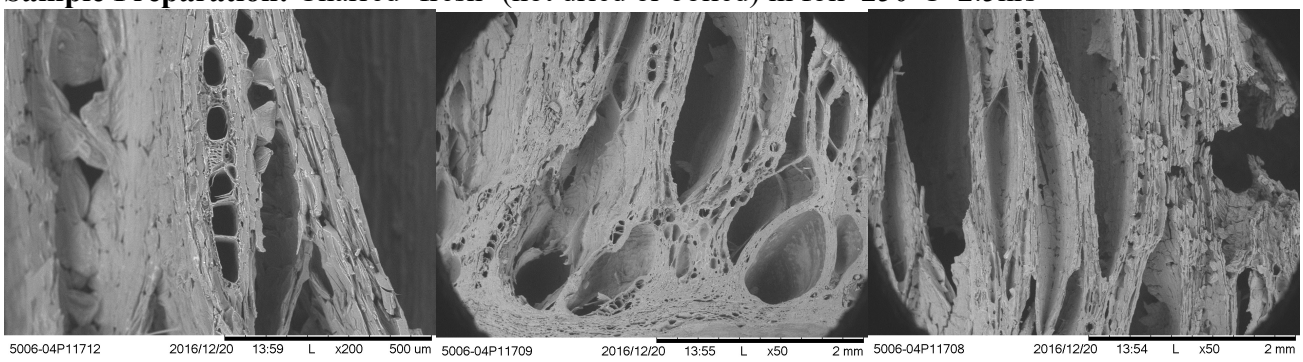
Scientific Name: *Manihot esculenta* **Common Name:** manioc **Type:** Stem

View: Vascular Tissue

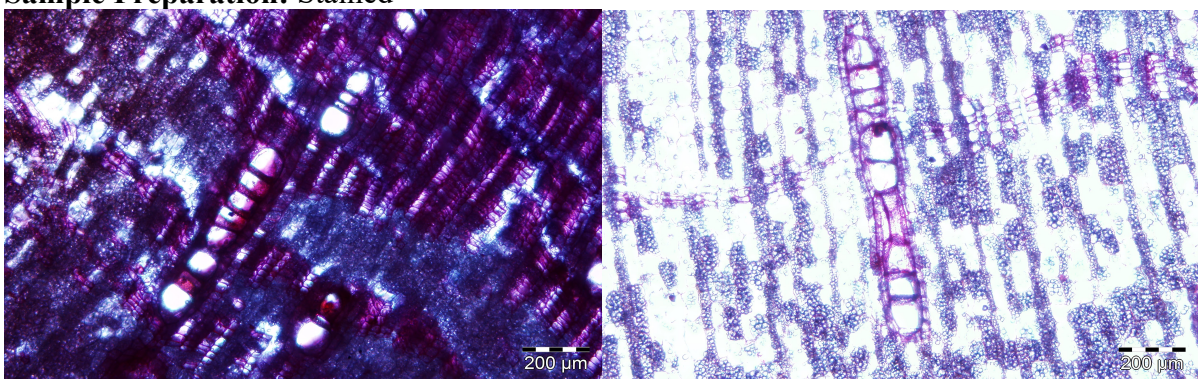
Sample Preparation: Dehydrated



Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



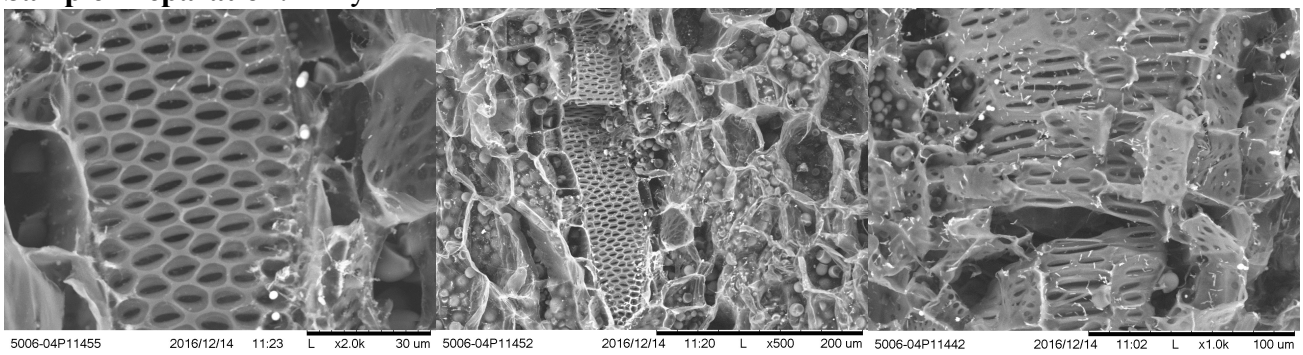
Sample Preparation: Stained



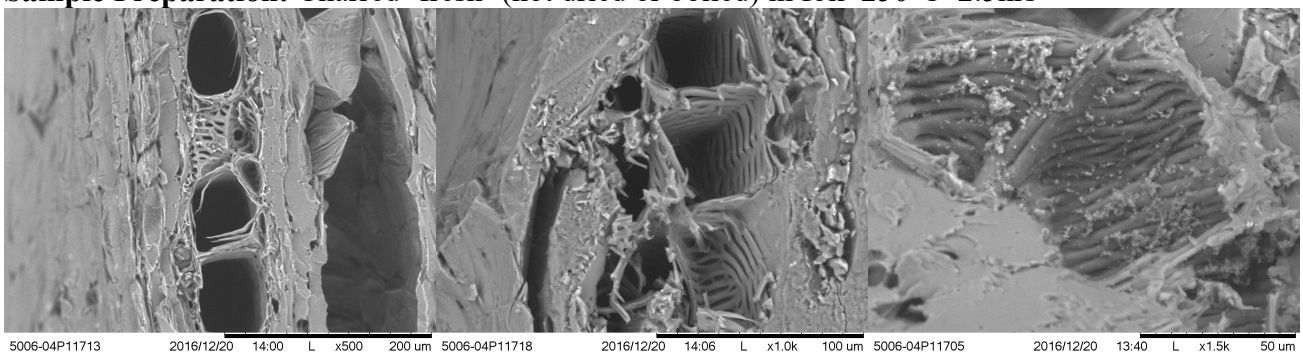
Scientific Name: *Manihot esculenta* **Common Name:** manioc **Type:** Stem

View: Xylem Perforation structure: helical/spiral or scalariform

Sample Preparation: Dehydrated



Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



Scientific Name: *Oxalis tuberosa*
Common Name: oca
Type: Stem

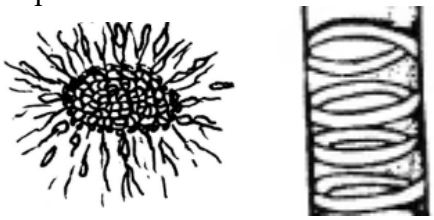


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Reticulate and Wrinkled: Reticulate and wrinkled surface, cellular pattern possibly visible.

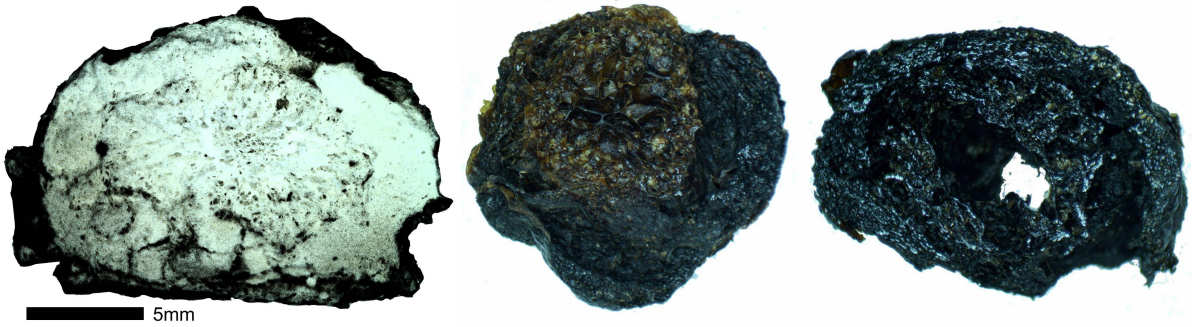
Periderm: Medium: discretely defined, 2-4 cells thick, irregular cell structure.

Vascular Tissue: Ovoid/Concentric: Bundles symmetrical and dense, up to 20 cells wide.
Xylem Perforation Structure: helical/spiral



Forms of Preparation:

- Dehydrated
- Stained
- Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs buried in sand
- Dried 150°F 24hrs Charred 250°C 2.0hrs in foil buried in sand
- Dried 150°F 24hrs Charred 250°C 2.5hrs in foil buried in sand
- Dried 150°F 12hrs Charred 250°C 2.0hrs in foil buried in sand
- Boiled 15min Charred 250°C 2.5hrs in foil buried in sand



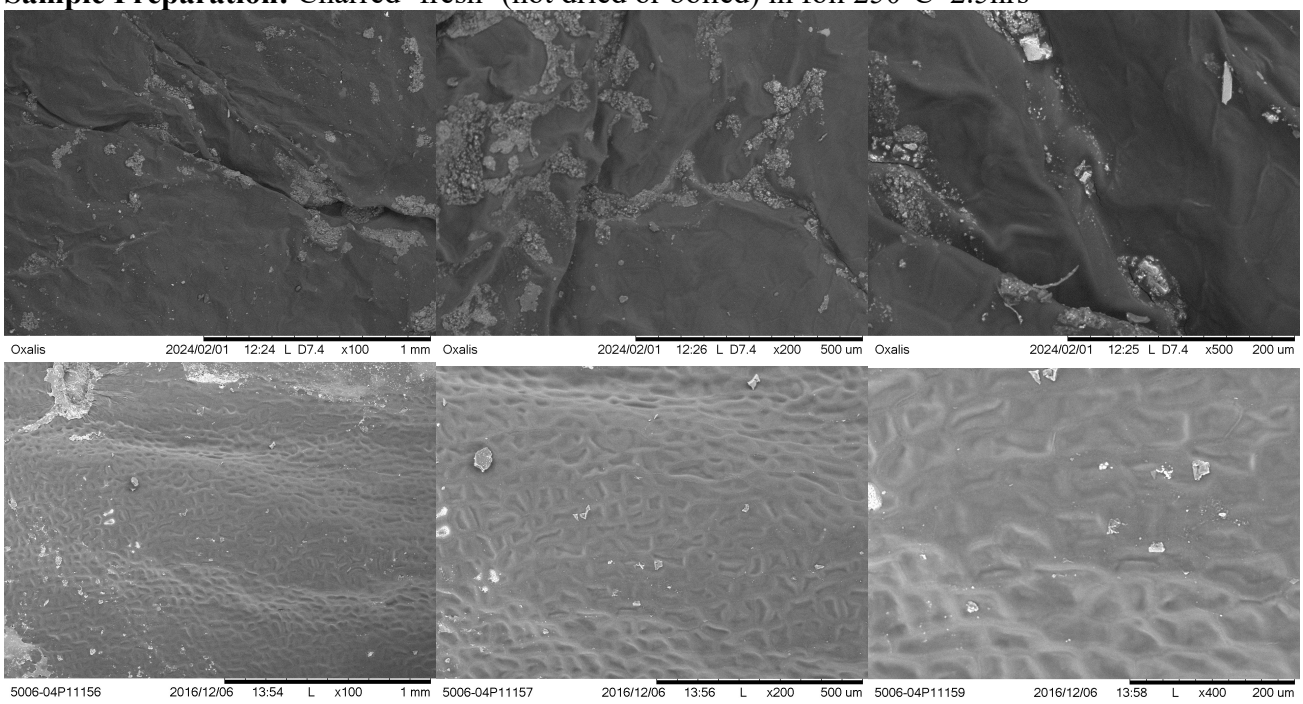
Unprocessed (stored frozen) Charred 250°C 2.5hrs Boiled, then Charred 250°C 2.5hrs

*Note that the center of the geophyte preserves less than the exterior when charred

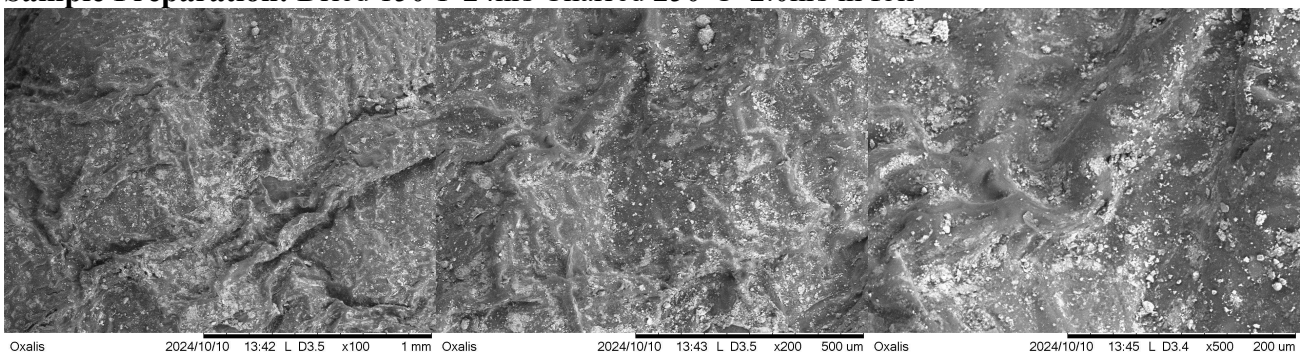
Scientific Name: *Oxalis tuberosa* **Common Name:** oca **Type:** Stem

View: Exterior Surface

Sample Preparation: Charred ‘fresh’ (not dried or boiled) in foil 250℃ 2.5hrs



Sample Preparation: Dried 150°F 24hrs Charred 250℃ 2.0hrs in foil



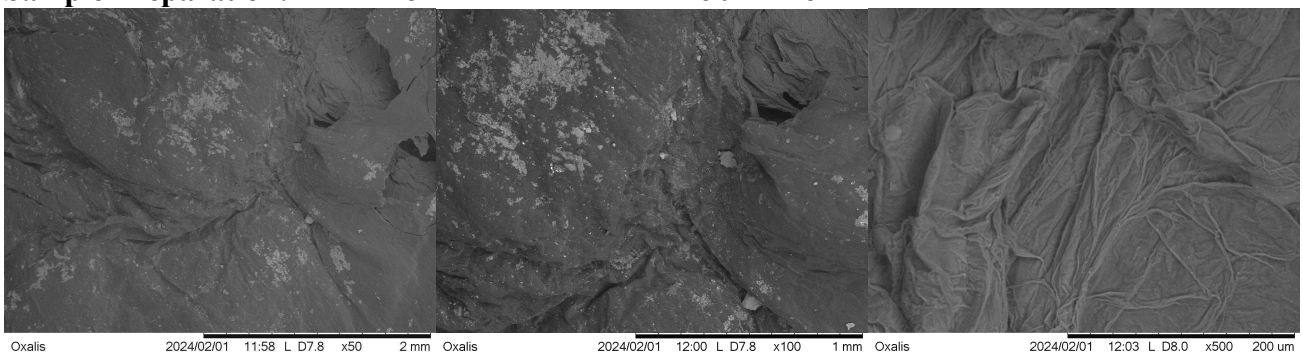
Sample Preparation: Dried 150°F 12hrs Charred 250℃ 2.0hrs in foil



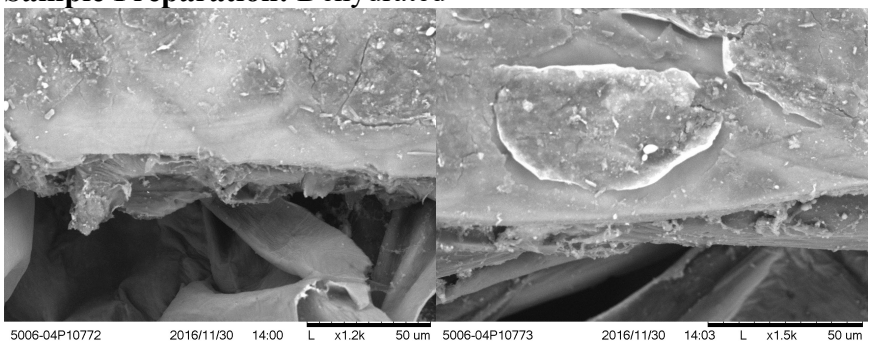
Scientific Name: *Oxalis tuberosa* **Common Name:** oca **Type:** stem

View: Exterior Surface Continued

Sample Preparation: Boiled 15min Charred in foil 250℃ 2.5hrs

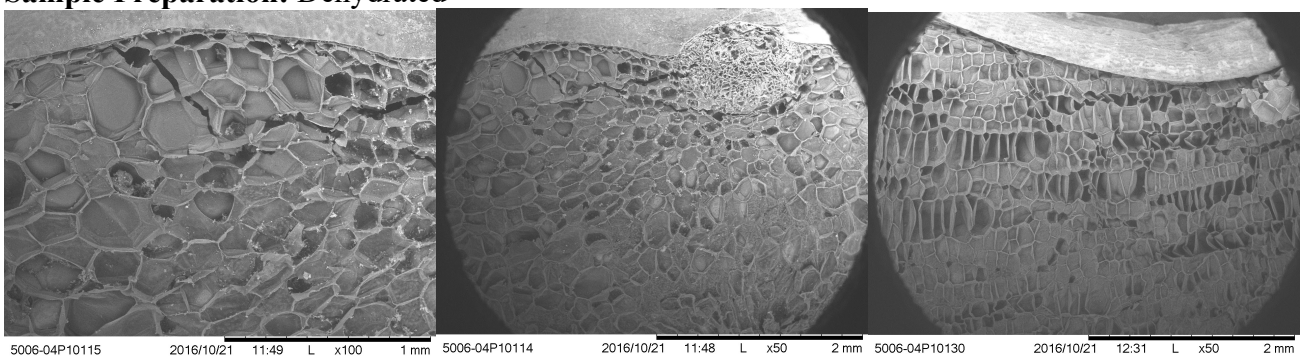


Sample Preparation: Dehydrated

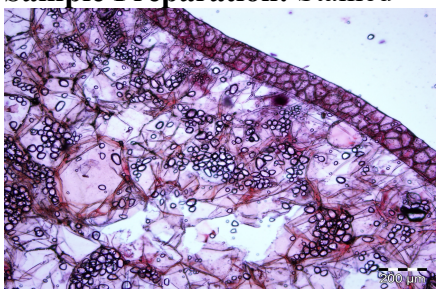


View: Periderm

Sample Preparation: Dehydrated



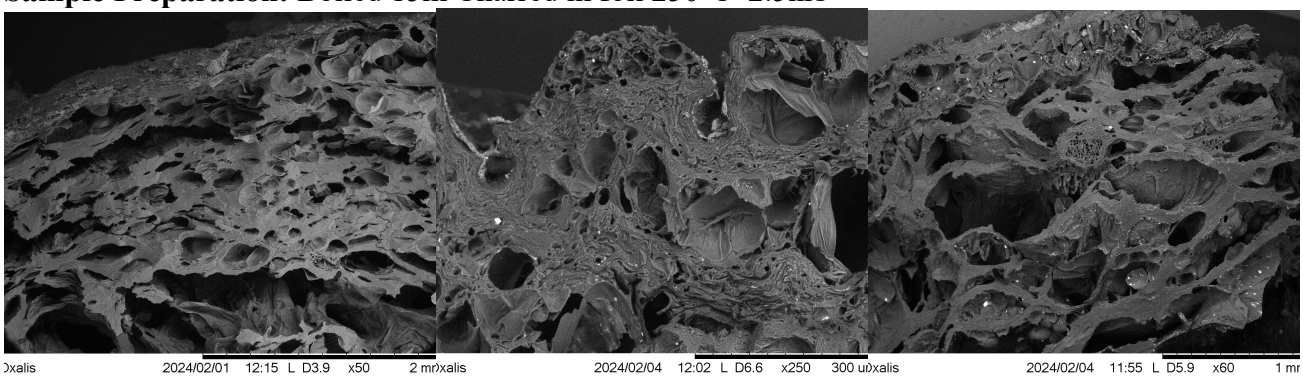
Sample Preparation: Stained



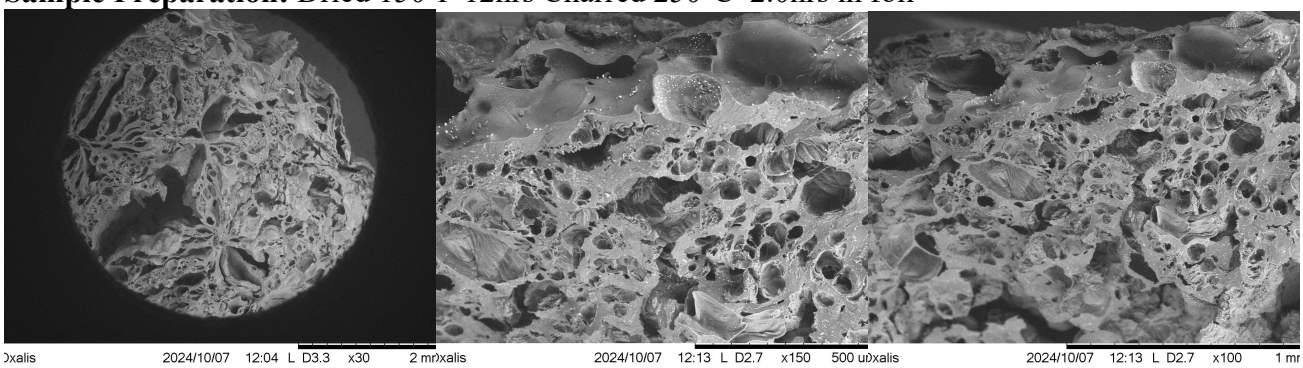
Scientific Name: *Oxalis tuberosa* **Common Name:** oca **Type:** stem

View: Periderm Continued

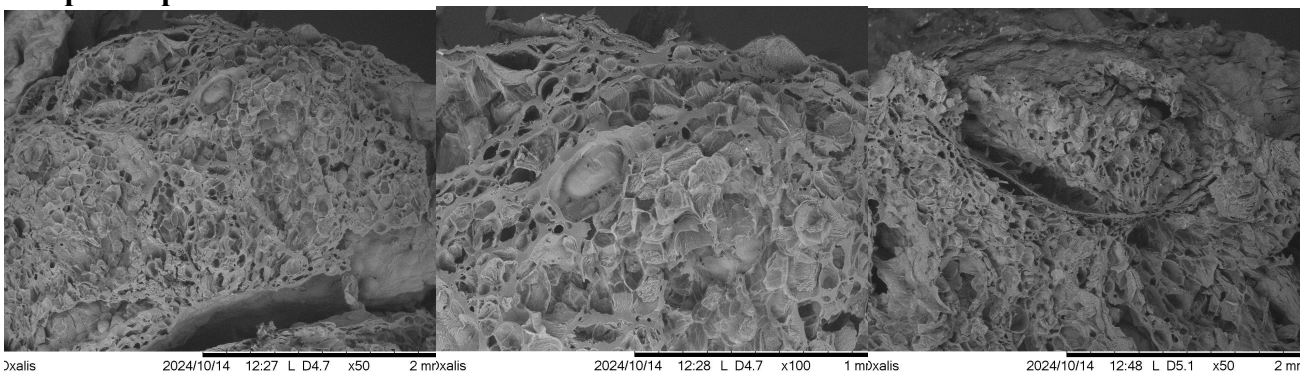
Sample Preparation: Boiled 15m Charred in foil 250°C 2.5hrs



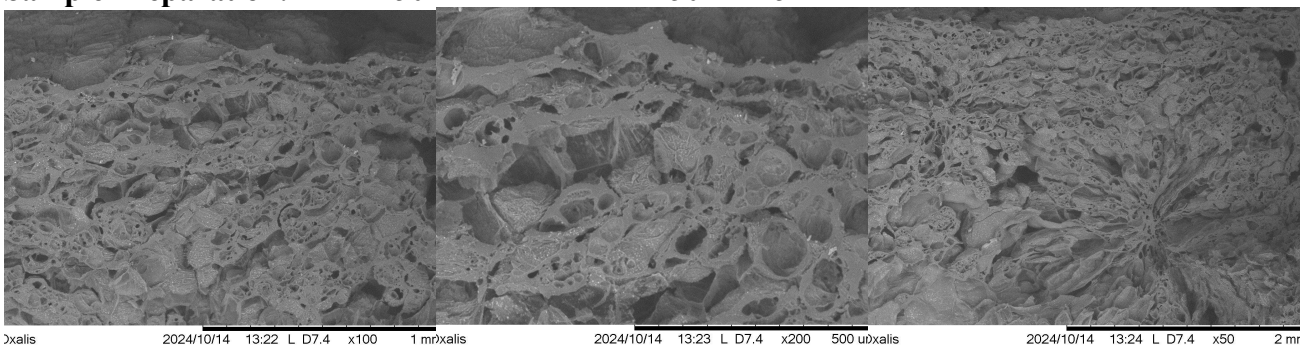
Sample Preparation: Dried 150°F 12hrs Charred 250°C 2.0hrs in foil



Sample Preparation: Dried 150°F 24hrs Charred 250°C 2.0hrs in foil



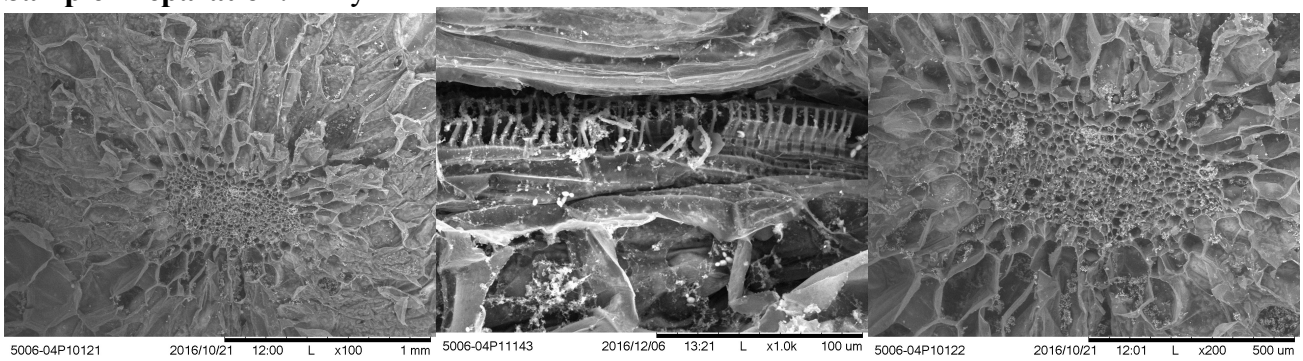
Sample Preparation: Dried 150°F 24hrs Charred 250°C 2.5hrs in foil



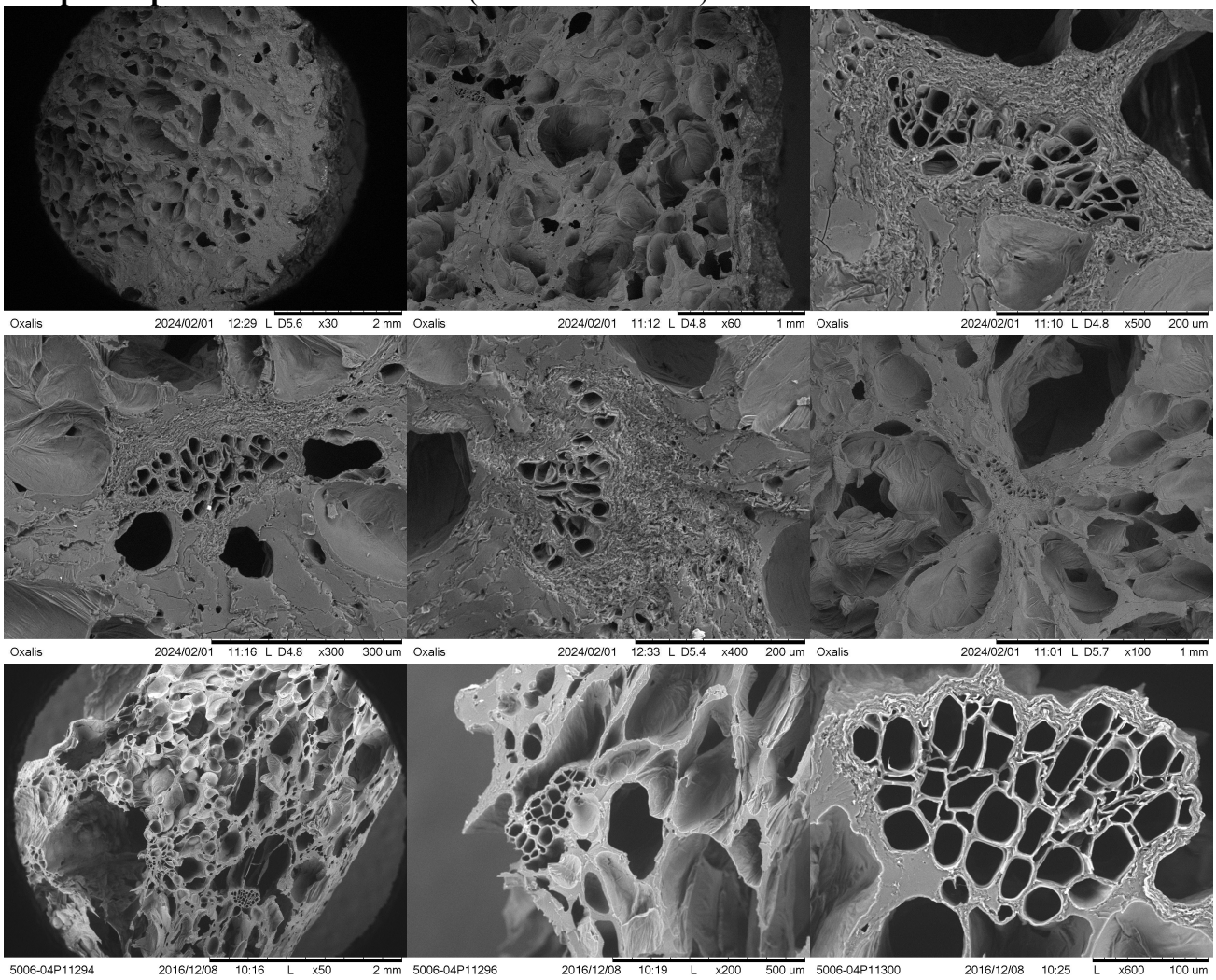
Scientific Name: *Oxalis tuberosa* **Common Name:** oca **Type:** stem

View: Vascular Tissue

Sample Preparation: Dehydrated



Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250℃ 2.5hrs

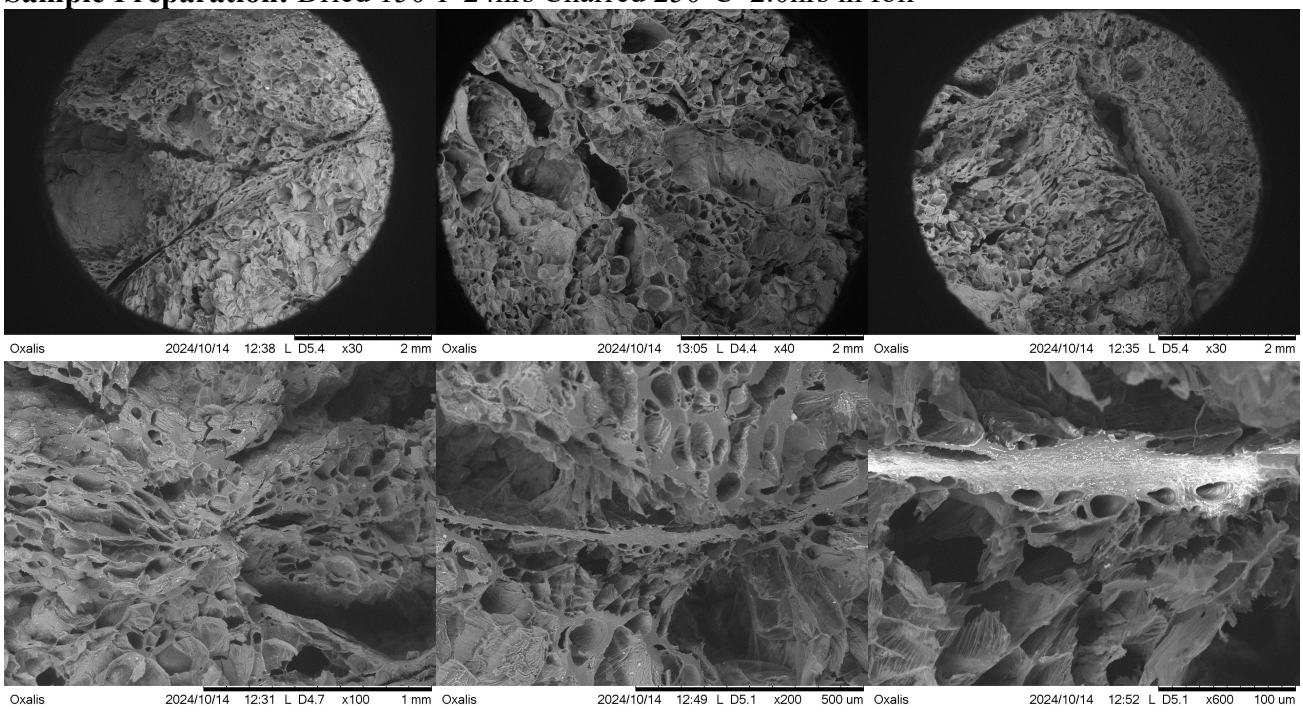


Scientific Name: *Oxalis tuberosa* **Common Name:** oca **Type: s**tem

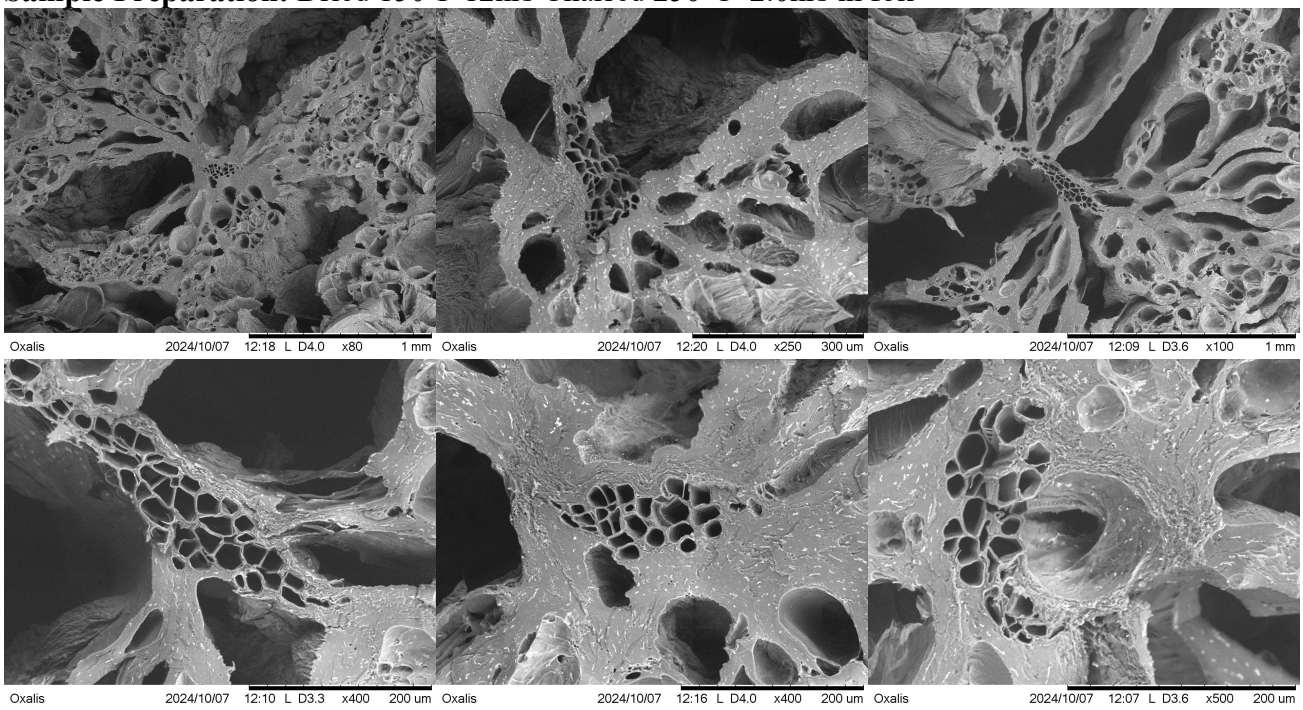
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View: Vascular Tissue Continued

Sample Preparation: Dried 150°F 24hrs Charred 250°C 2.0hrs in foil



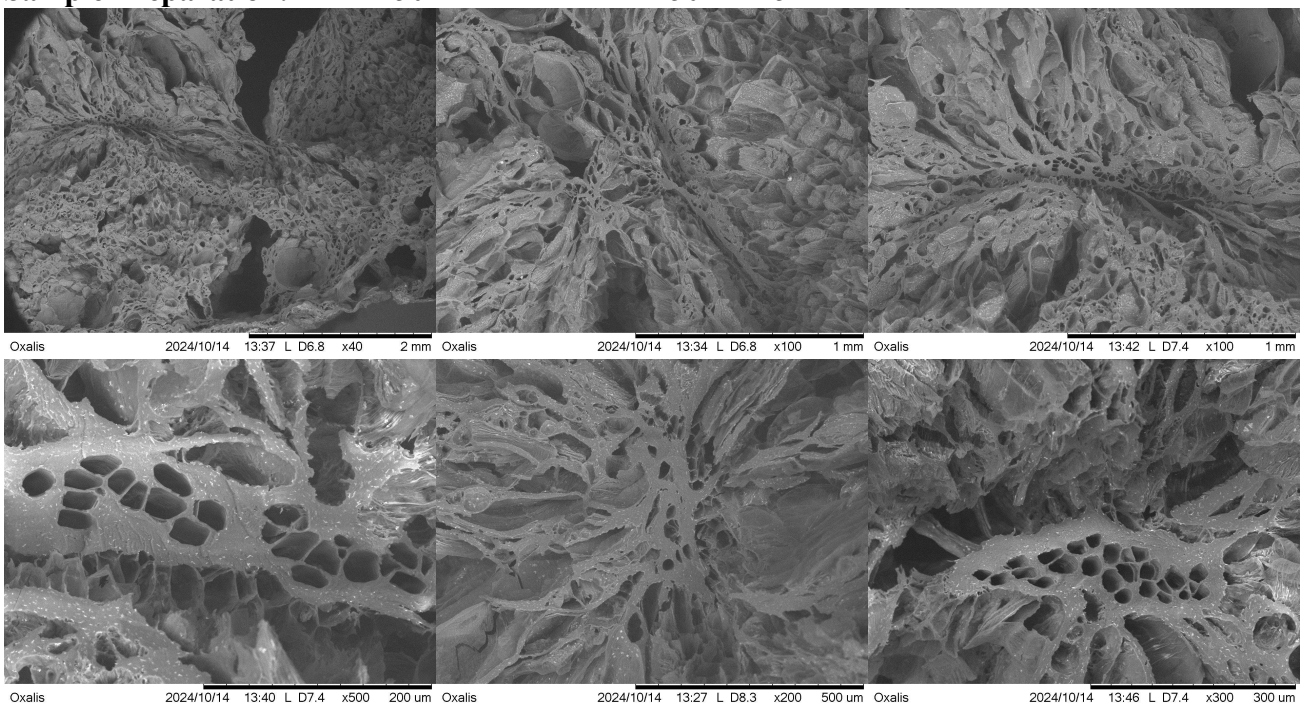
Sample Preparation: Dried 150°F 12hrs Charred 250°C 2.0hrs in foil



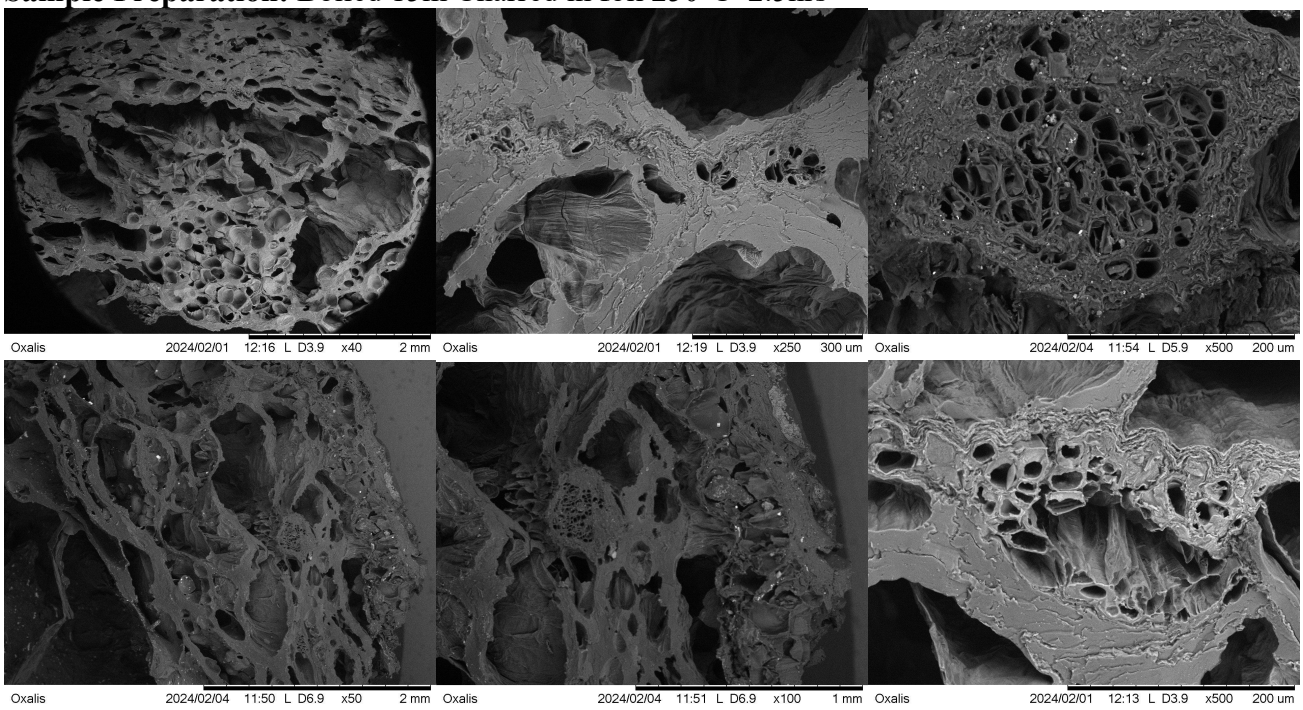
Scientific Name: *Oxalis tuberosa* **Common Name:** oca **Type: s**tem

View: Vascular Tissue Continued

Sample Preparation: Dried 150°F 24hrs Charred 250°C 2.5hrs in foil



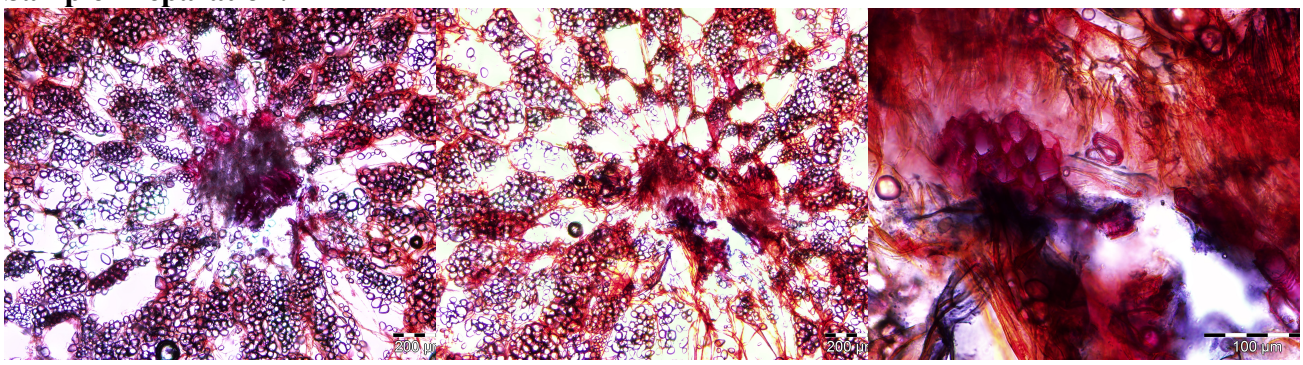
Sample Preparation: Boiled 15m Charred in foil 250°C 2.5hrs



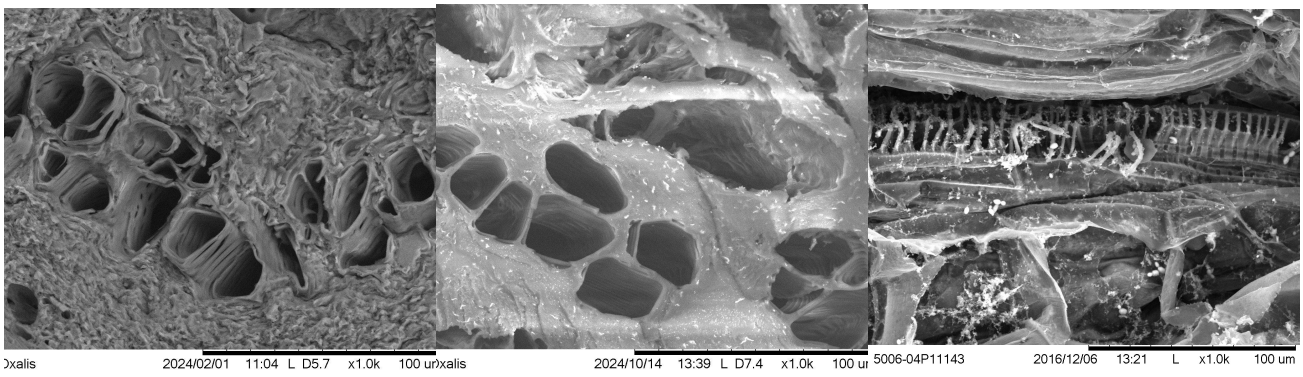
Scientific Name: *Oxalis tuberosa* **Common Name:** oca **Type:** stem

View: Vascular Tissue Continued

Sample Preparation: Stained



View: Xylem perforation structure: helical/spiral



Scientific Name: *Oxalis tuberosa* (freeze-dried variety)
Common Name: calla
Type: Stem

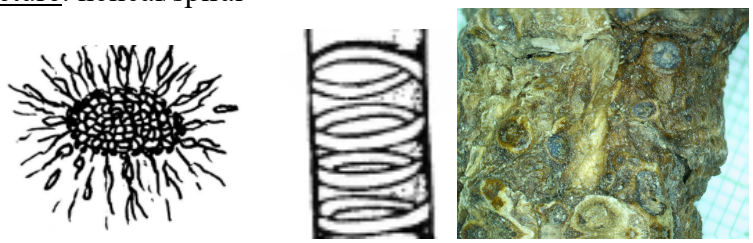


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Smooth/Wrinkled: Wrinkled surface, notably less reticulate pattern than non-freeze dried form, cellular pattern slightly visible.

Periderm: Medium: discretely defined, 2-4 cells thick, irregular cell structure.

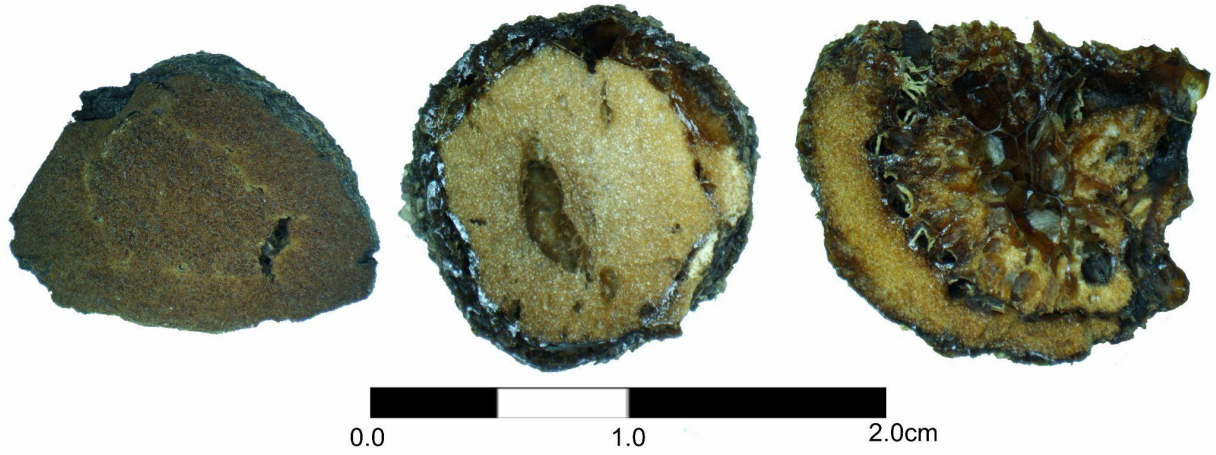
Vascular Tissue: Ovoid/Concentric: Bundles symmetrical and dense, up to 20 cells wide. Partially concealed by preserved starch.
Xylem Perforation Structure: helical/spiral



Forms of Preparation:

- Charred 'fresh' (not processed) in foil 250°C 2.5hrs buried in sand
- Soaked 2 Days Charred 200°C in foil 2.5hrs
- Soaked 2 Days, Boiled 10min Charred in foil 200°C 2.5hrs
- Soaked 2 Days, Boiled 10min Charred without foil 200°C 2.5hrs

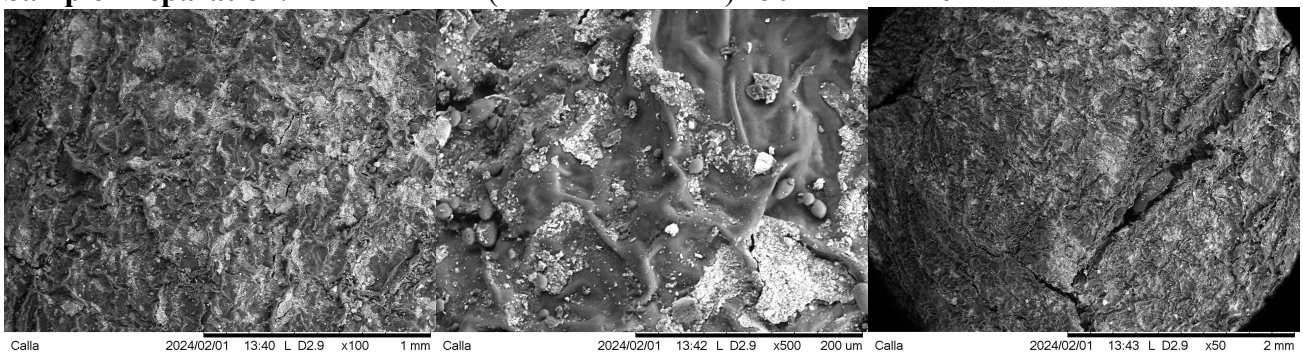
Charred 250°C 2.5hrs Soaked, Boiled, Charred, Foil Soaked, Charred, no Foil



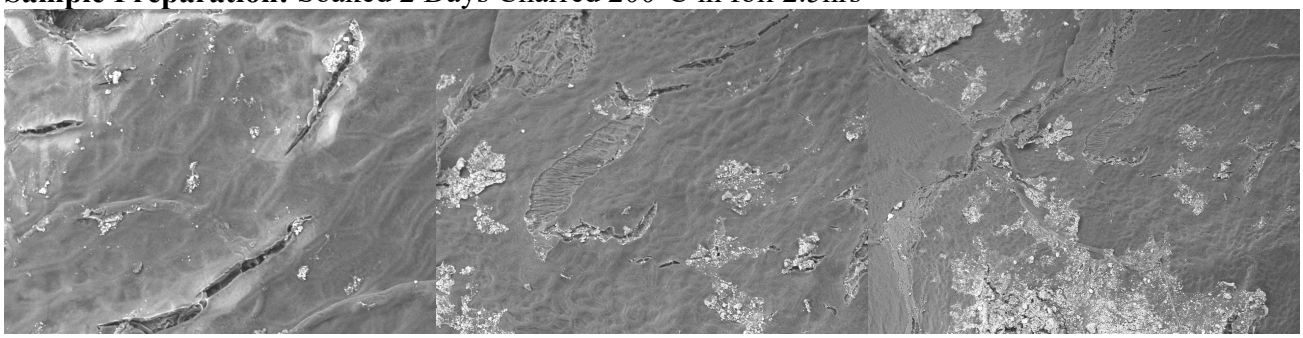
Scientific Name: *Oxalis tuberosa* **Common Name:** calla (freeze dried oca) **Type:** Stem

View: Exterior Surface

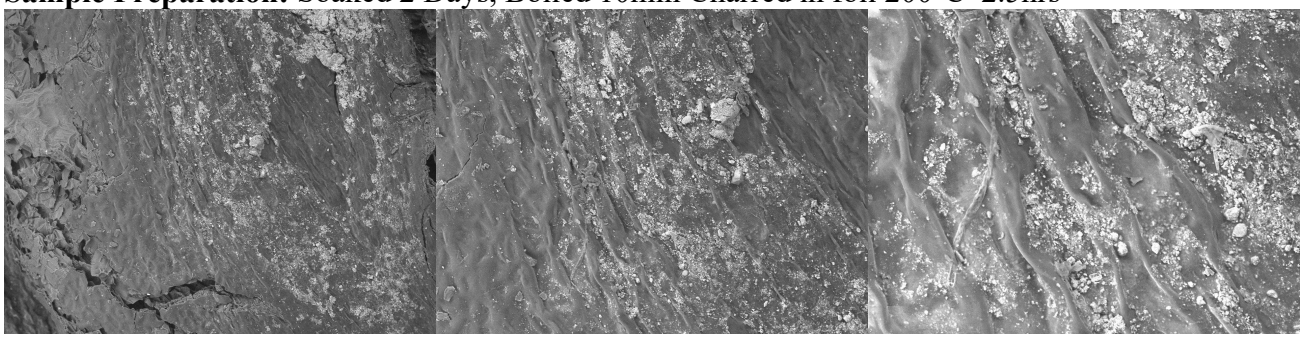
Sample Preparation: Charred Fresh (not boiled/soaked) 250℃ in foil 2.5hrs



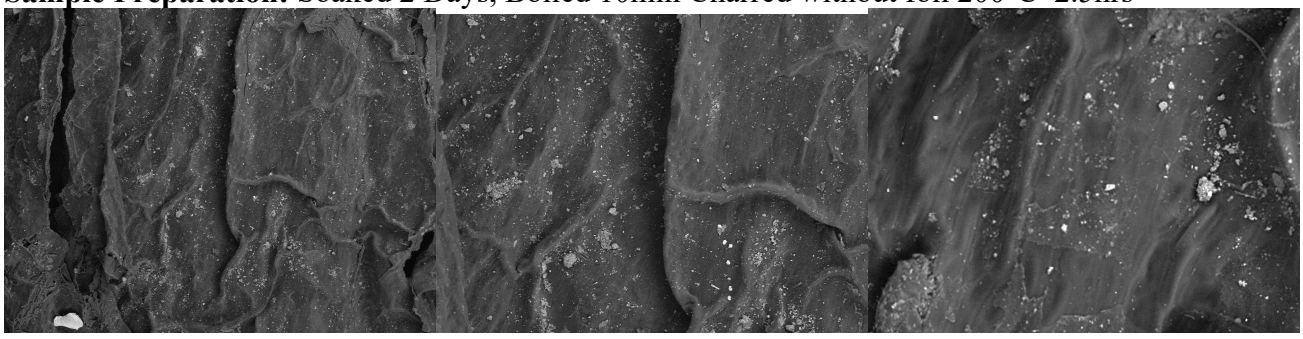
Sample Preparation: Soaked 2 Days Charred 200℃ in foil 2.5hrs



Sample Preparation: Soaked 2 Days, Boiled 10min Charred in foil 200℃ 2.5hrs



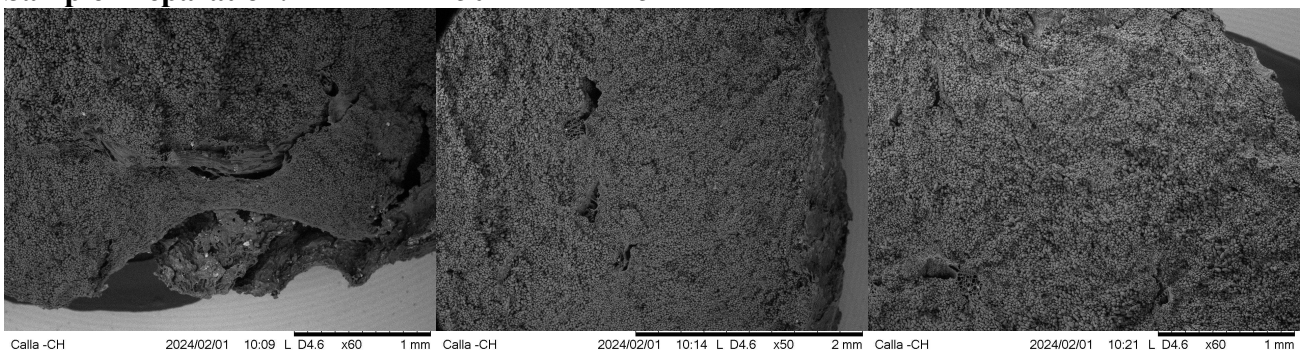
Sample Preparation: Soaked 2 Days, Boiled 10min Charred without foil 200℃ 2.5hrs



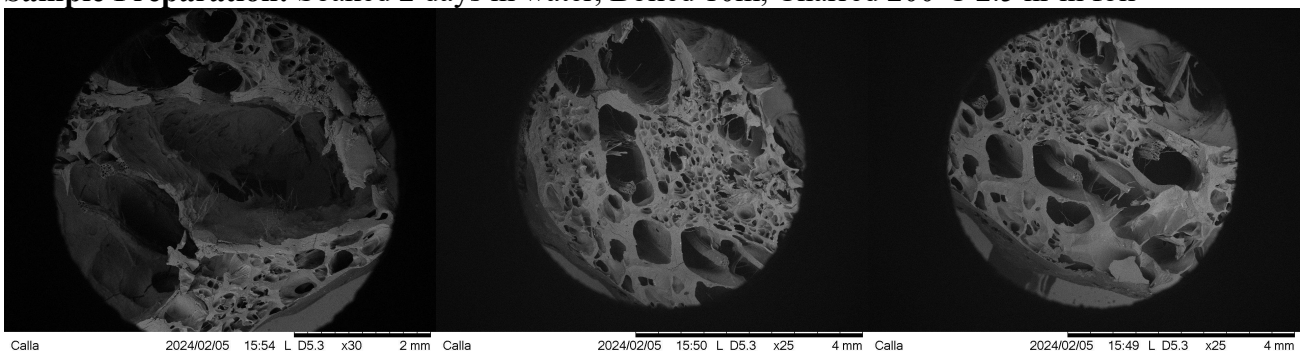
Scientific Name: *Oxalis tuberosa* **Common Name:** calla (freeze dried oca) **Type:** Stem

View: Periderm

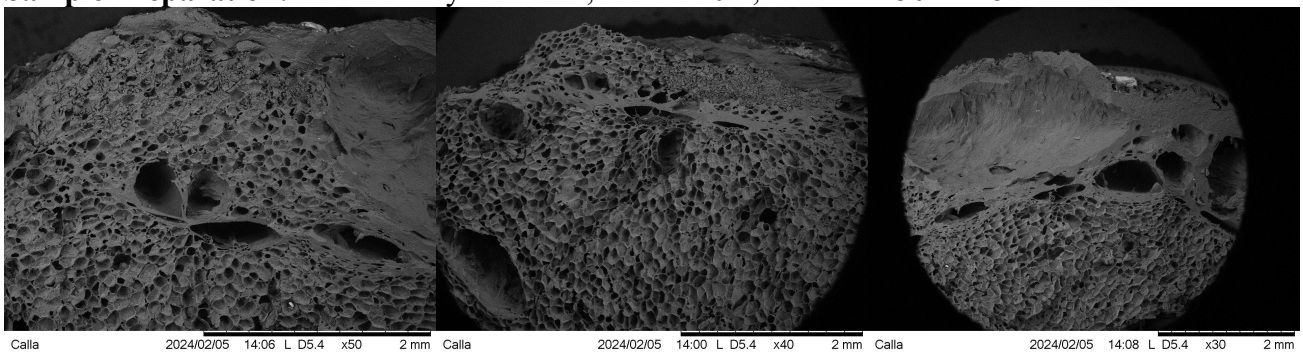
Sample Preparation: Charred at 250°C in foil 2.5hrs



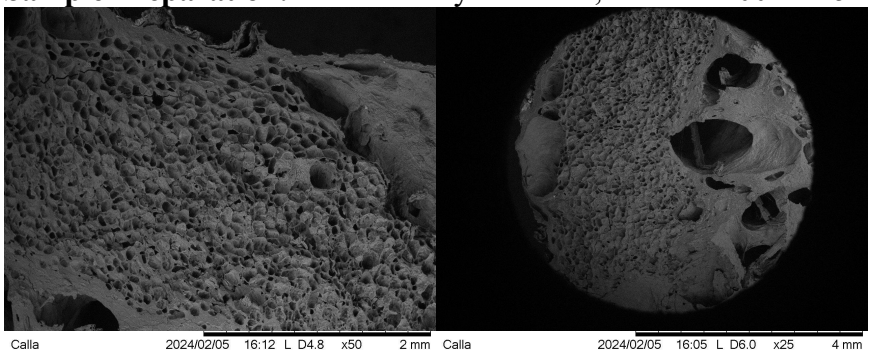
Sample Preparation: Soaked 2 days in water, Boiled 10m, Charred 200°C 2.5 hr in foil



Sample Preparation: Soaked 2days in water, Boiled 10m, Charred 250°C 2.5 hrs No Foil



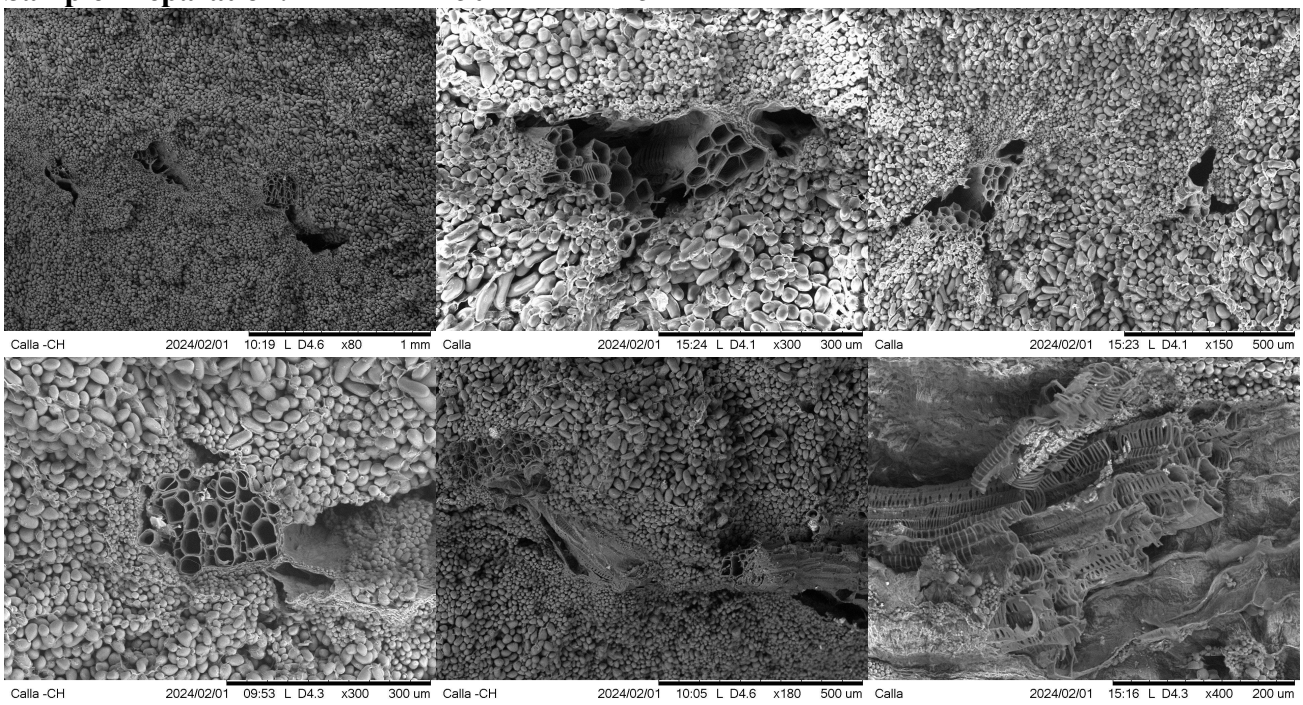
Sample Preparation: Soaked 2 days in water, Charred 200°C 2.5hr in foil



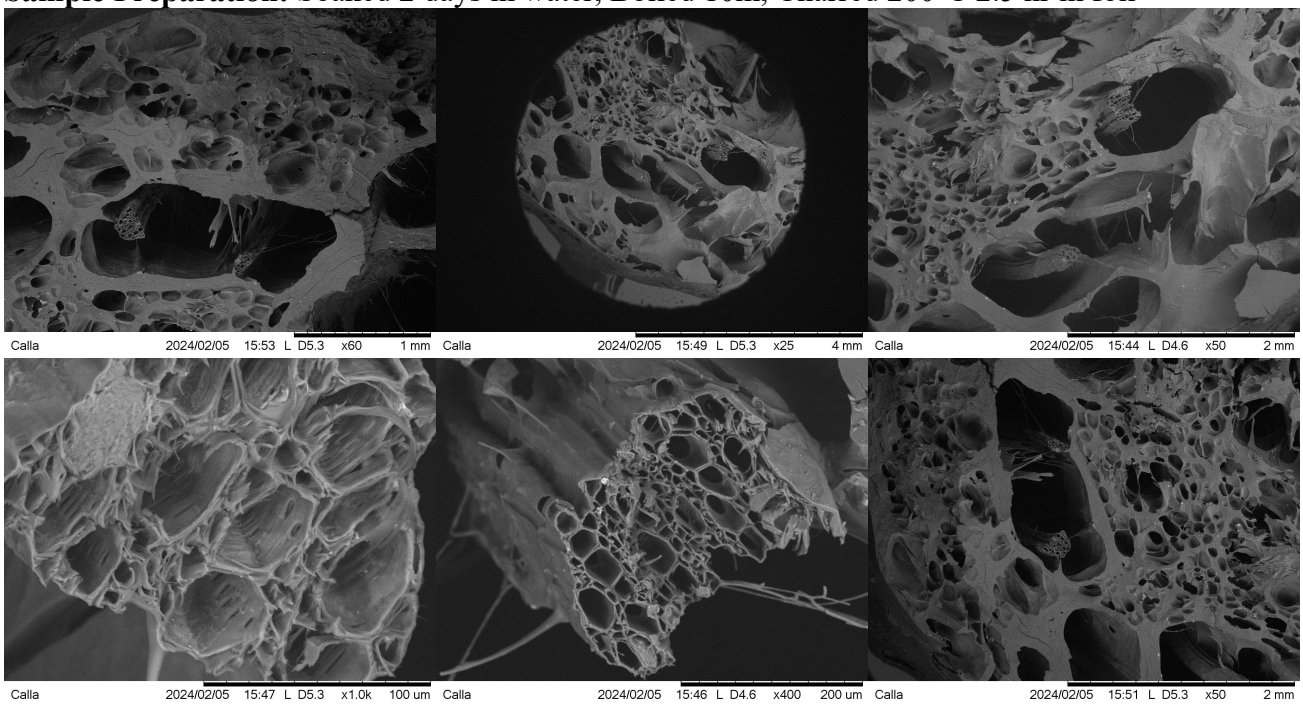
Scientific Name: *Oxalis tuberosa* **Common Name:** calla (freeze dried oca) **Type:** Stem

View: Vascular Tissue

Sample Preparation: Charred at 250°C in foil 2.5hrs



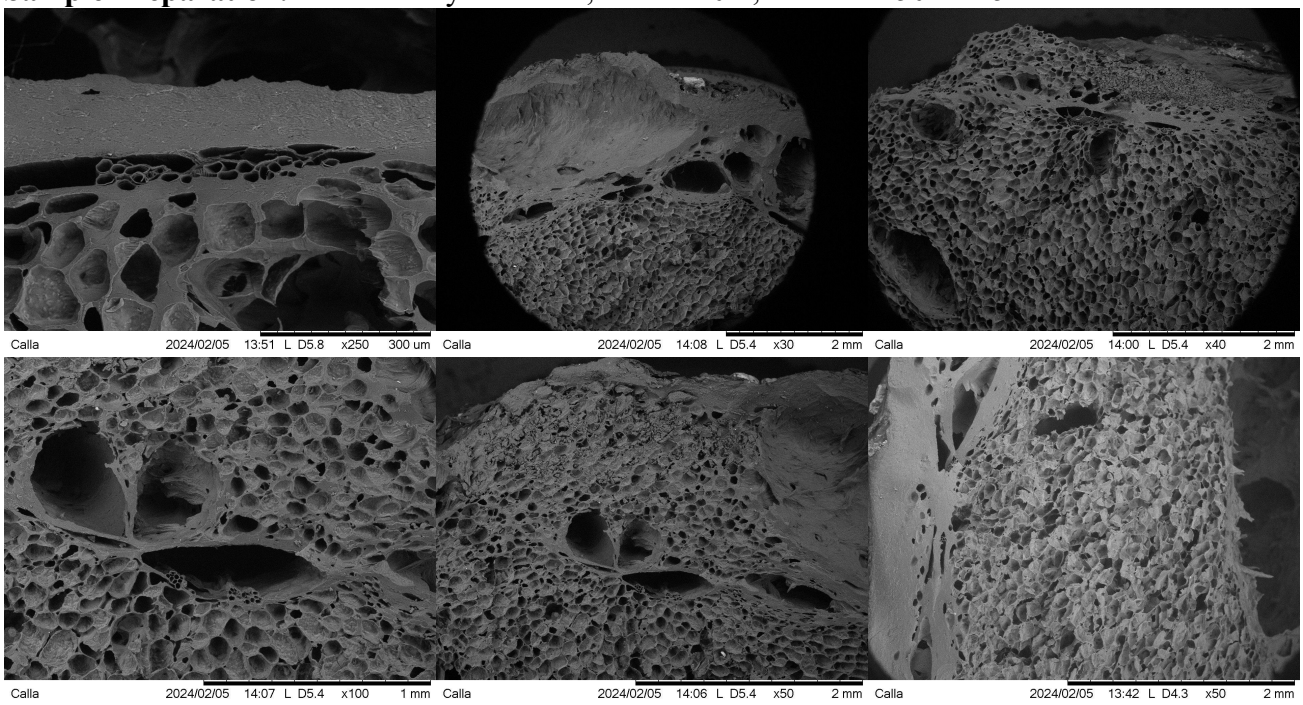
Sample Preparation: Soaked 2 days in water, Boiled 10m, Charred 200°C 2.5 hr in foil



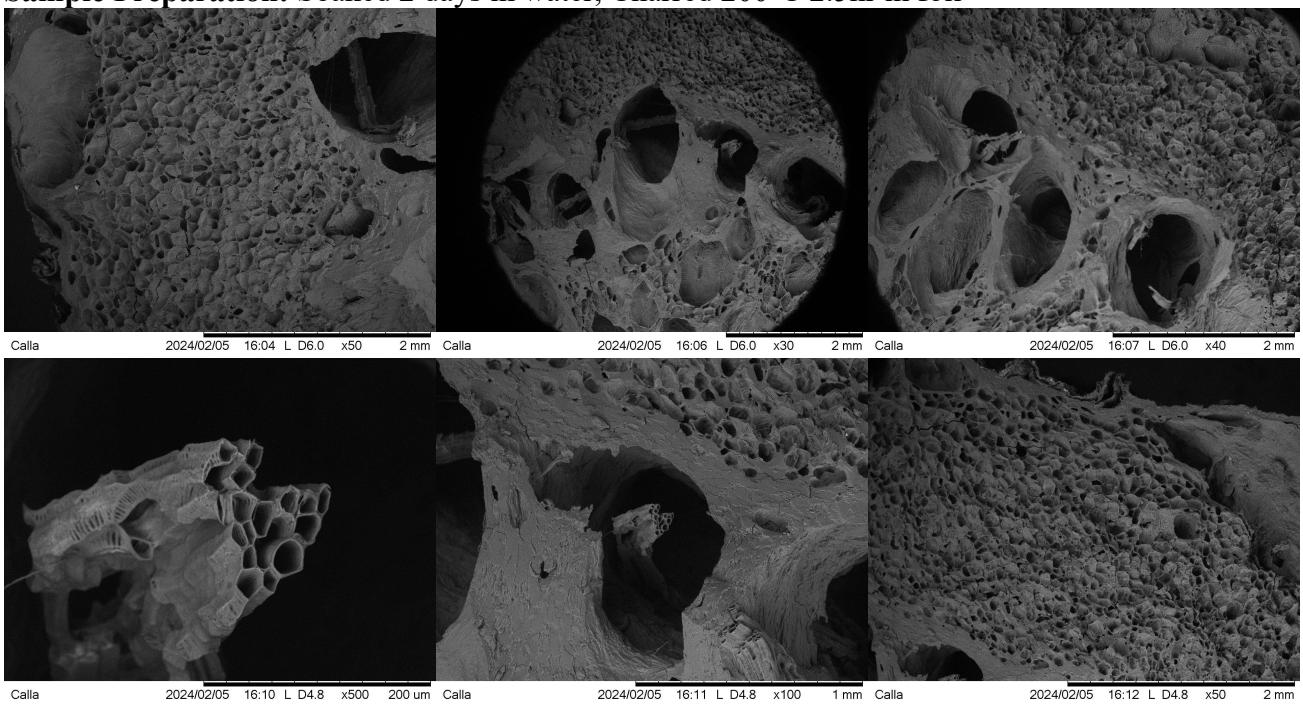
Scientific Name: *Oxalis tuberosa* **Common Name:** calla (freeze dried oca) **Type:** Stem

View: Vascular Tissue Continued

Sample Preparation: Soaked 2days in water, Boiled 10m, Charred 250℃ 2.5 hrs No Foil

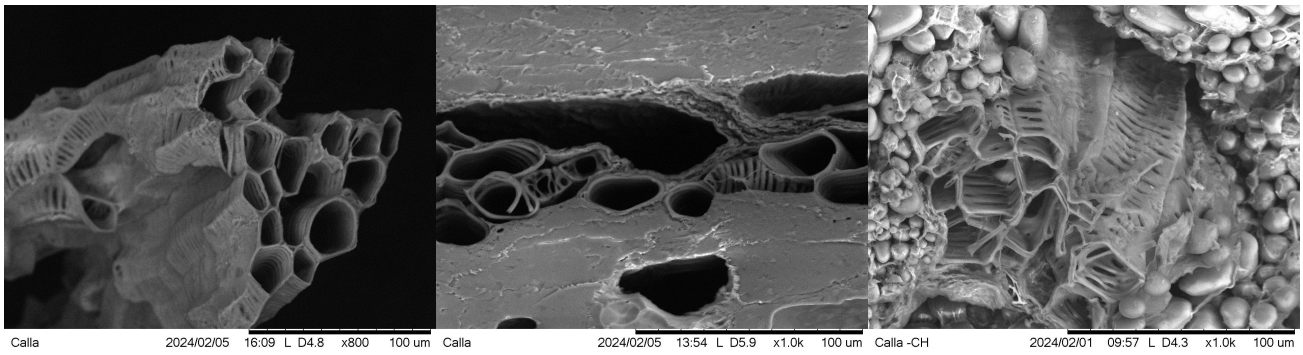


Sample Preparation: Soaked 2 days in water, Charred 200℃ 2.5hr in foil



Scientific Name: *Oxalis tuberosa* **Common Name:** calla (freeze dried oca) **Type:** Stem

View: Xylem perforation structure: spiral/helical



Scientific Name: *Pachyrhizus erosus*
Common Name: jicama
Type: Root



SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Reticulate and Wrinkled: rectangular cellular pattern visible on surface, reticulate and lightly wrinkled.

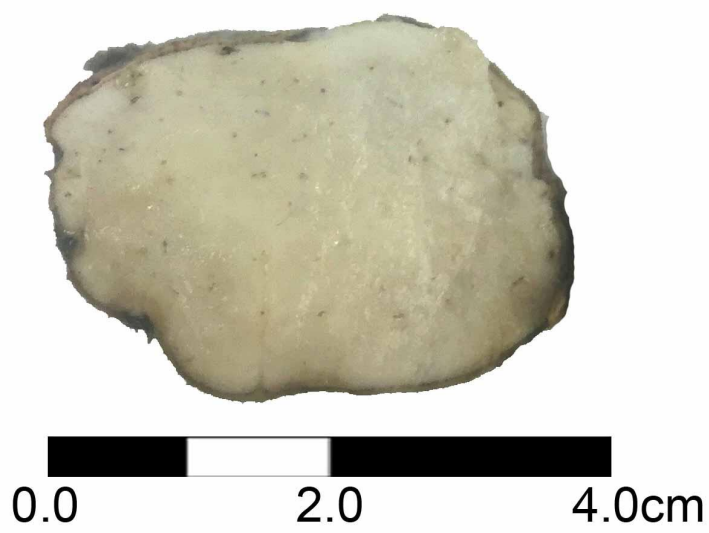
Periderm: Thick: dense layer of cells, 10+ cells, irregularly shaped.

Vascular Tissue: Ovoid/Irregular: concentrated in small bundles of 3 to 5 xylem cells in diameter. Somewhat rounded shape with cells radiating outwards. Very similar to Smallanthus.
Xylem Perforation Structure: scalariform



Forms of Preparation:

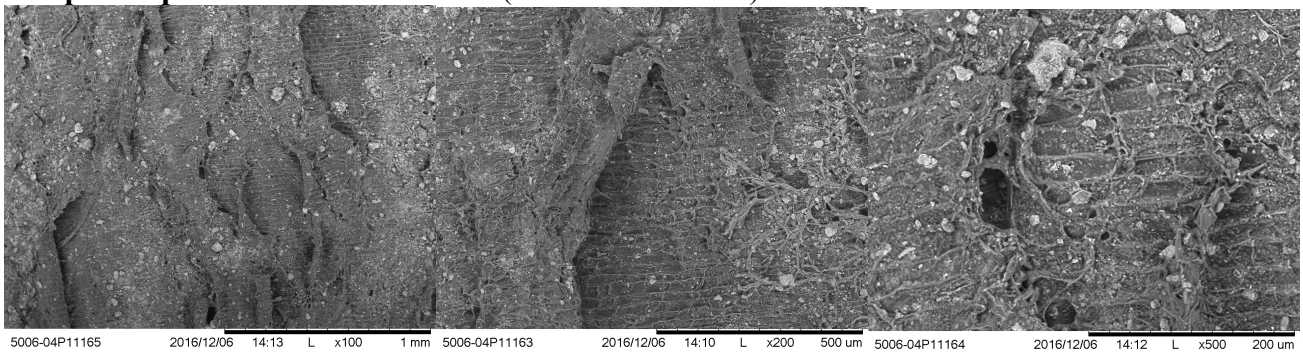
- Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs buried in sand
- Dehydrated
- Stained



Scientific Name: *Pachyrhizus erosus* **Common Name:** jicama **Type:** Root

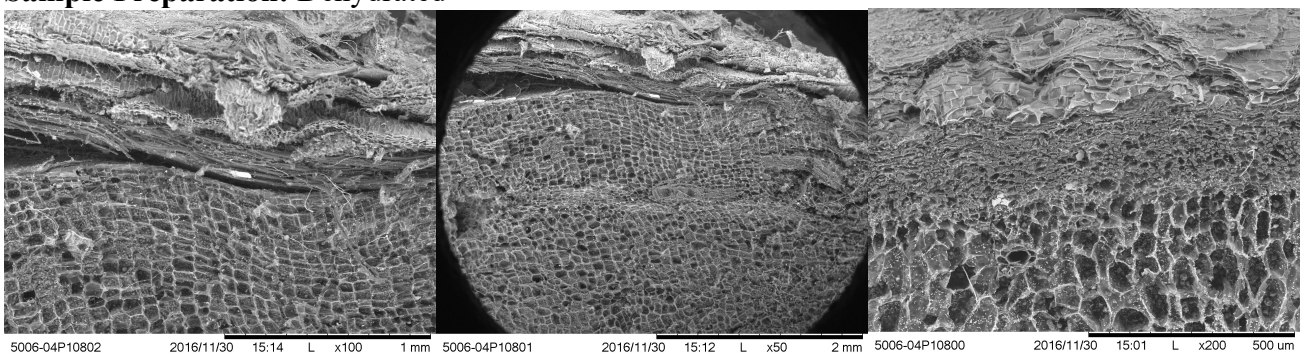
View: Exterior Surface

Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs

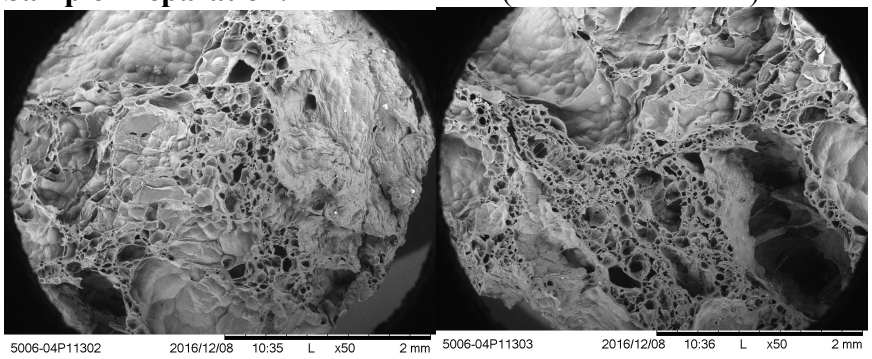


View: Periderm

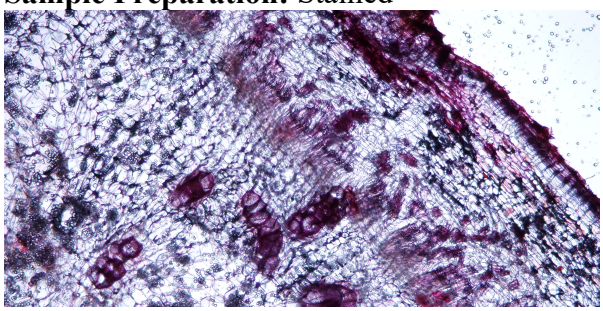
Sample Preparation: Dehydrated



Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs



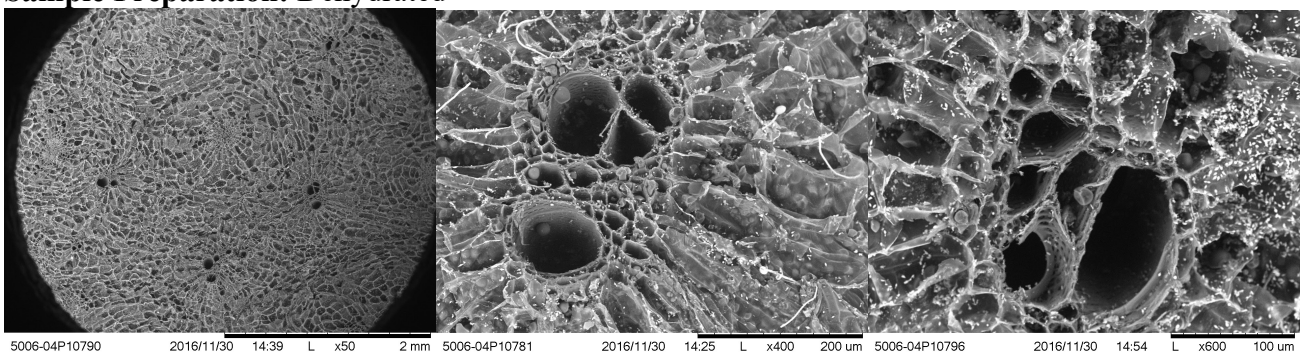
Sample Preparation: Stained

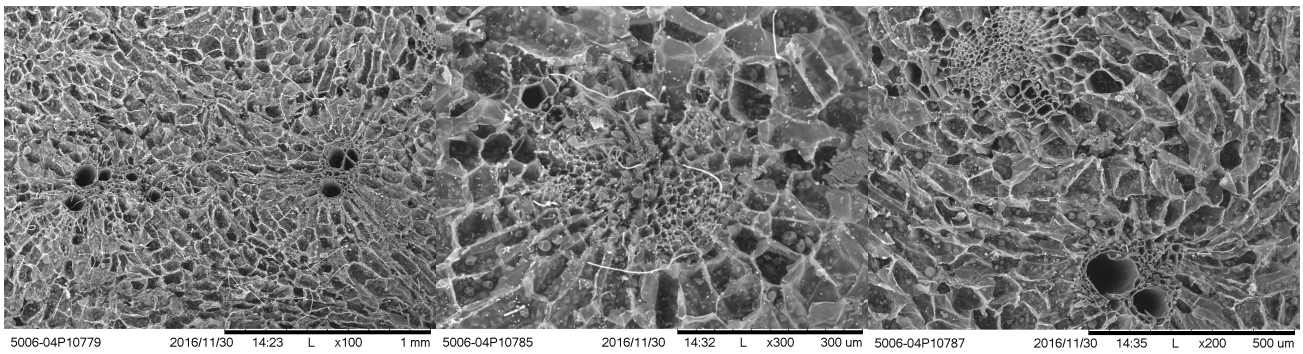


Scientific Name: *Pachyrhizus erosus* **Common Name:** jicama **Type:** Root

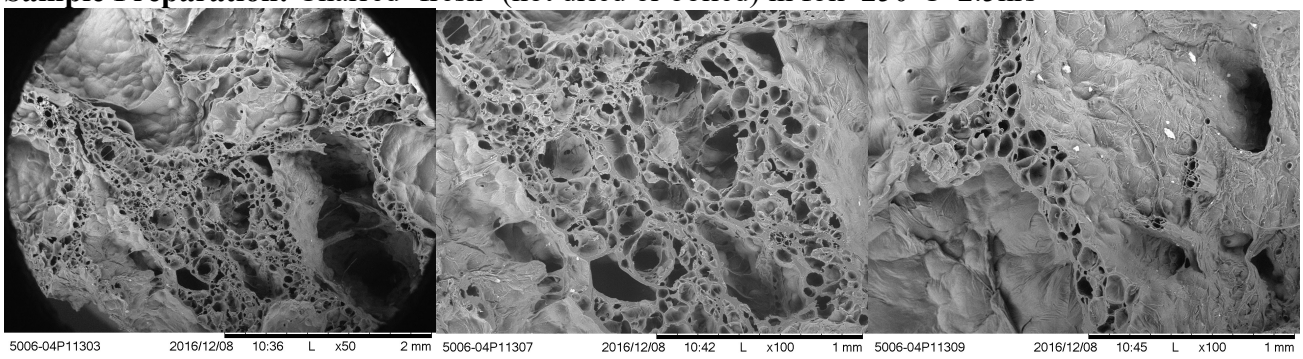
View: Vascular Tissue

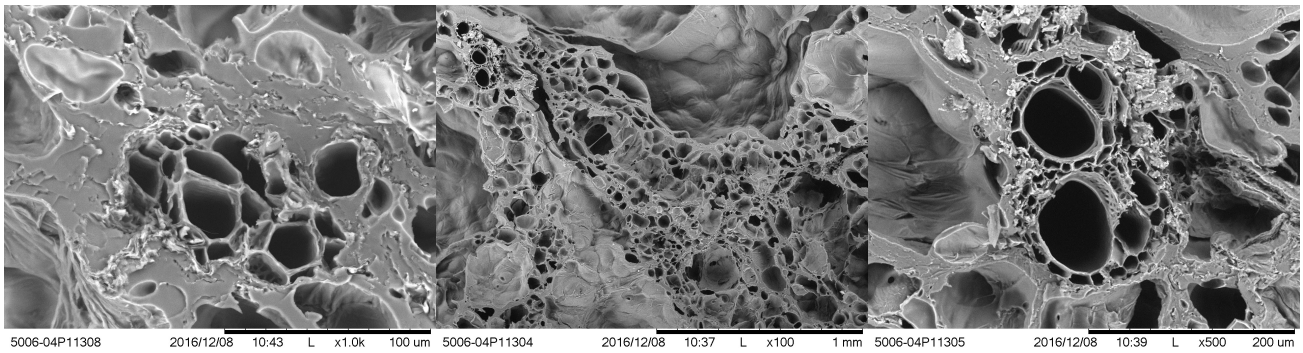
Sample Preparation: Dehydrated





Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs

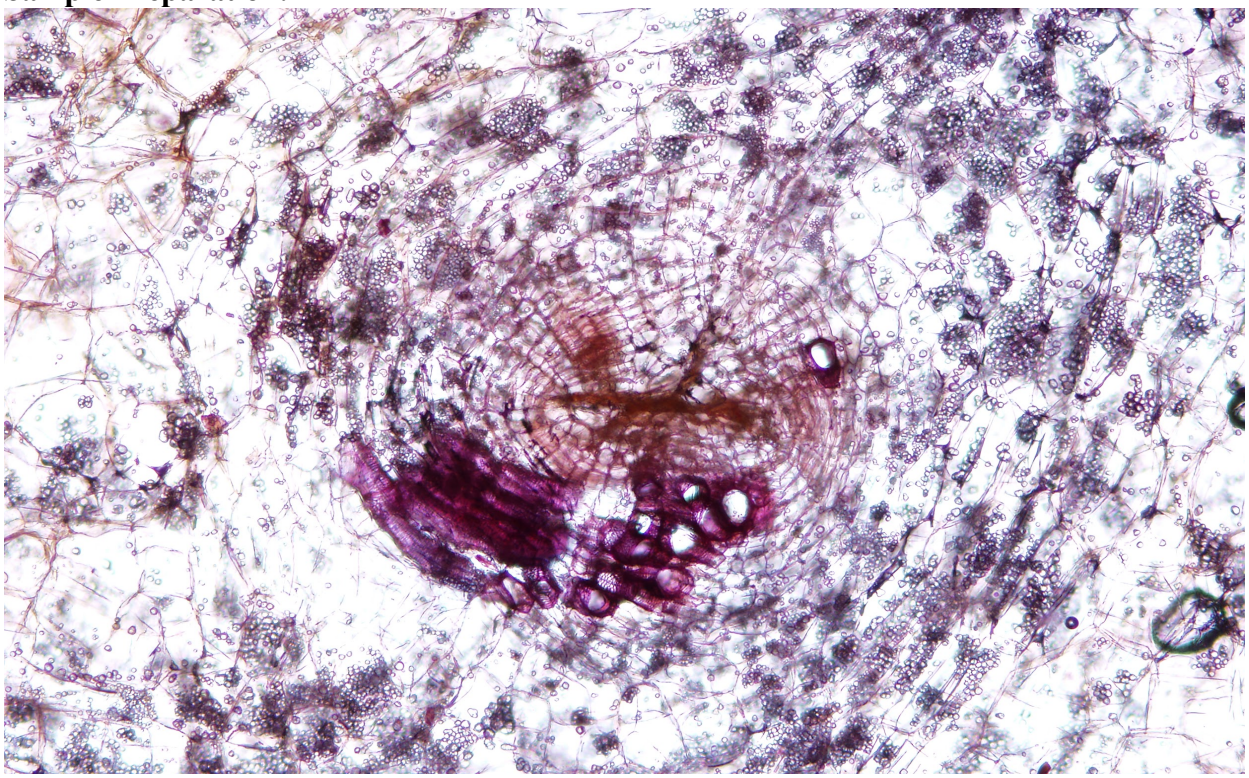




Scientific Name: *Pachyrhizus erosus* **Common Name:** jicama **Type:** Root

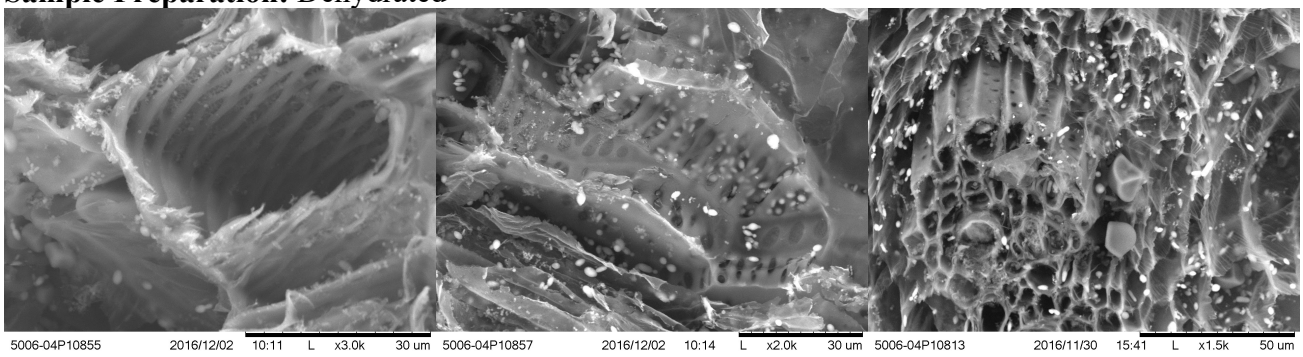
View: Vascular Tissue Continued

Sample Preparation: Stained



View: Xylem perforation structure: scalariform

Sample Preparation: Dehydrated



Scientific Name: *Schoenoplectus californicus subsp tatora*
Common Name: totora
Type: rhizome

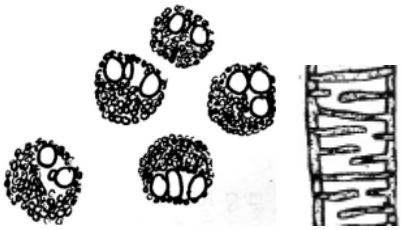


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Reticulate/Striated: striated with subtle hints of cellular structure visible.

Periderm: Thick: clearly defined 8-12 cells thick, irregular cell structure, solidified when charred.

Vascular Tissue: Ovoid/Concentric: concentrated in numerous small bundles with 2-3 xylem cells in diameter. Surrounded by phloem (rounded in overall bundle shape).
Xylem Perforation Structure: Scalariform



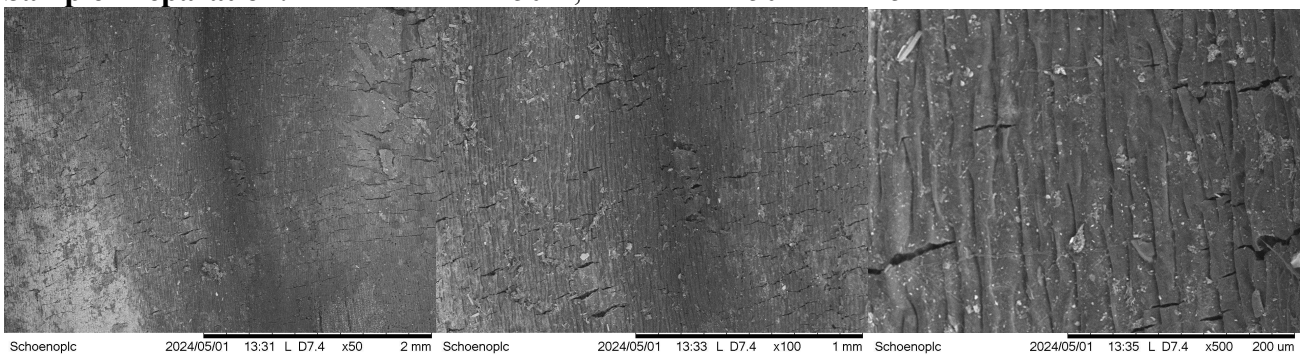
Forms of Preparation:

- Dried 12 hrs at 150°F, Charred at 250°C for 1.5hrs
- Dried 12 hrs at 150°F, Charred at 250°C for 2.0 hrs
- Dried 12 hrs at 150°F, Charred at 250°C for 2.5hrs
- Dried 12 hrs at 150°F, Charred at 250°C for 3.0 hrs

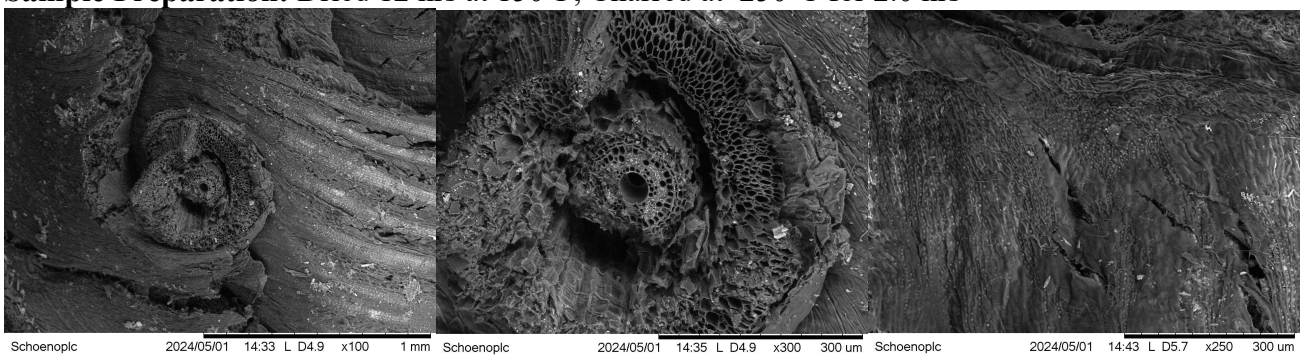
Scientific Name: *Schoenoplectus californicus subsp tatora* **Common Name:** totora **Type:** rhizome

View: Exterior Surface

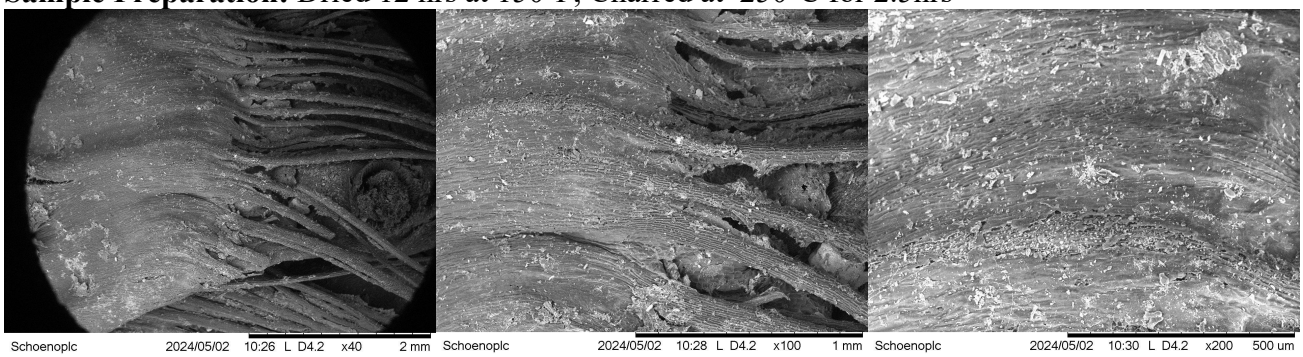
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 1.5hrs



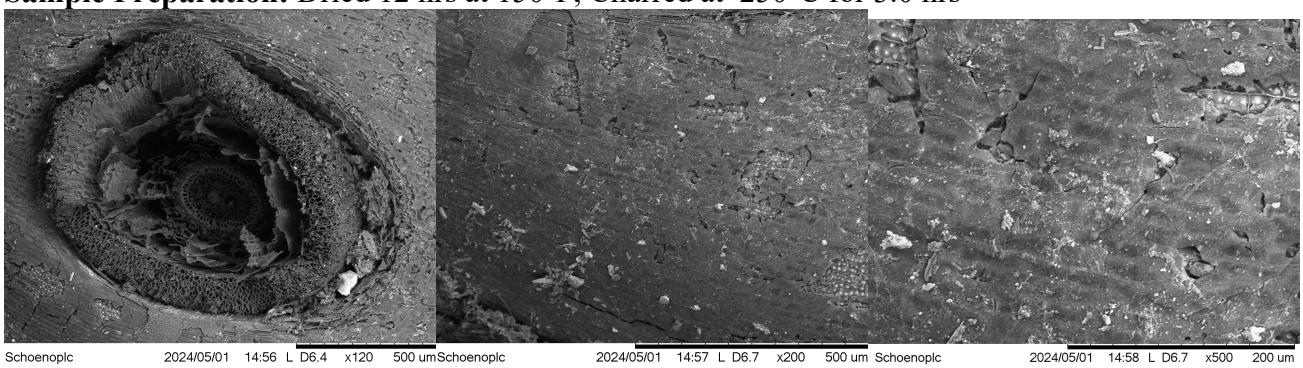
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 2.0 hrs



Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 2.5hrs



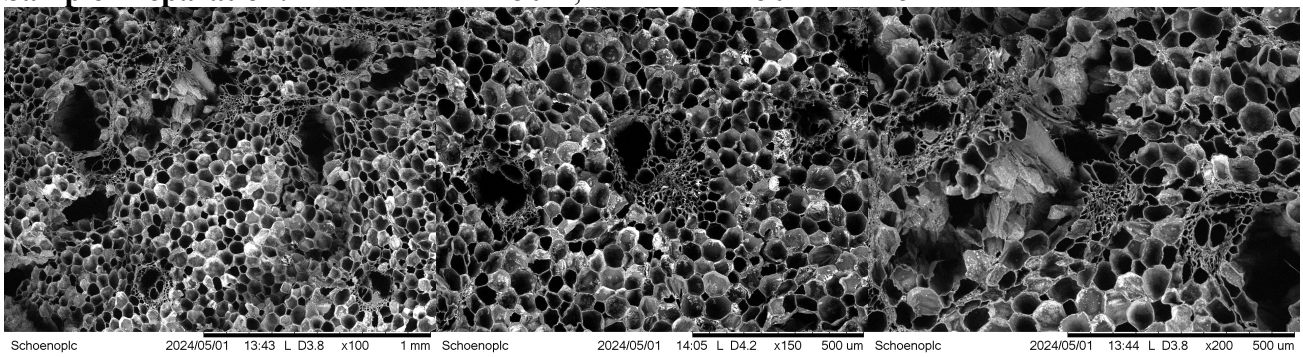
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 3.0 hrs



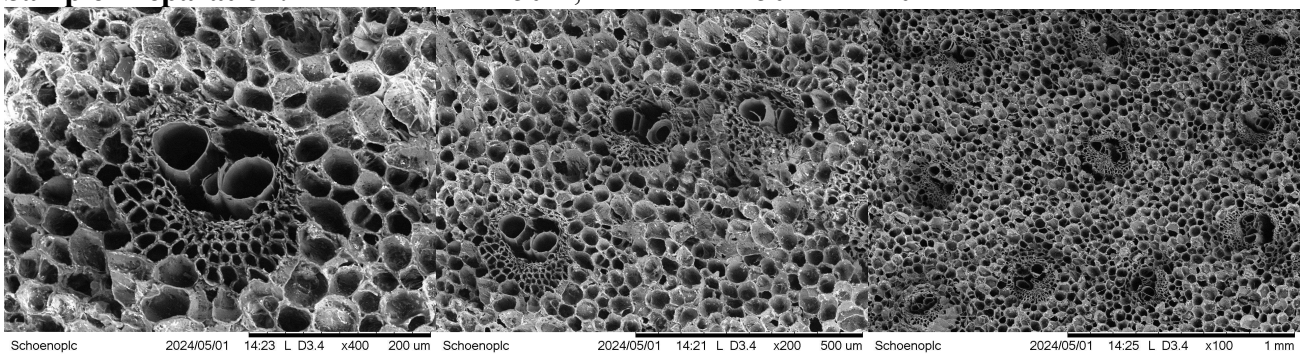
Scientific Name: *Schoenoplectus californicus subsp tatora* **Common Name:** totora **Type:** rhizome

View: Vascular Tissue

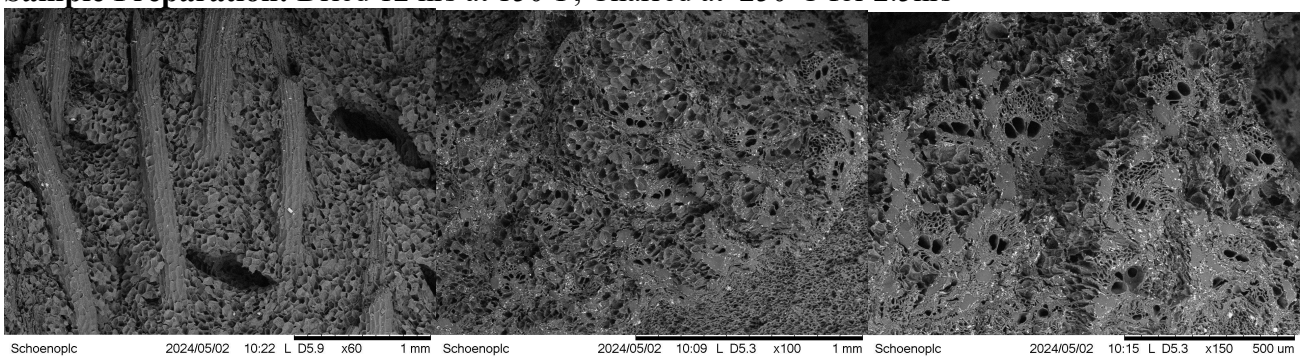
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 1.5 hrs



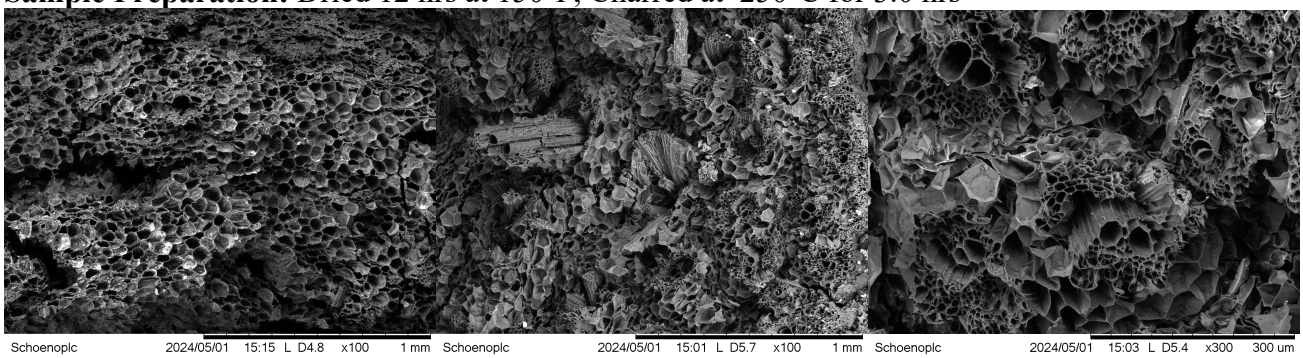
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 2.0 hrs



Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 2.5hrs



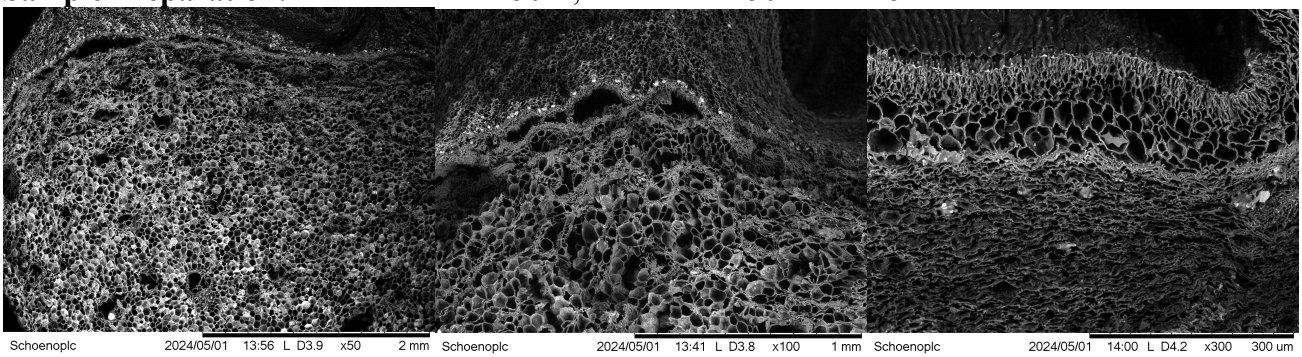
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 3.0 hrs



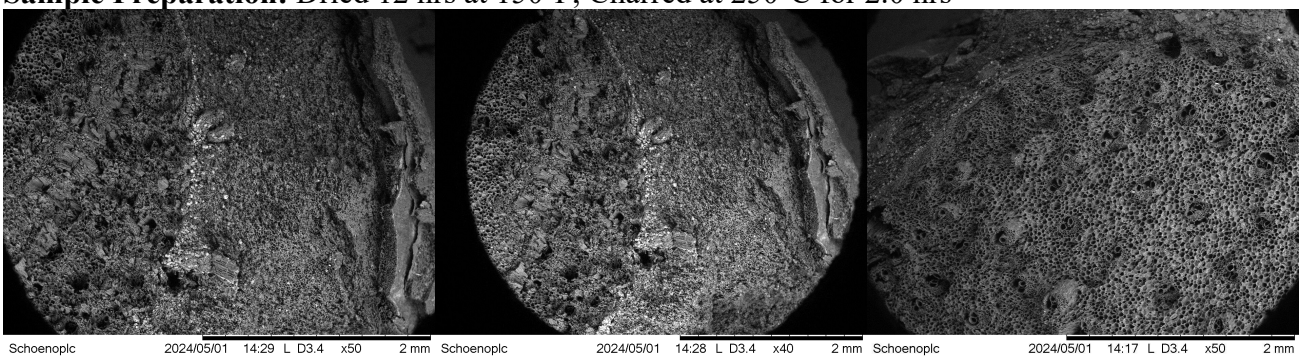
Scientific Name: *Schoenoplectus californicus subsp tatora* **Common Name:** totora **Type:** rhizome

View: Periderm

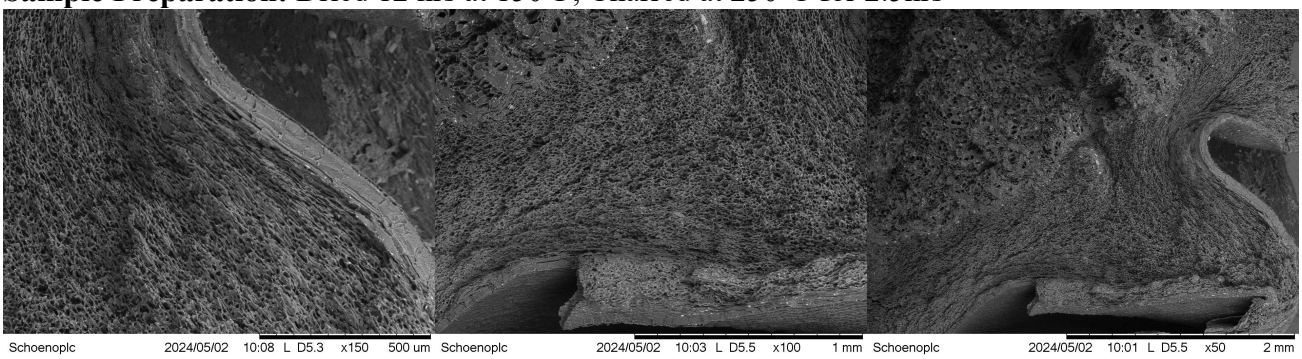
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 1.5 hrs



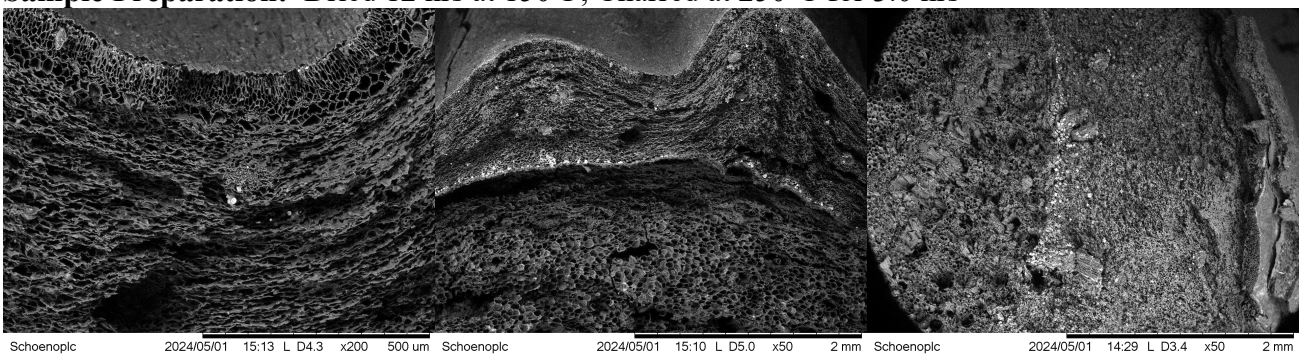
Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 2.0 hrs



Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 2.5hrs



Sample Preparation: Dried 12 hrs at 150°F, Charred at 250°C for 3.0 hrs



Scientific Name: *Smallanthus sonchifolius*
Common Name: yacón
Type: Root



SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Smooth: relatively smooth, some cellular patterning visible.

Periderm: Thick: Extremely thick (20+ cells), dense irregular cell shape.

Vascular Tissue: Irregular: in very small, isolated bundles or chains with only a few xylem cells in diameter. Irregular or chained shape. Very similar to Pachyrhizus.
Xylem Perforation Structure: scalariform



Forms of Preparation:

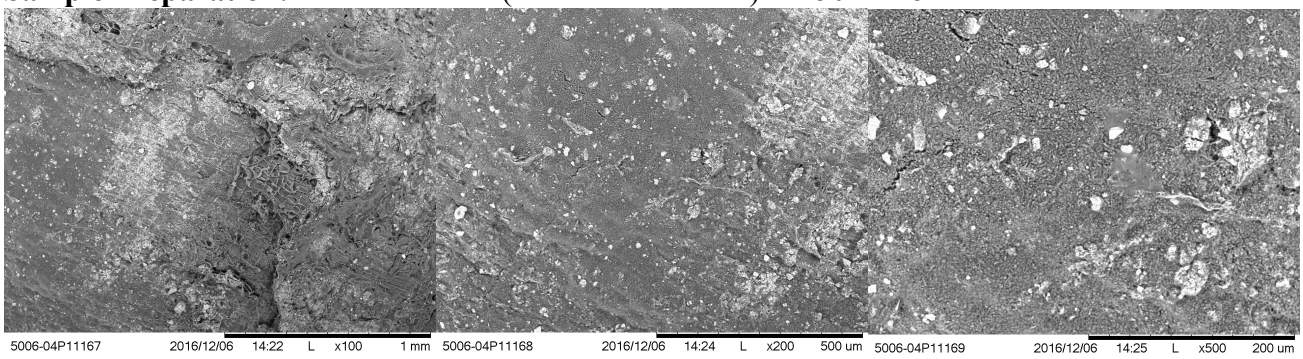
- Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs buried in sand
- Dehydrated
- Stained



Scientific Name: *Smallanthus sonchifolius* **Common Name:** yacón **Type:** Root

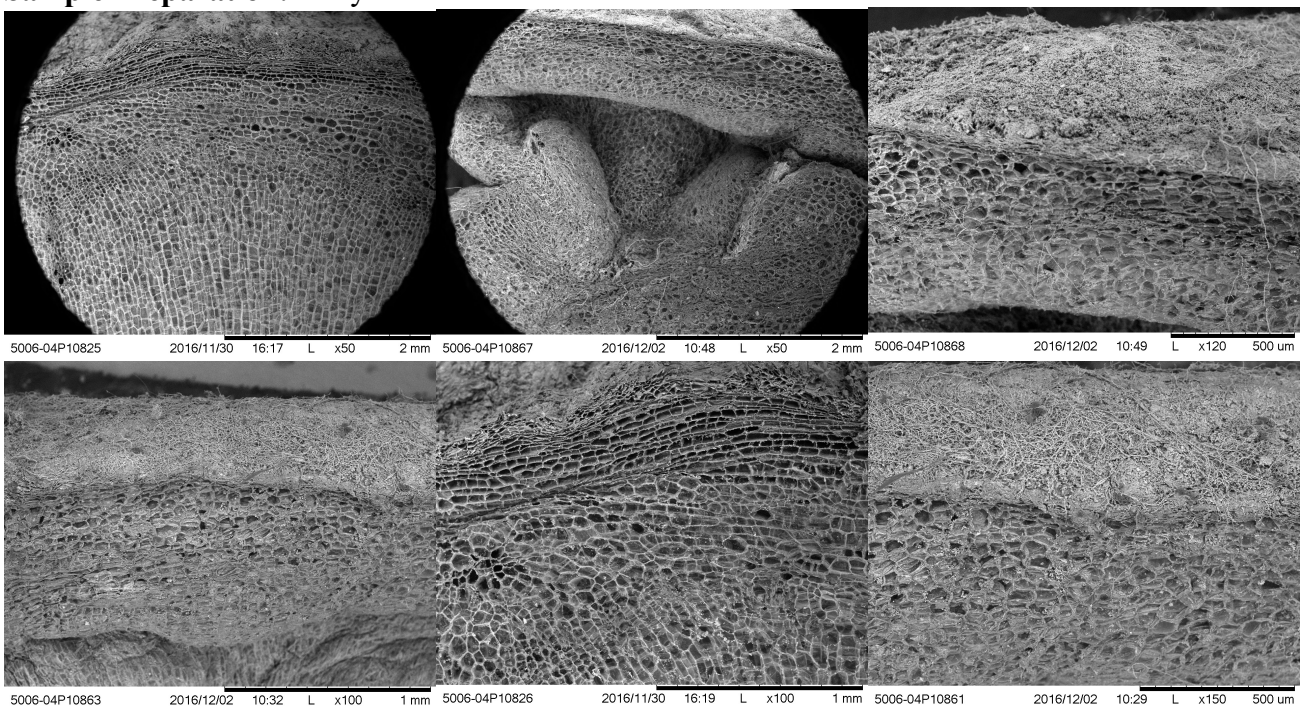
View: Exterior Surface

Sample Preparation: Charred 'fresh' (not boiled or dried) at 250°C 2.5hrs

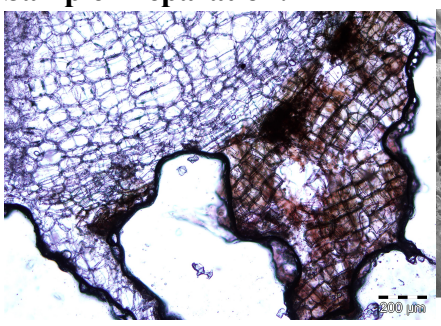


View: Periderm

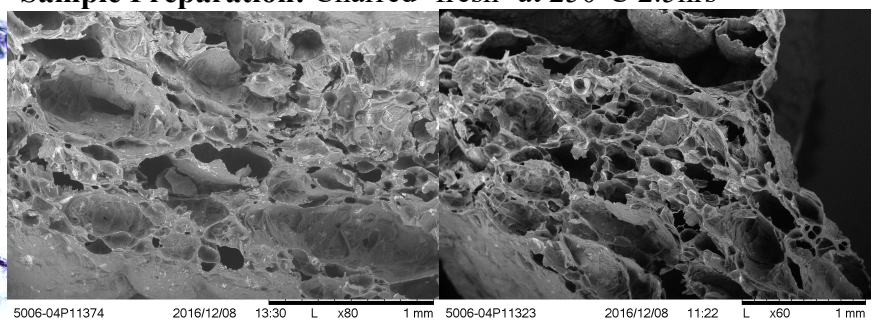
Sample Preparation: Dehydrated



Sample Preparation: Stained



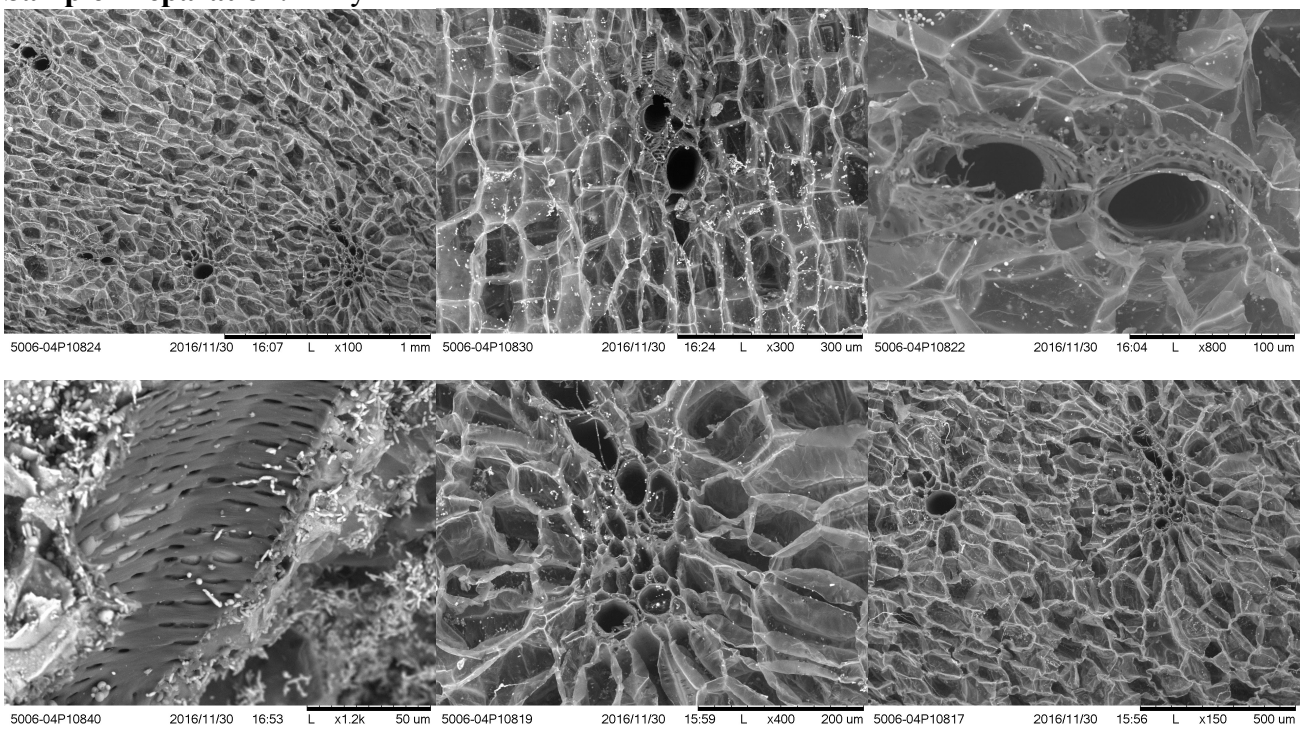
Sample Preparation: Charred 'fresh' at 250°C 2.5hrs



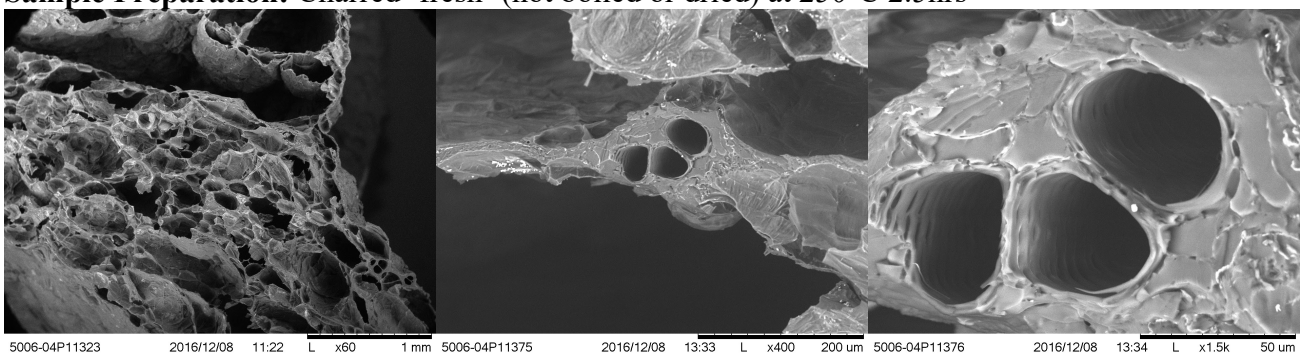
Scientific Name: *Smallanthus sonchifolius* **Common Name:** yacón **Type:** Root

View: Vascular Tissue

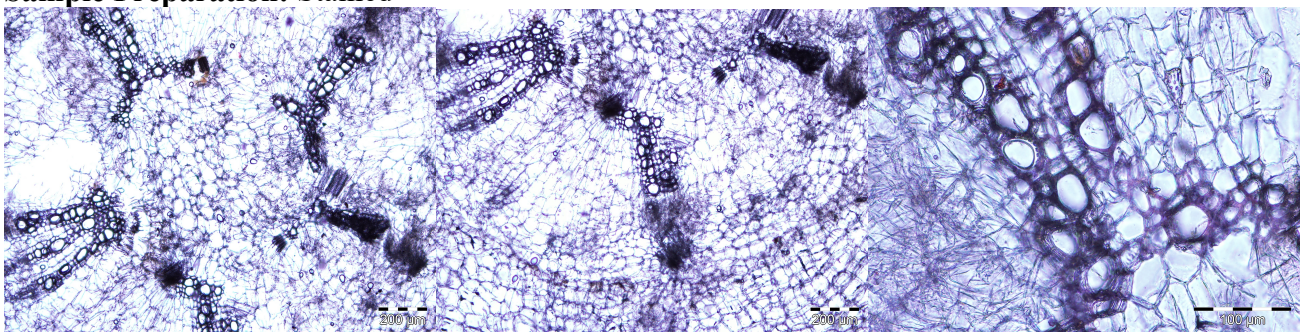
Sample Preparation: Dehydrated



Sample Preparation: Charred ‘fresh’ (not boiled or dried) at 250°C 2.5hrs



Sample Preparation: Stained



Scientific Name: *Solanum tuberosum*
Common Name: papa
Type: Stem

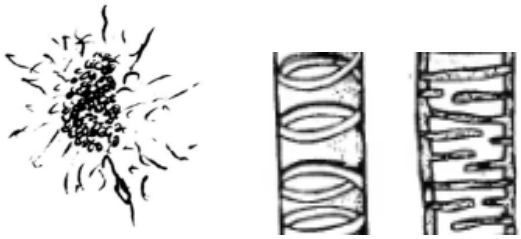


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Undefferentiated: poorly defined, heavily textured with fine wrinkles.

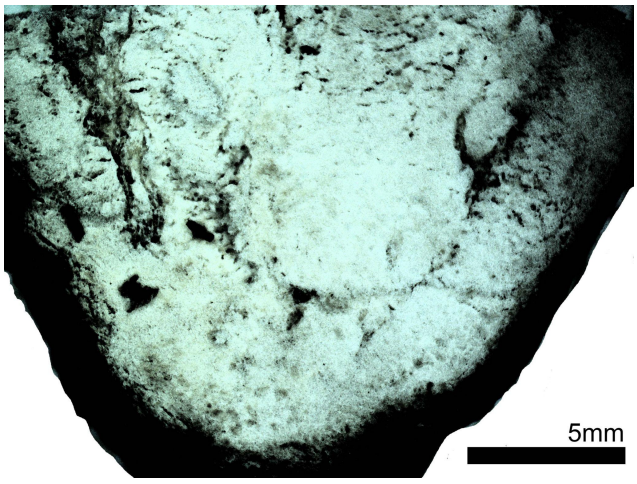
Periderm: Medium: discretely defined, 3-5 cells thick, regular to irregular cell structure.

Vascular Tissue: Ovoid/Irregular: concentrated in indistinct bundles that can be 10+ cells wide in diameter. Inconsistent, irregular shapes without a clear, distinct border. Preserves poorly.
Xylem Perforation Structure: helical/spiral and scalariform



Forms of Preparation:

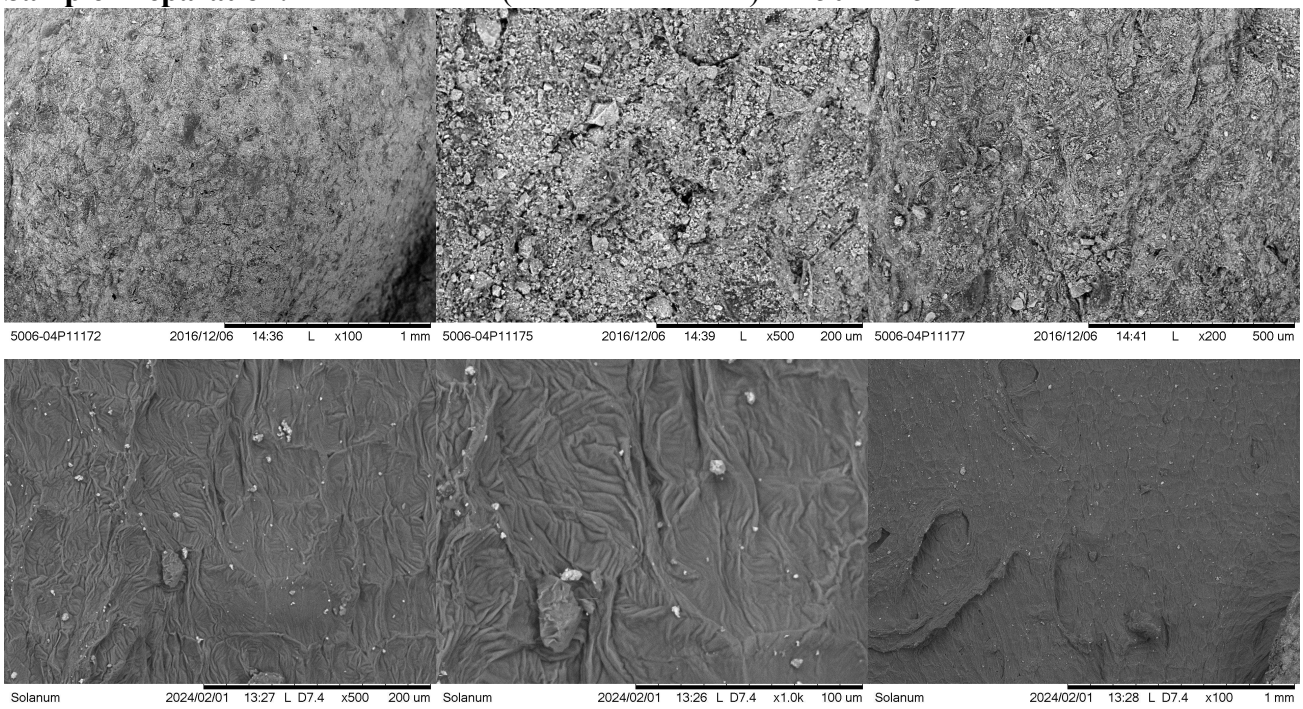
- Dehydrated
- Stained
- Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs buried in sand
- Boiled 20min Charred 250°C for 2.5hrs in foil
- Dried 12hrs 150°F Charred 250°C 2.0hrs in foil
- Dried 12hrs 150°F Charred 250°C 2.5hrs in foil



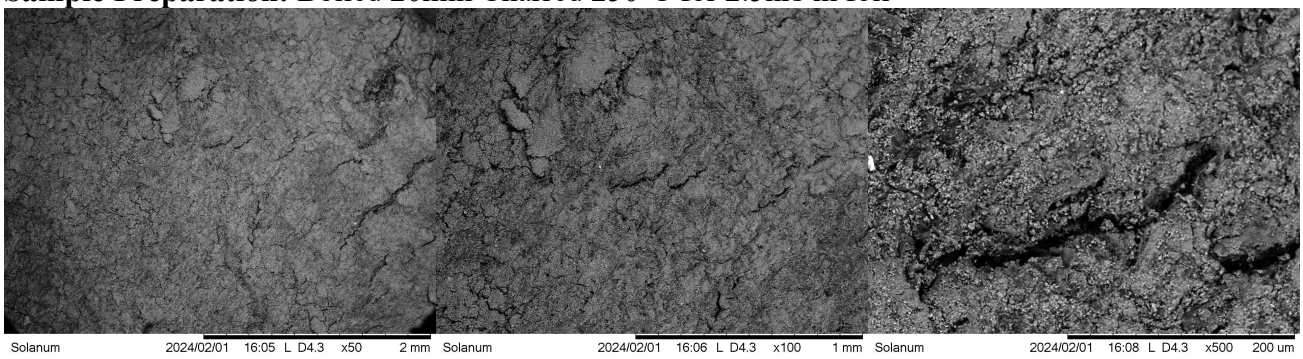
Scientific Name: *Solanum tuberosum* **Common Name:** papa **Type:** Stem

View: Exterior Surface

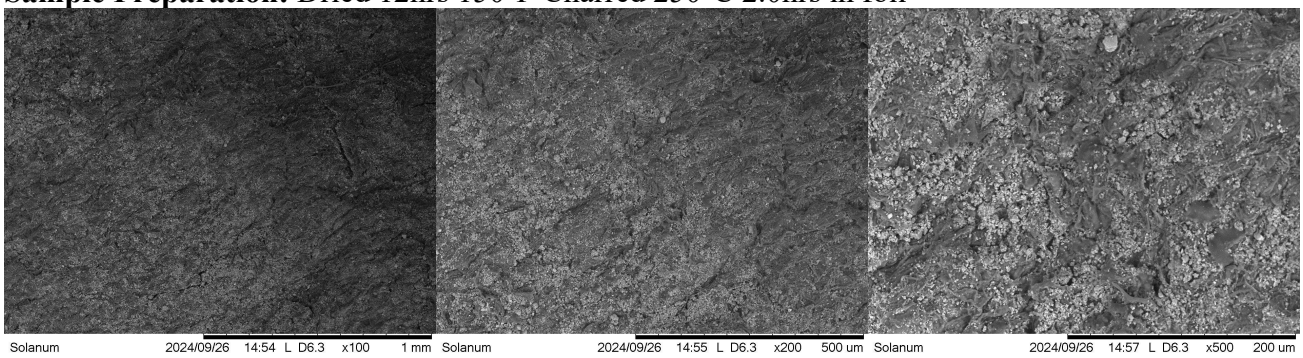
Sample Preparation: Charred ‘fresh’ (not boiled or dried) at 250°C 2.5hrs



Sample Preparation: Boiled 20min Charred 250°C for 2.5hrs in foil



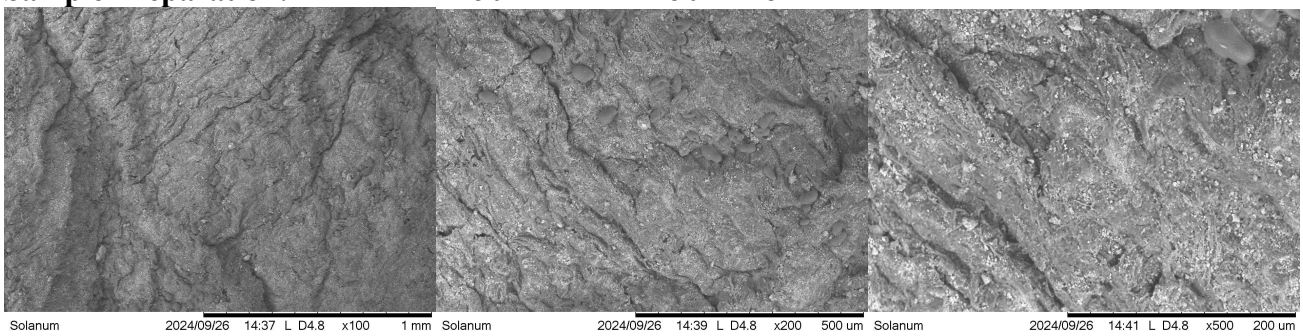
Sample Preparation: Dried 12hrs 150°F Charred 250°C 2.0hrs in foil



Scientific Name: *Solanum tuberosum* **Common Name:** papa **Type:** Stem

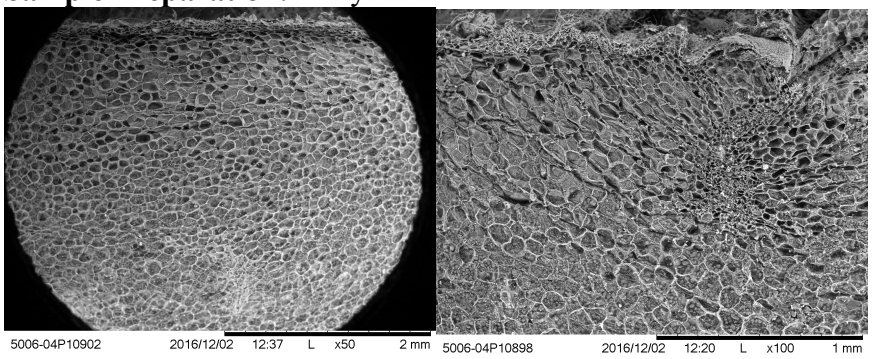
View: Exterior Surface Continued

Sample Preparation: Dried 12hrs 150°F Charred 250°C 2.5hrs in foil

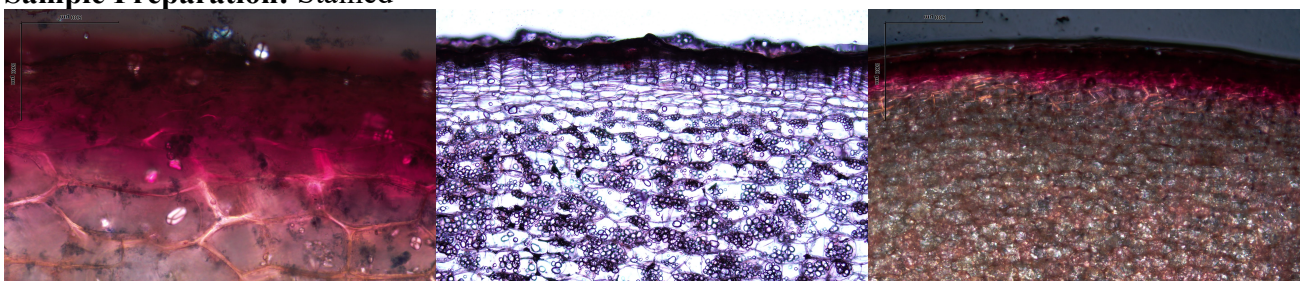


View: Periderm

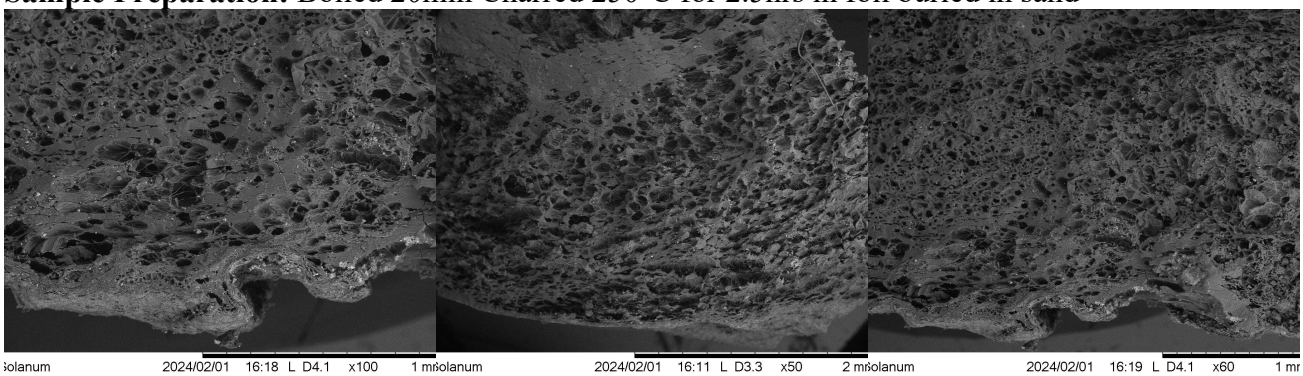
Sample Preparation: Dehydrated



Sample Preparation: Stained



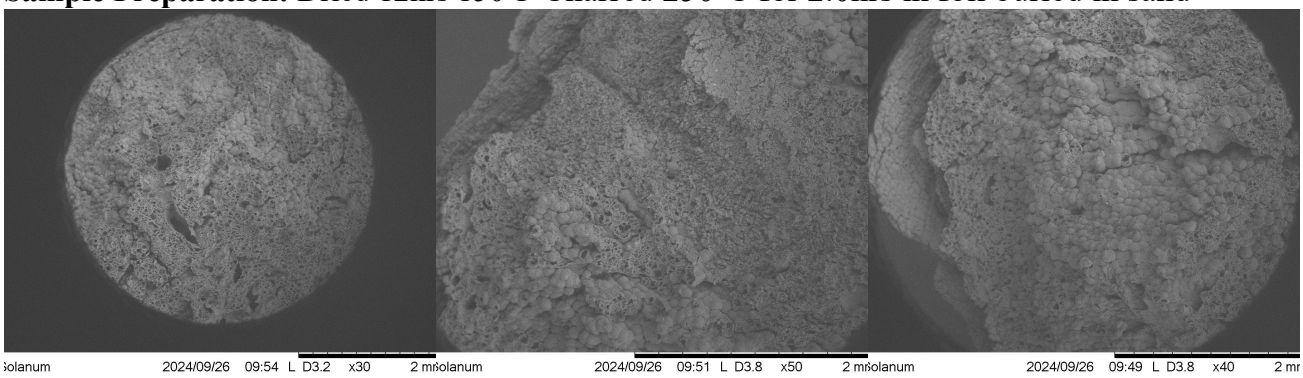
Sample Preparation: Boiled 20min Charred 250°C for 2.5hrs in foil buried in sand



Scientific Name: *Solanum tuberosum* **Common Name:** papa **Type:** Stem

View: Periderm Continued

Sample Preparation: Dried 12hrs 150°F Charred 250°C for 2.0hrs in foil buried in sand

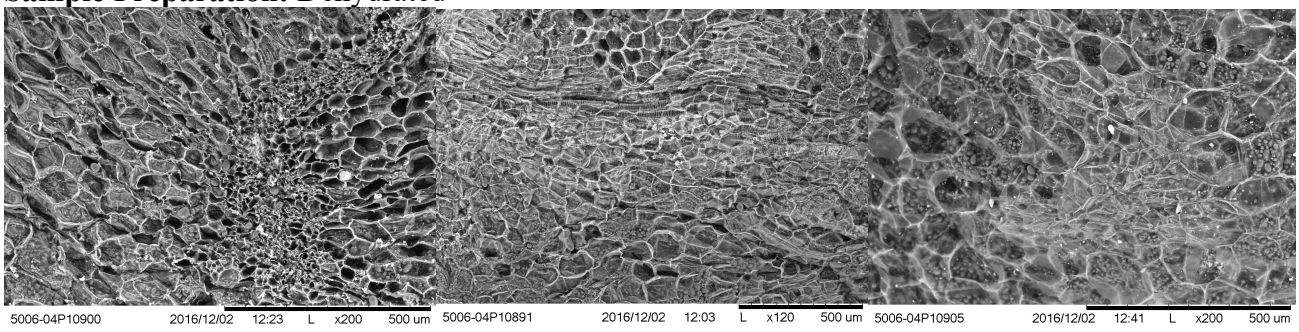


Sample Preparation: Dried 12hrs 150°F Charred 250°C for 2.5hrs in foil buried in sand

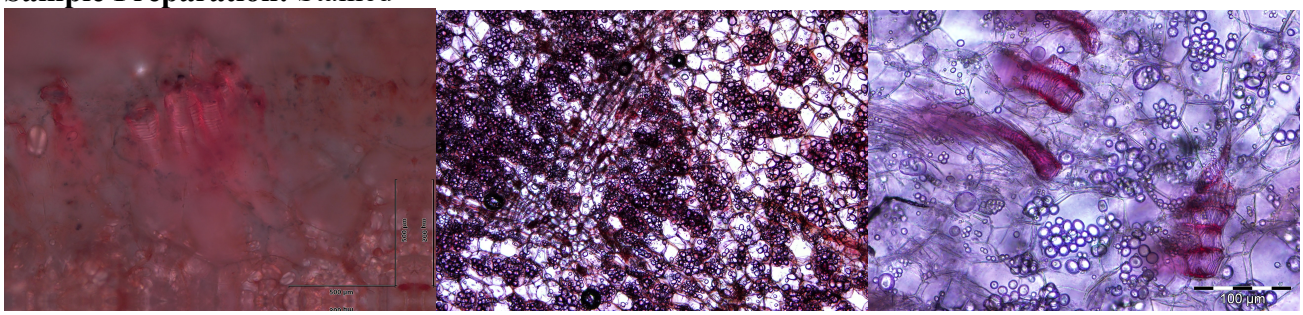


View: Vascular Tissue

Sample Preparation: Dehydrated



Sample Preparation: Stained

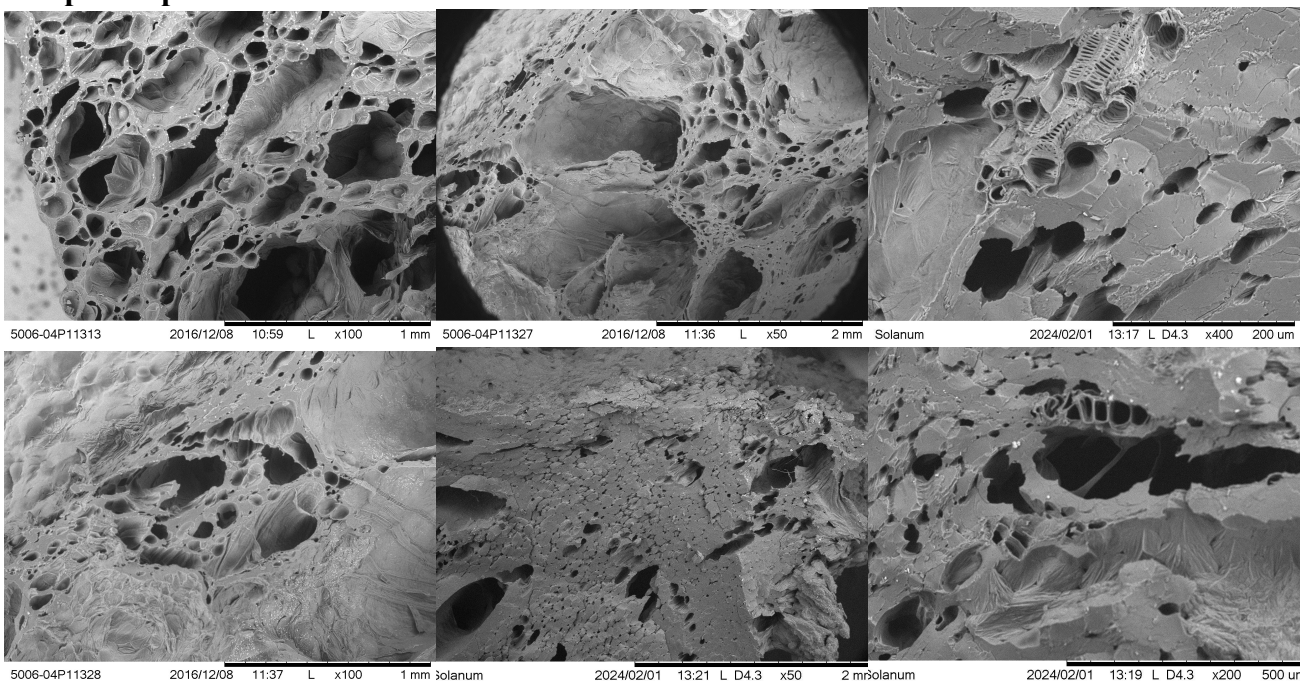


Scientific Name: *Solanum tuberosum* **Common Name:** papa **Type:** Stem

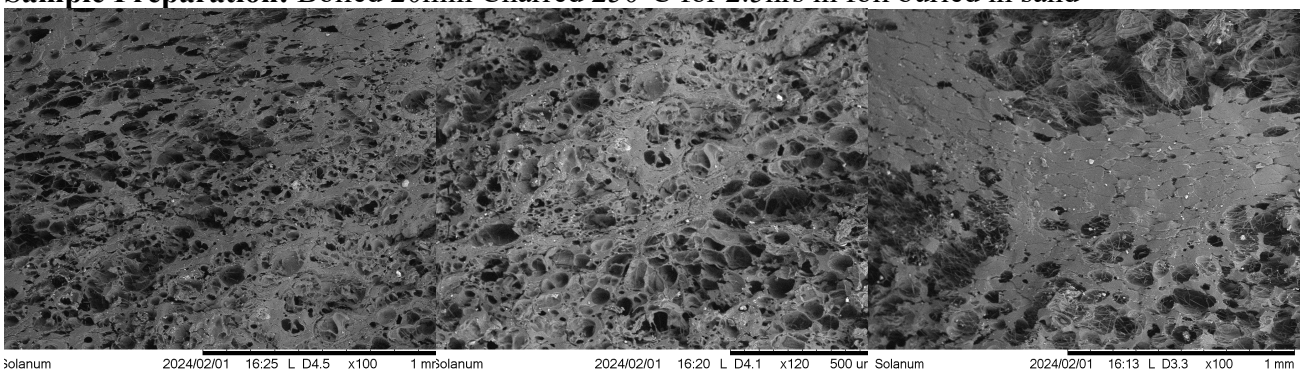
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View: Vascular Tissue Continued

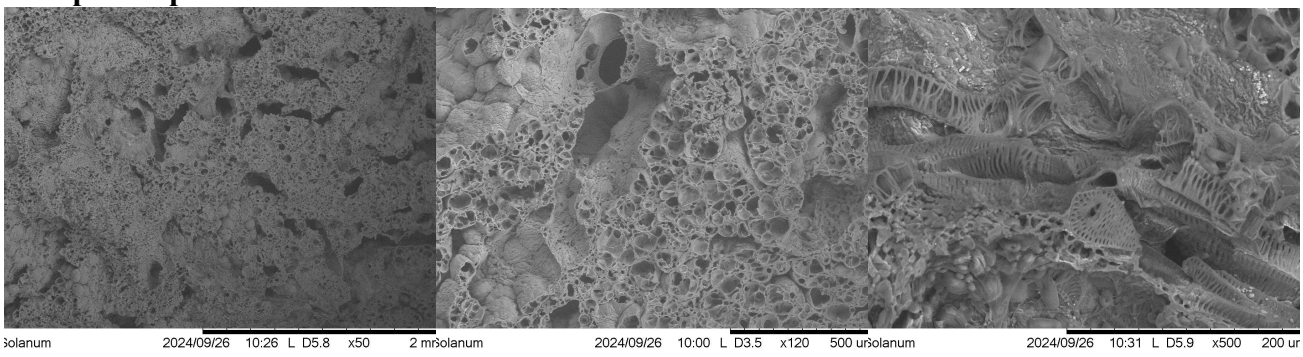
Sample Preparation: Charred 250°C for 2.5hrs in foil buried in sand



Sample Preparation: Boiled 20min Charred 250°C for 2.5hrs in foil buried in sand



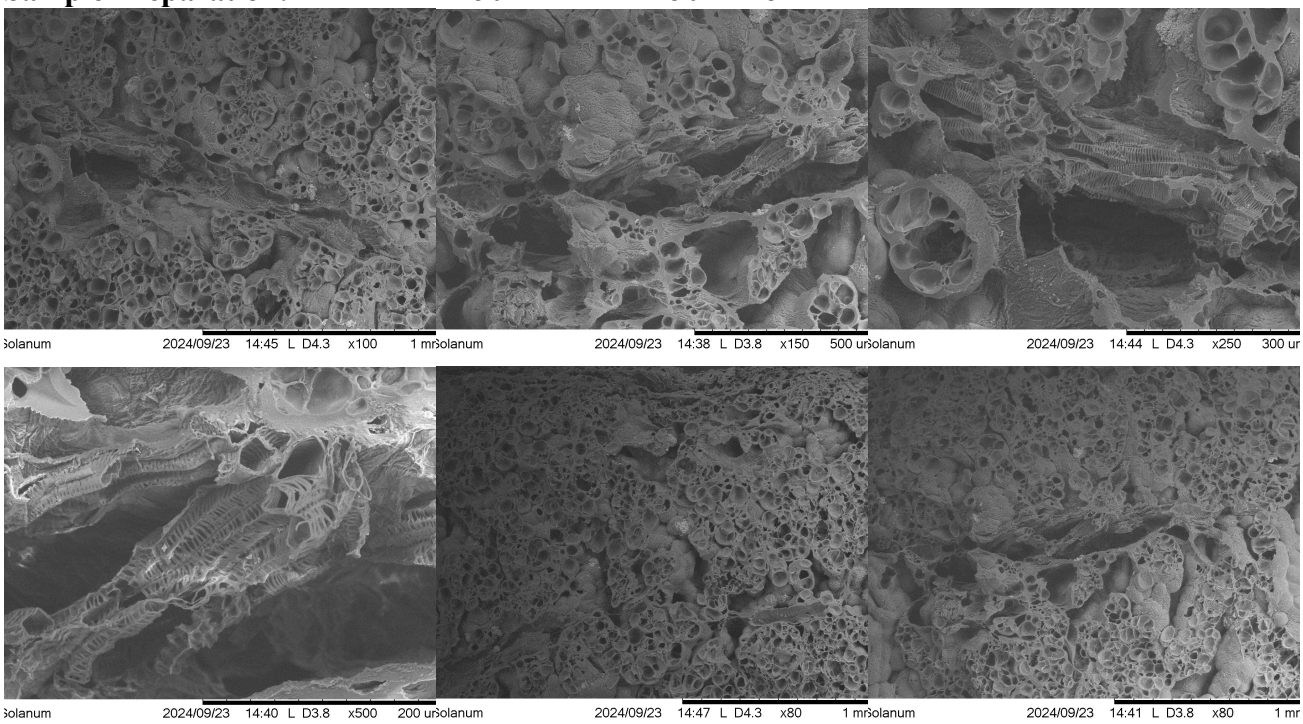
Sample Preparation: Dried 12hrs 150°F Charred 250°C 2.0hrs in foil



Scientific Name: *Solanum tuberosum* **Common Name:** papa **Type:** Stem

View: Vascular Tissue Continued

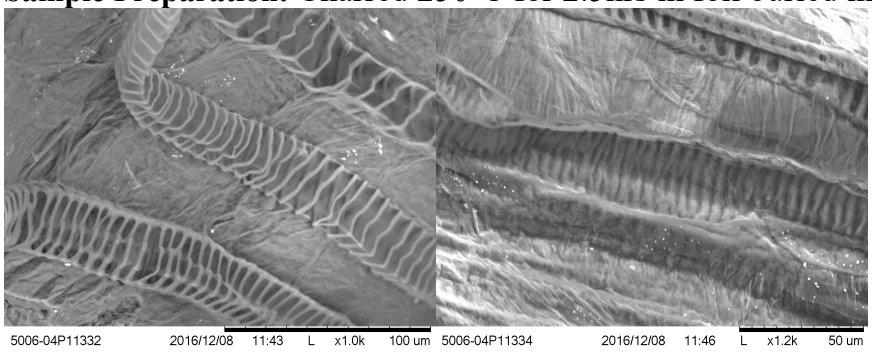
Sample Preparation: Dried 12hrs 150°F Charred 250°C 2.5hrs in foil



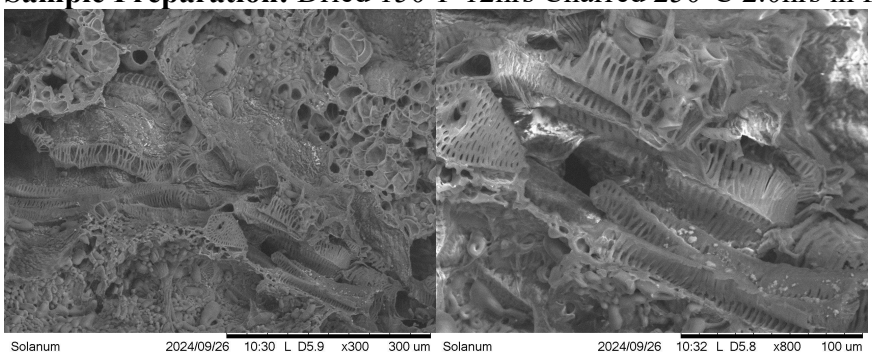
Scientific Name: *Solanum tuberosum* **Common Name:** papa **Type:** Stem

View: Xylem perforation structure: helical/spiral and scalariform

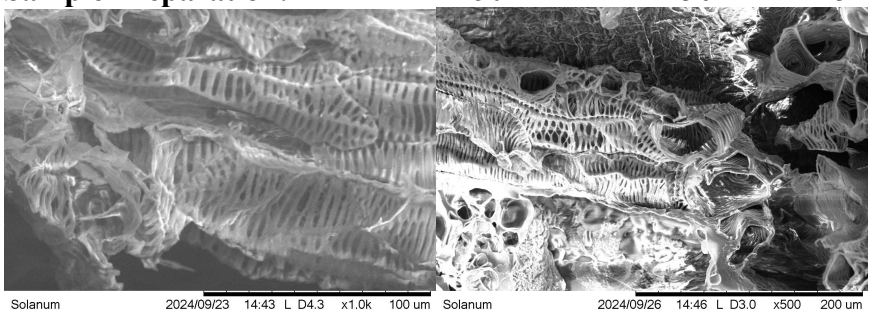
Sample Preparation: Charred 250°C for 2.5hrs in foil buried in sand



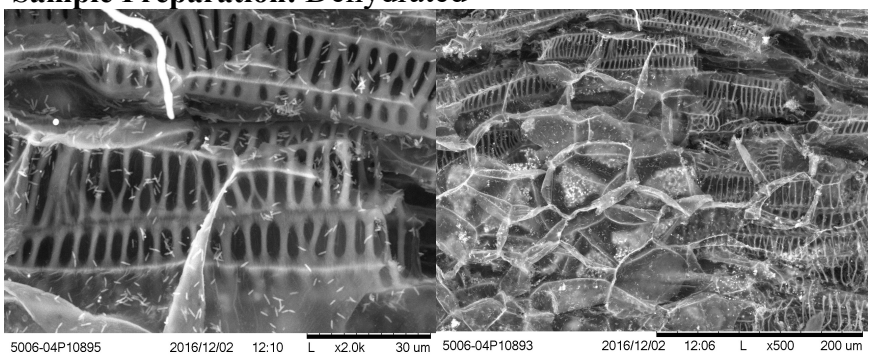
Sample Preparation: Dried 150°F 12hrs Charred 250°C 2.0hrs in foil buried in sand



Sample Preparation: Dried 12hrs 150°F Charred 250°C for 2.5hrs in foil buried in sand



Sample Preparation: Dehydrated



Scientific Name: *Solanum tuberosum* L.
Common Name: chuño (freeze-dried papa)
Type: Stem

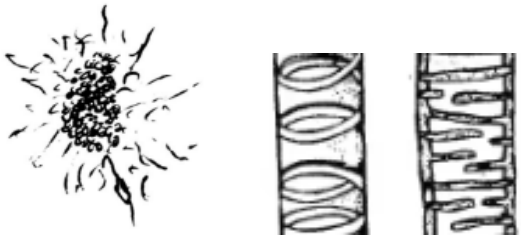


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Undifferentiated: poorly defined, heavily textured with fine wrinkles.

Periderm: Medium:discretely defined, 3-5 cells thick, regular to irregular cell structure.

Vascular Tissue: Ovoid/Irregular: concentrated in indistinct bundles that can be 10+ cells wide in diameter. Inconsistent, irregular shapes without a clear, distinct border. Preserves poorly. Partially concealed by preserved starch.
Xylem Perforation Structure: helical/spiral and scalariform



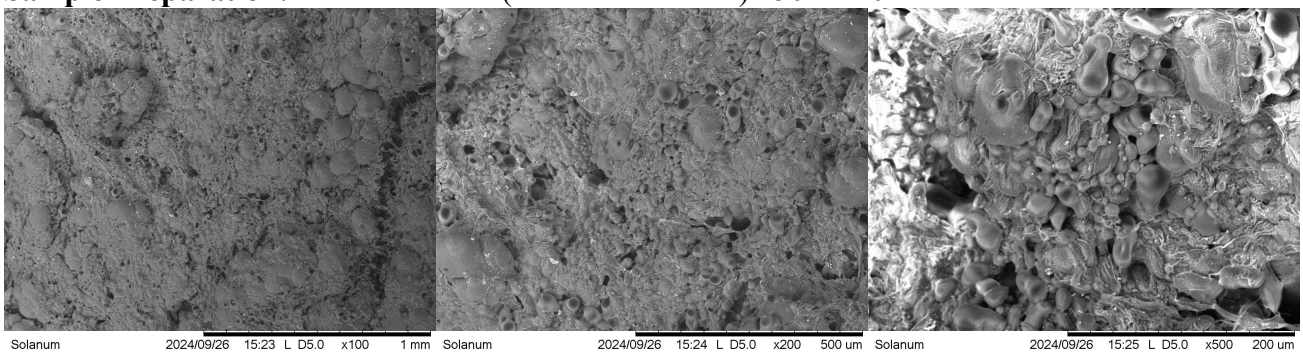
Forms of Preparation:

- Charred ‘fresh’ (not dried or boiled) in foil 250°C 2.0hrs buried in sand
- Charred ‘fresh’ (not dried or boiled) in foil 250°C 2.5hrs buried in sand
- Soaked 2days Charred 200°C for 2.5hrs in foil buried in sand
- Soaked 2days Charred 200°C for 2.5hrs without foil buried in sand

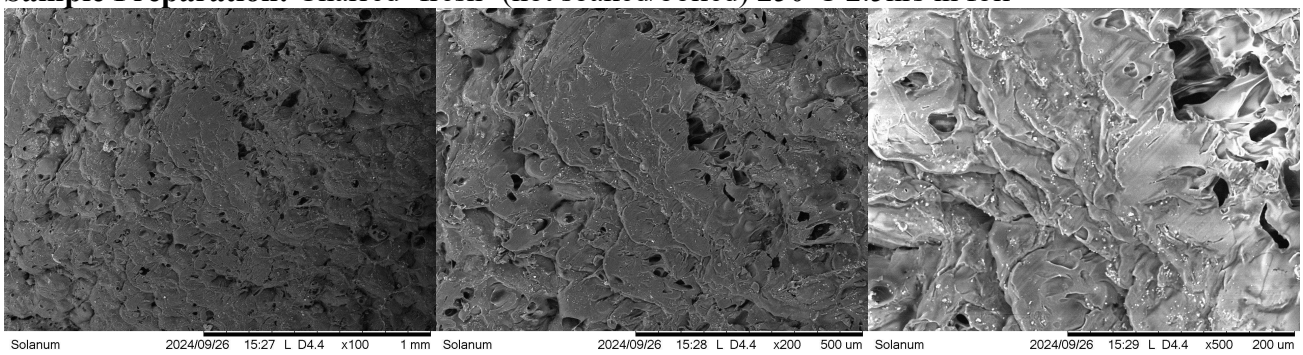
Scientific Name: *Solanum tuberosum* **Common Name:** chuño (freeze-dried papa) **Type:** Stem

View: Exterior Surface

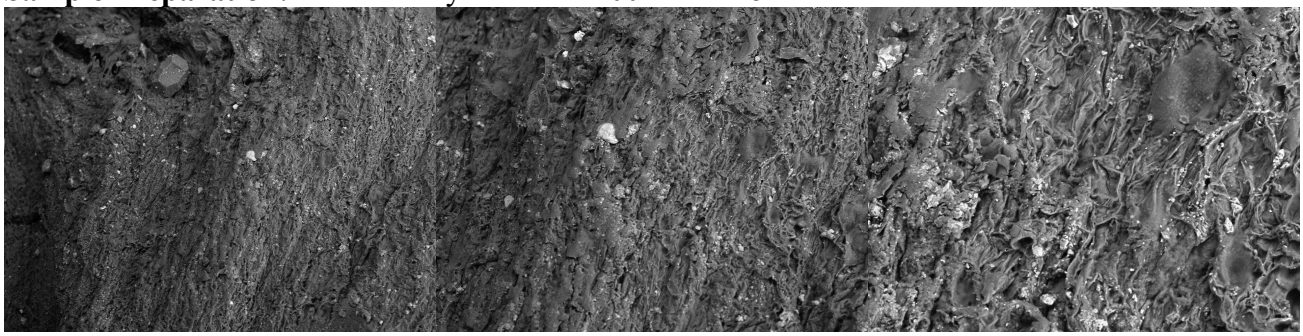
Sample Preparation: Charred ‘fresh’ (not soaked/boiled) 250°C 2.0hrs in foil



Sample Preparation: Charred ‘fresh’ (not soaked/boiled) 250°C 2.5hrs in foil



Sample Preparation: Soaked 2days Charred 200°C for 2.5hrs in foil



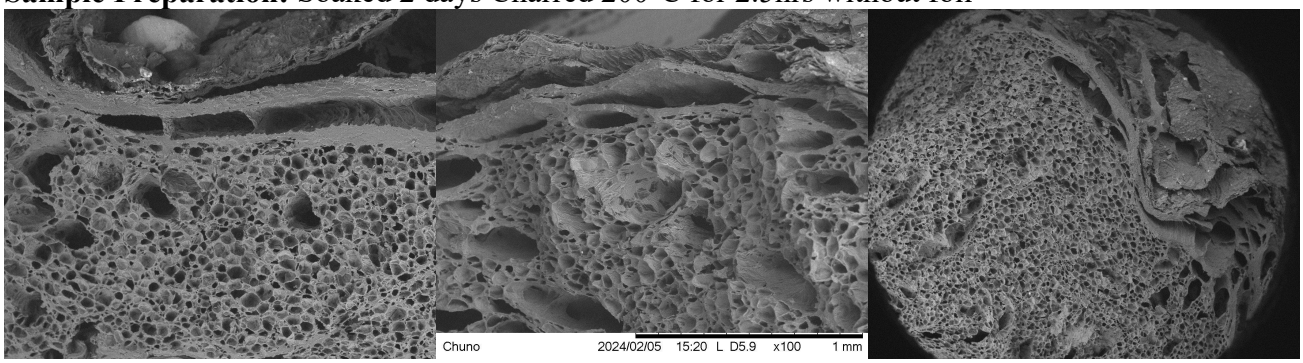
Sample Preparation: Soaked 2 days Charred 200°C for 2.5hrs without foil



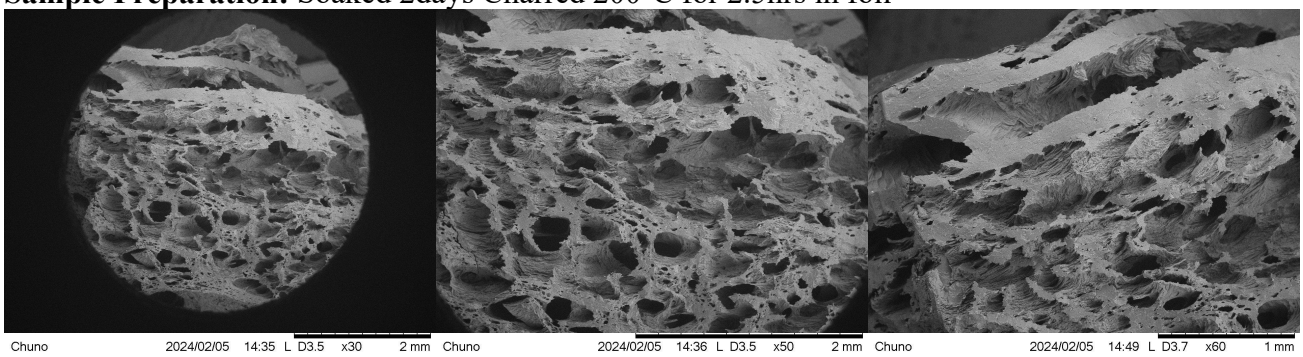
Scientific Name: *Solanum tuberosum* **Common Name:** chuño (freeze-dried papa) **Type:** Stem

View: Periderm

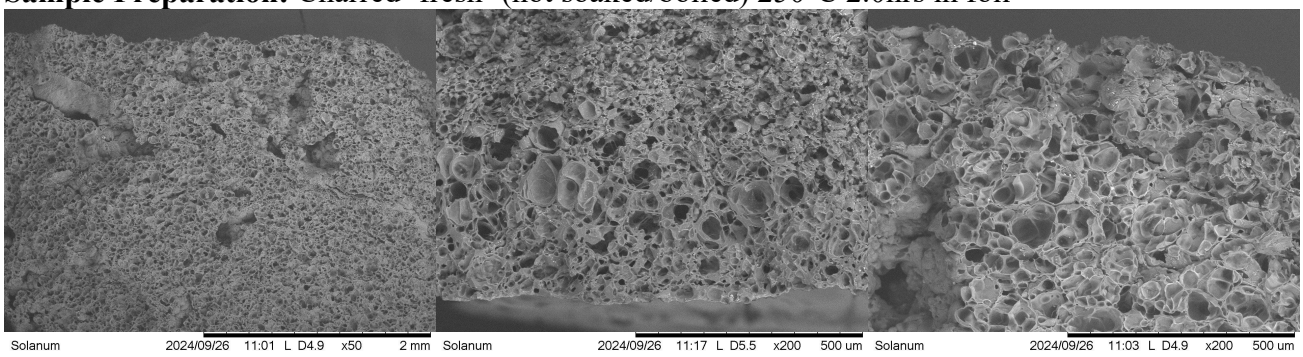
Sample Preparation: Soaked 2 days Charred 200℃ for 2.5hrs without foil



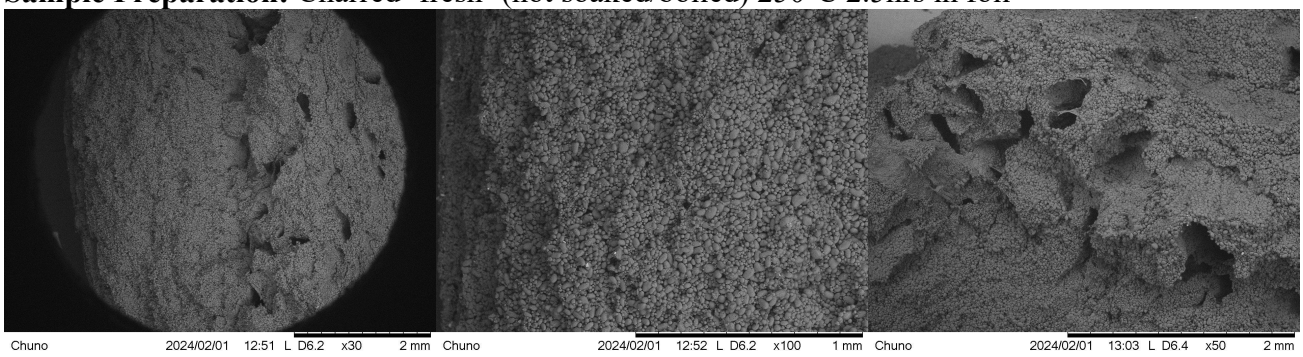
Sample Preparation: Soaked 2days Charred 200℃ for 2.5hrs in foil



Sample Preparation: Charred ‘fresh’ (not soaked/boiled) 250℃ 2.0hrs in foil



Sample Preparation: Charred ‘fresh’ (not soaked/boiled) 250℃ 2.5hrs in foil

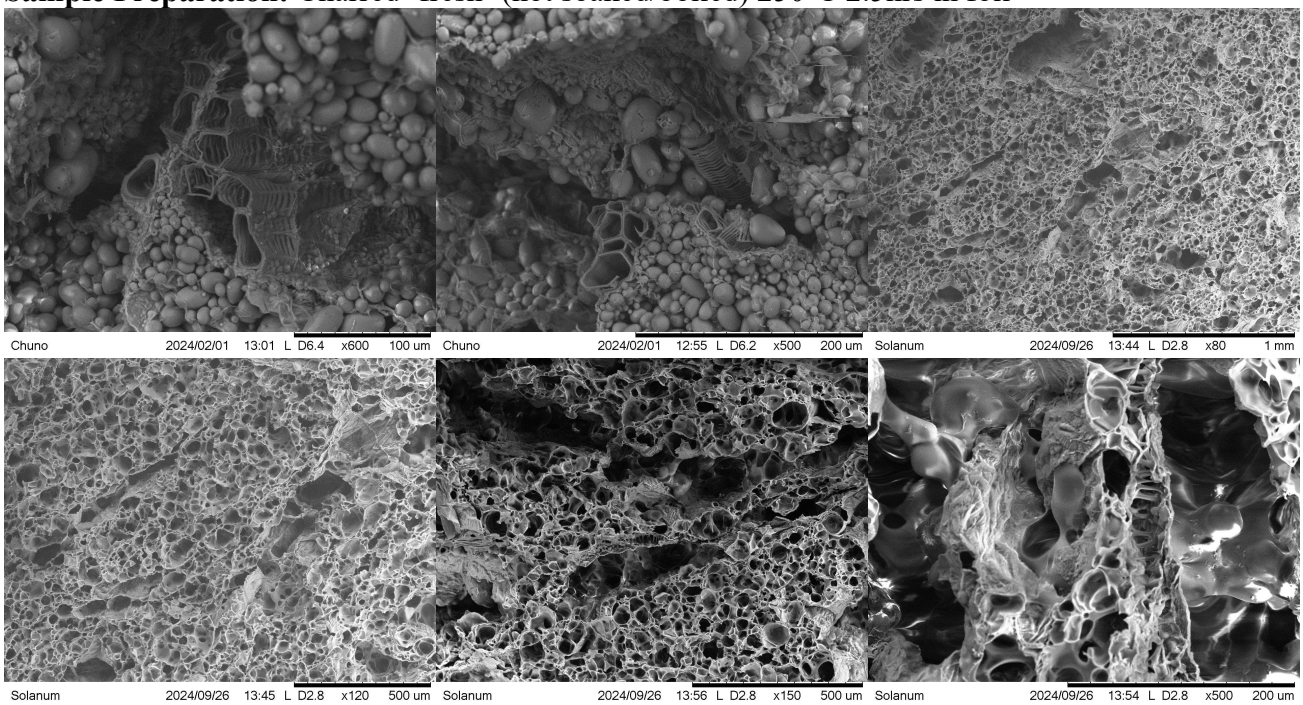


Scientific Name: *Solanum tuberosum* **Common Name:** chuño (freeze-dried papa) **Type:** Stem

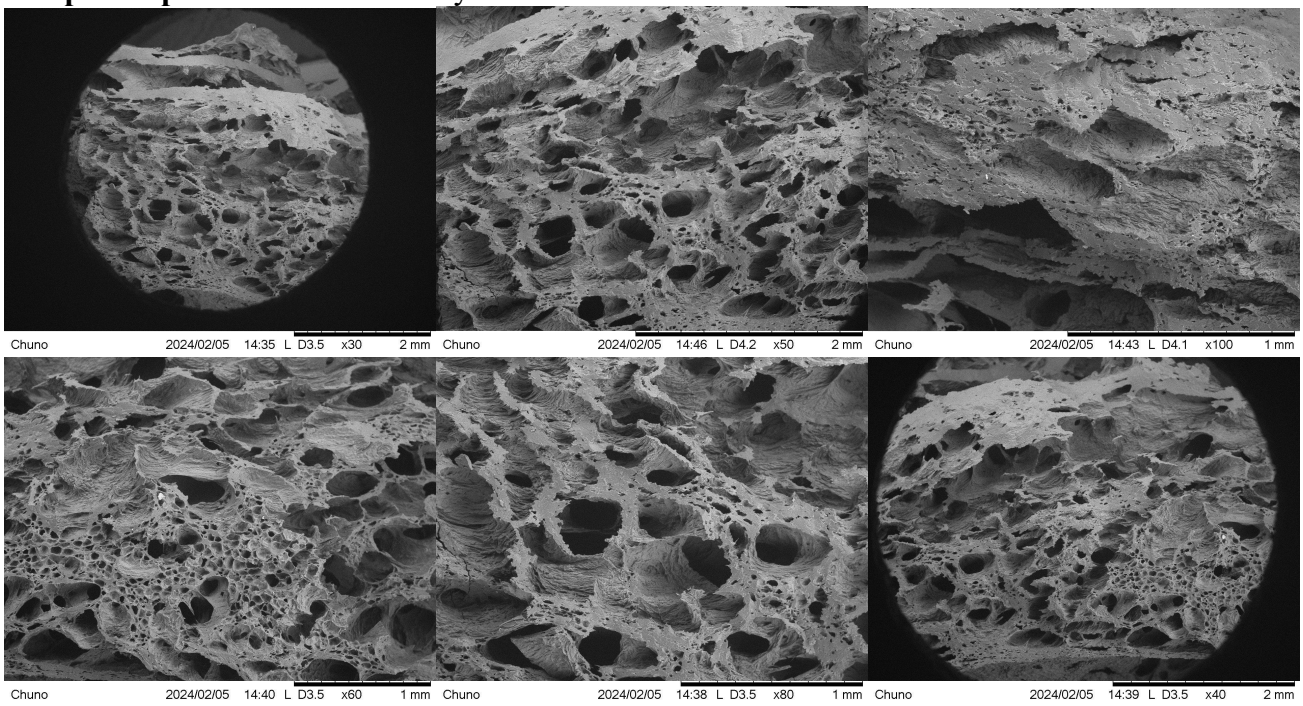
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View: Vascular Tissue

Sample Preparation: Charred ‘fresh’ (not soaked/boiled) 250°C 2.5hrs in foil



Sample Preparation: Soaked 2 days Charred 200°C for 2.5hrs in foil

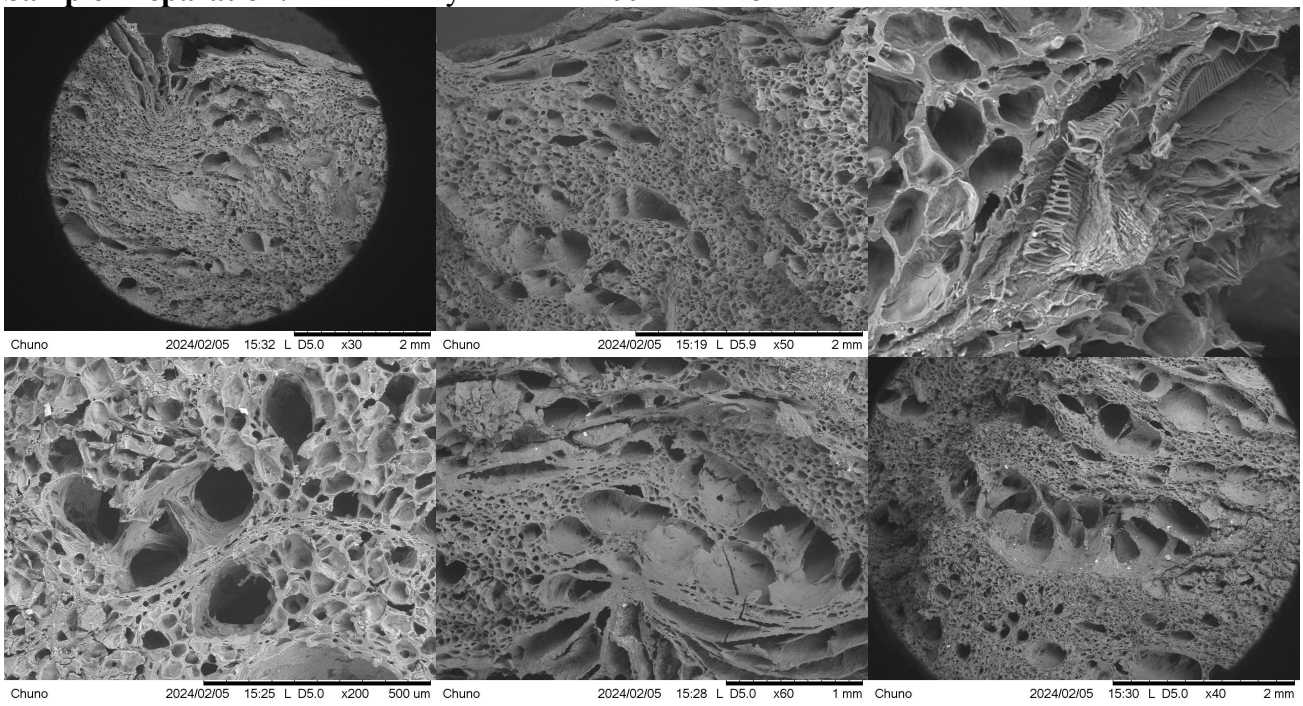


Scientific Name: *Solanum tuberosum* **Common Name:** chuño (freeze-dried papa) **Type:** Stem

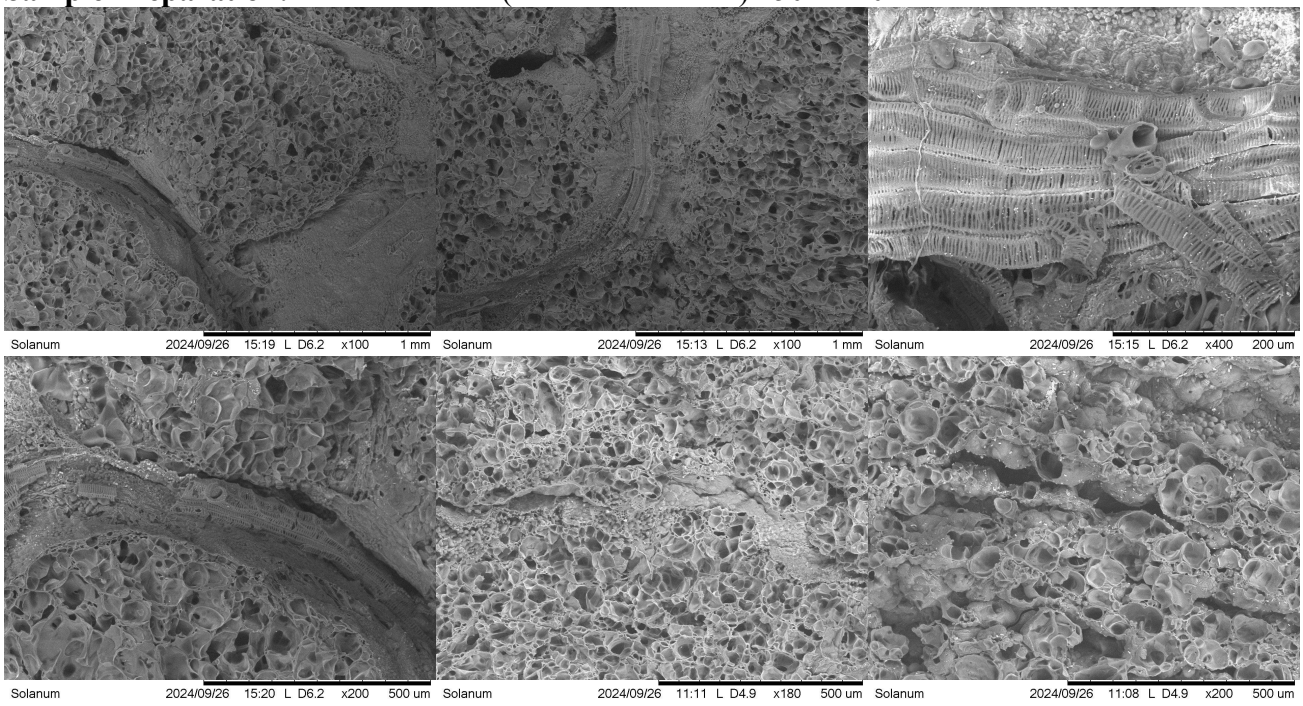
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View: Vascular Tissue Continued

Sample Preparation: Soaked 2days Charred 200°C for 2.5hrs without foil



Sample Preparation: Charred 'fresh' (not soaked/boiled) 250°C 2.0hrs in foil



Scientific Name: *Tropaeolum tuberosum*
Common Name: mashua
Type: root

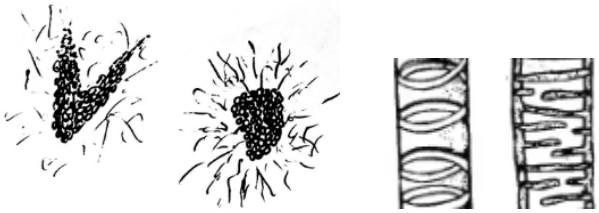


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Wrinkled/Reticulate: Large folds with cellular structure visible at high magnifications.

Periderm: Medium: discretely defined, 2-4 cells thick, irregular cell structure.

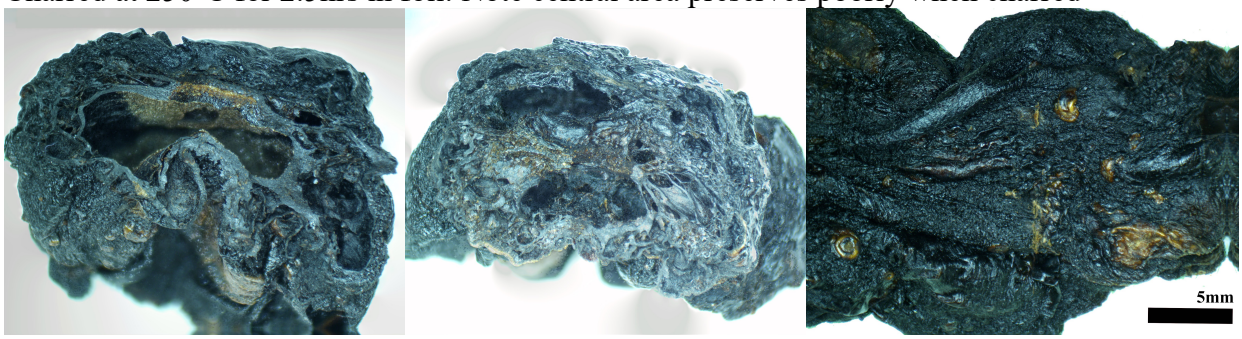
Vascular Tissue: Irregular: concentrated in irregular and angular shaped bundles with 6+ xylem cells in diameter. Can appear similar to Oxalis, but tends to be less well preserved. Cells tend to radiate outwards.
Xylem Perforation Structure: Spiral/helical and scalariform



Forms of Preparation:

- Dehydrated
- Stained
- Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs buried in sand
- Boiled 20min Charred 250°C 2.5hrs then 70°C 7 days buried in sand
- Dried 150°F 12hrs, Charred 250°C 1.5hrs, in foil buried in sand
- Dried 150°F 12hrs, Charred 250°C 2.0hrs, in foil buried in sand
- Dried 150°F 12hrs, Charred 250°C 2.5hrs, in foil buried in sand
- Dried 150°F 12hrs, Charred 250°C 3.0hrs, in foil buried in sand

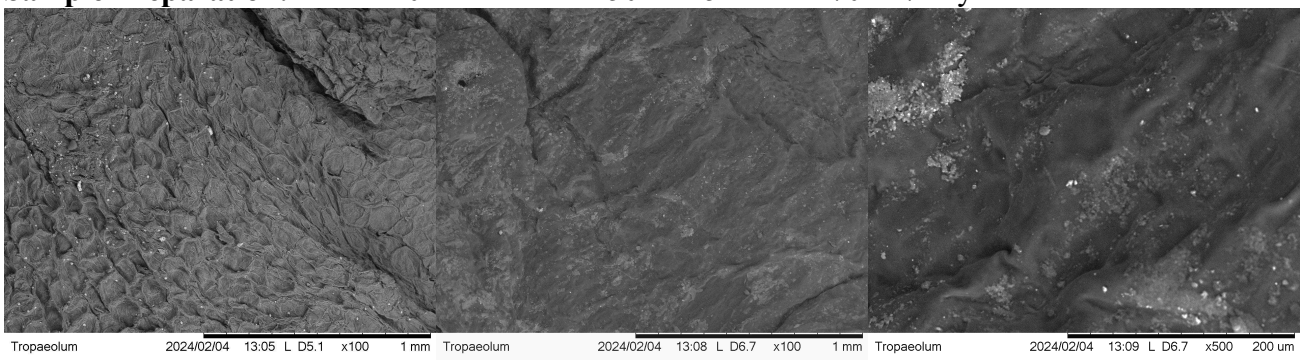
Charred at 250°C for 2.5hrs in foil: Note central area preserves poorly when charred



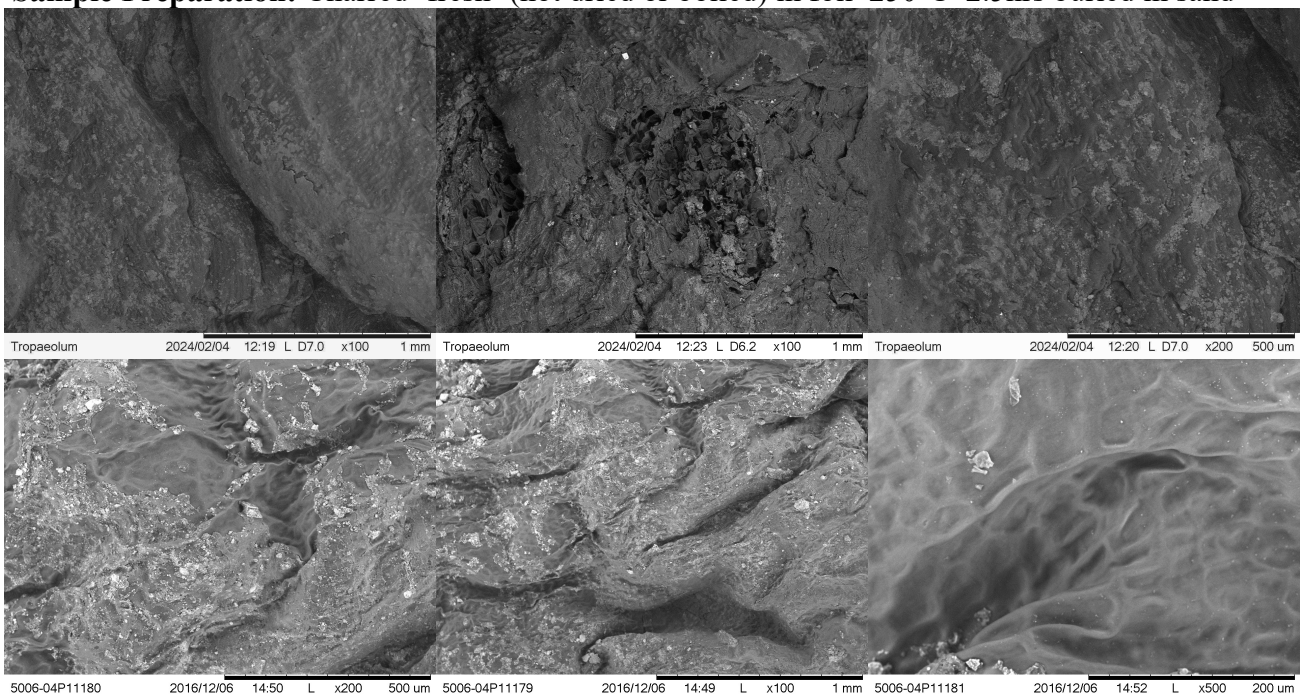
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Exterior Surface

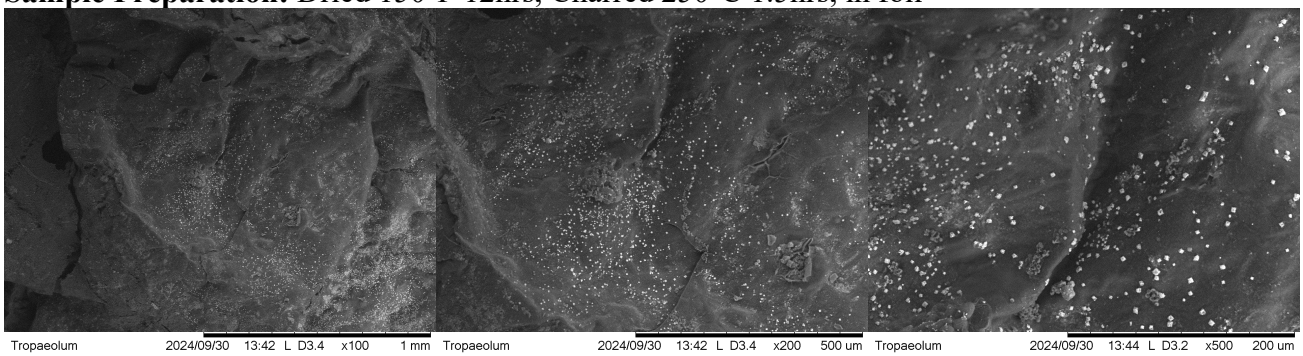
Sample Preparation: Boiled 20min Charred 250°C 2.5hrs then 70°C 7 days



Sample Preparation: Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs buried in sand



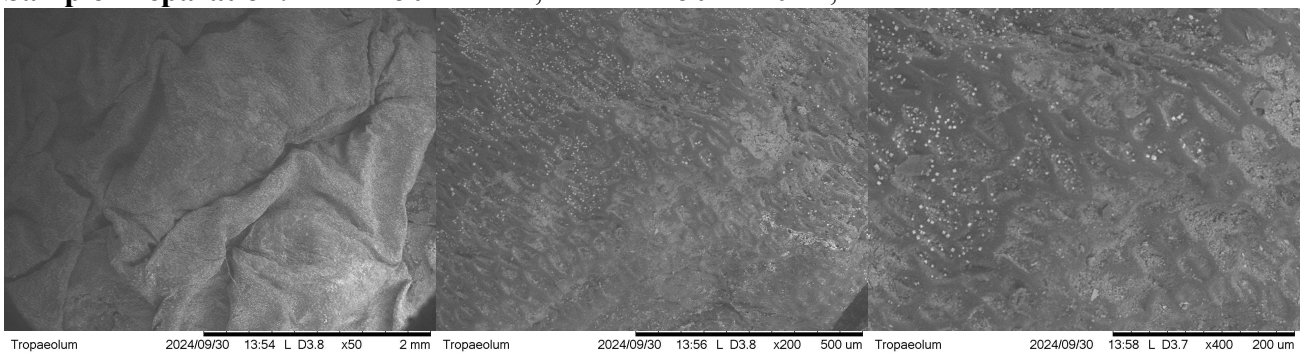
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 1.5hrs, in foil



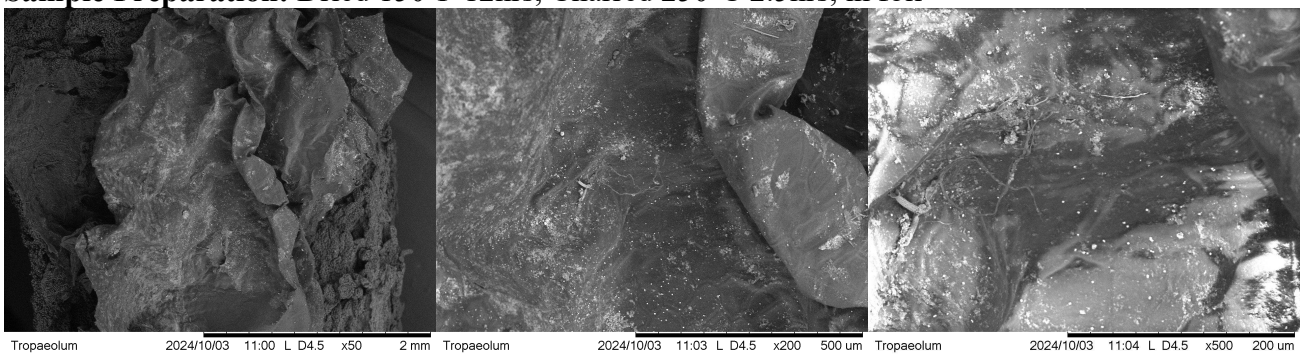
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Exterior Surface Continued

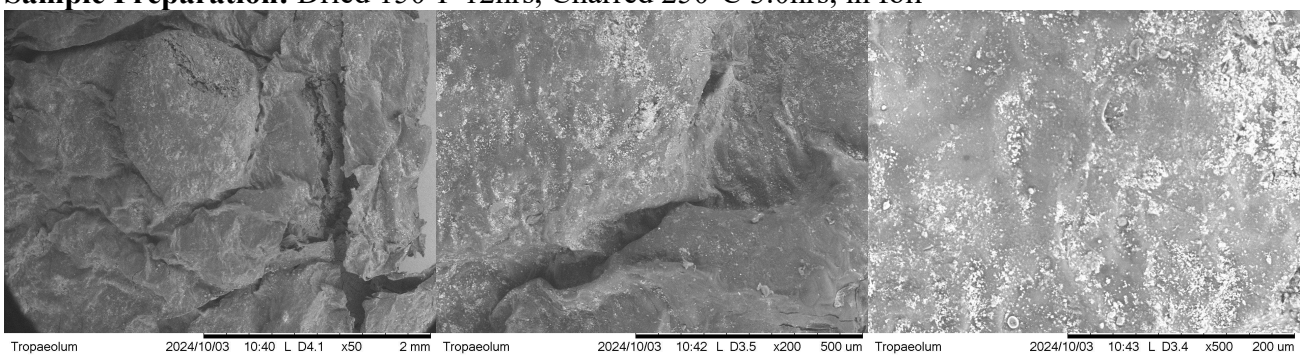
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.0hrs, in foil



Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.5hrs, in foil



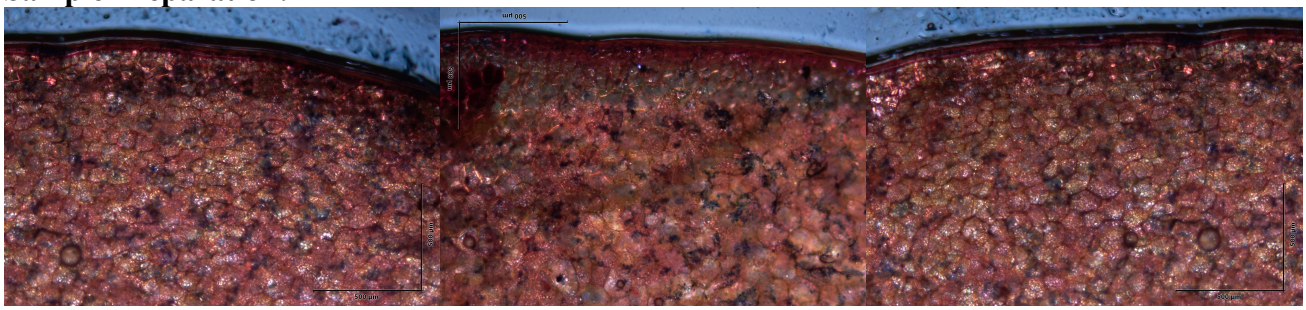
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 3.0hrs, in foil



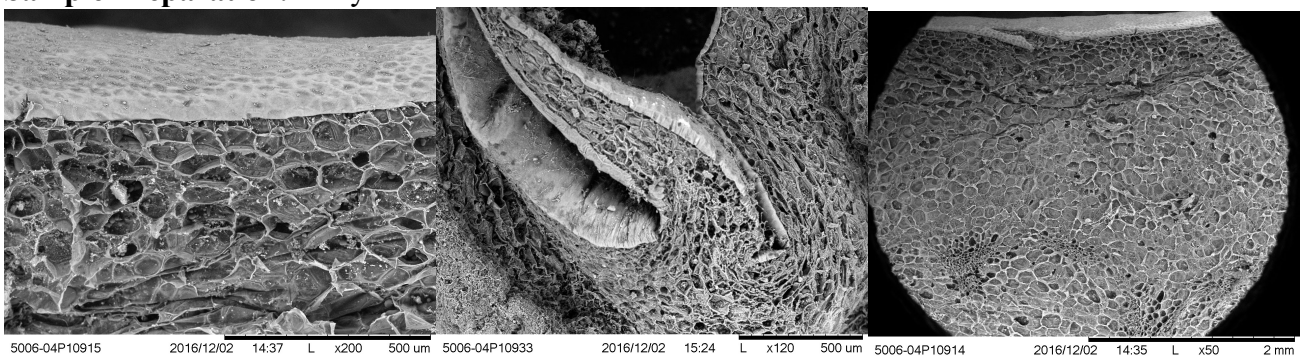
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Periderm

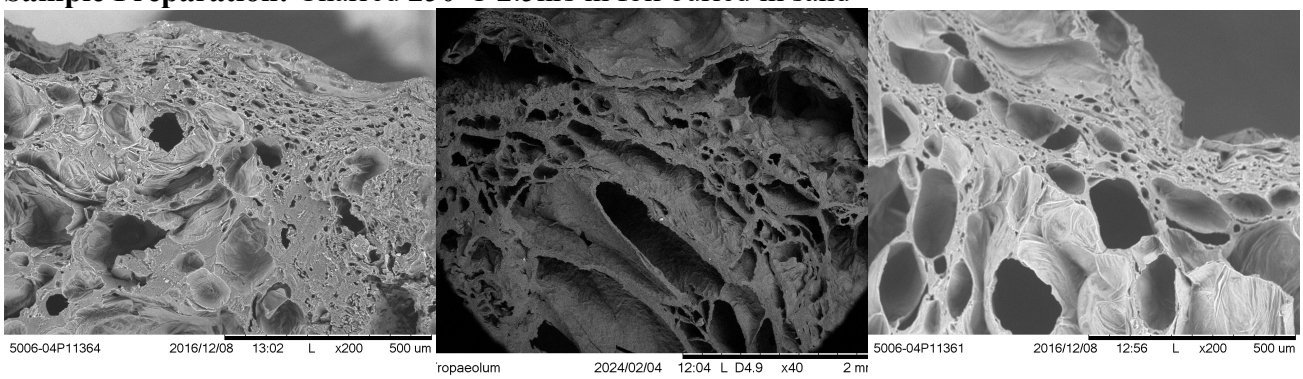
Sample Preparation: Stained



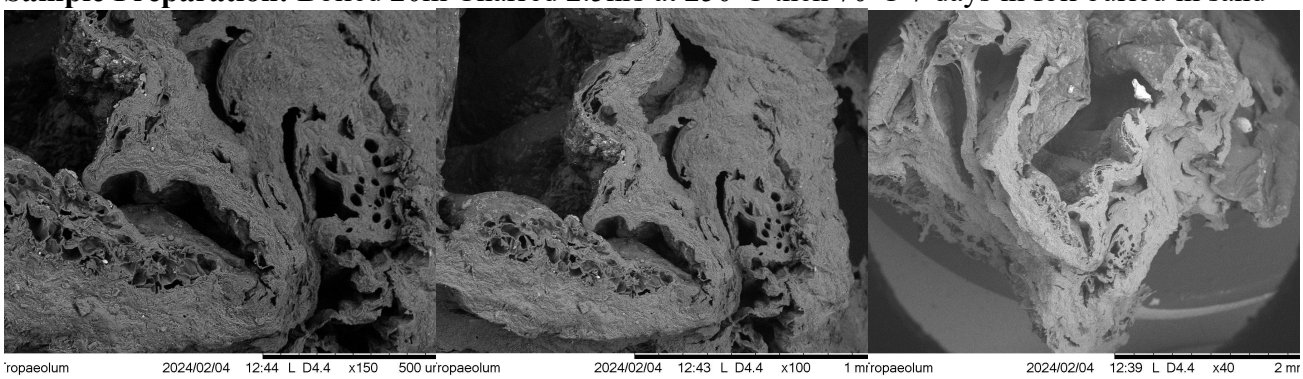
Sample Preparation: Dehydrated



Sample Preparation: Charred 250°C 2.5hrs in foil buried in sand



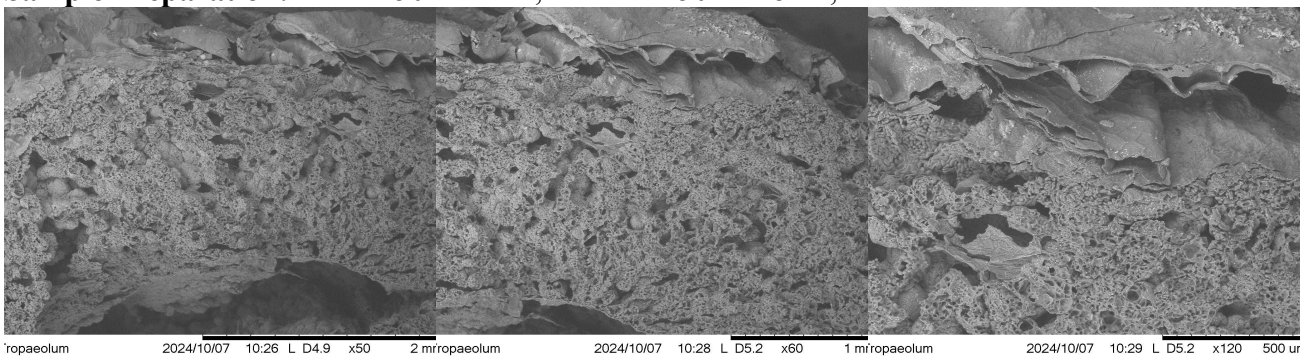
Sample Preparation: Boiled 20m Charred 2.5hrs at 250°C then 70°C 7 days in foil buried in sand



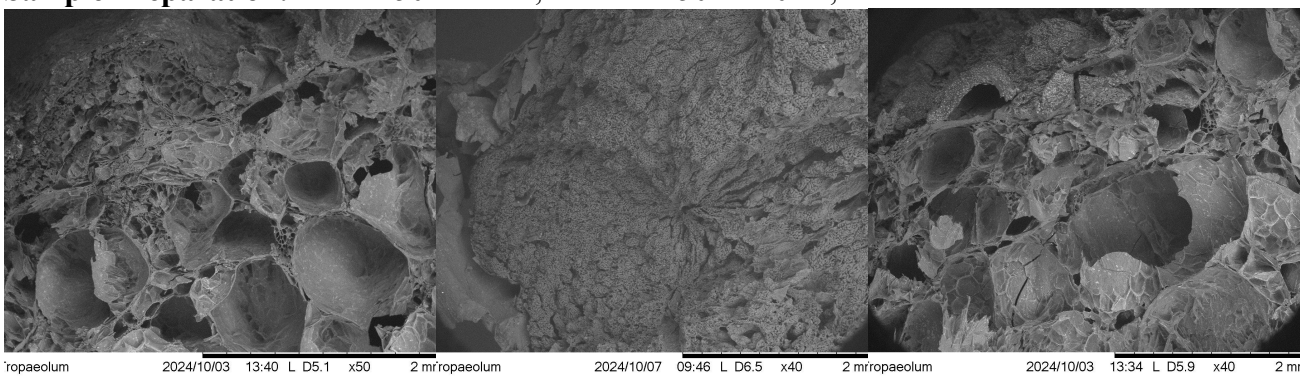
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Periderm Continued

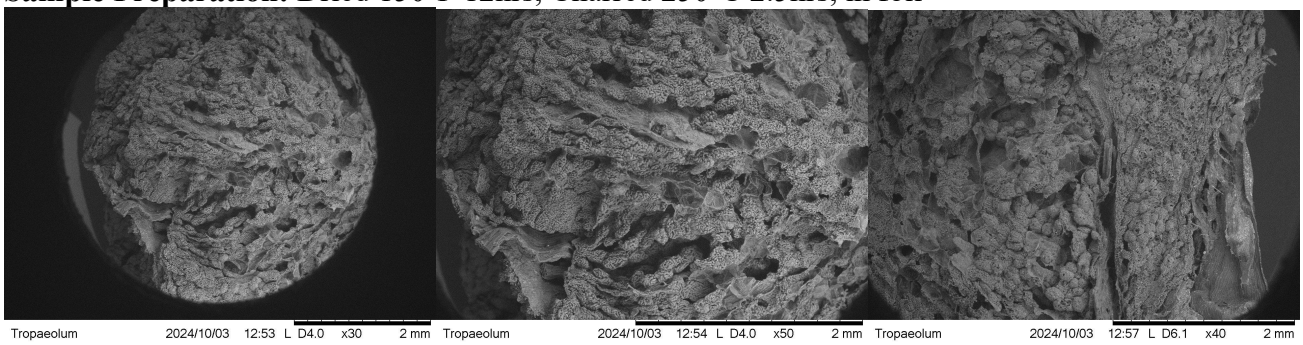
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 1.5hrs, in foil



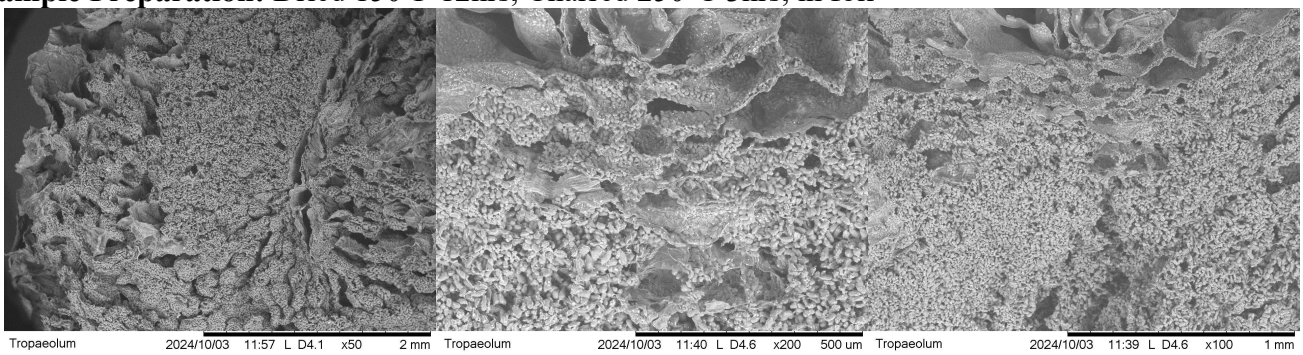
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.0hrs, in foil



Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.5hrs, in foil



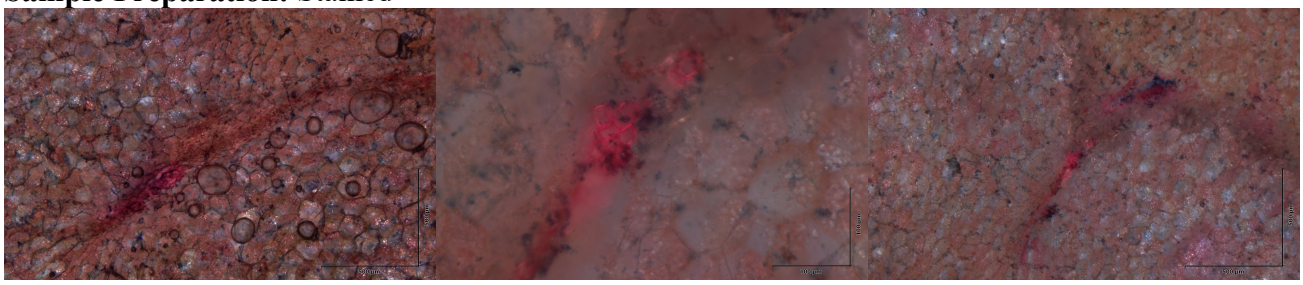
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 3hrs, in foil



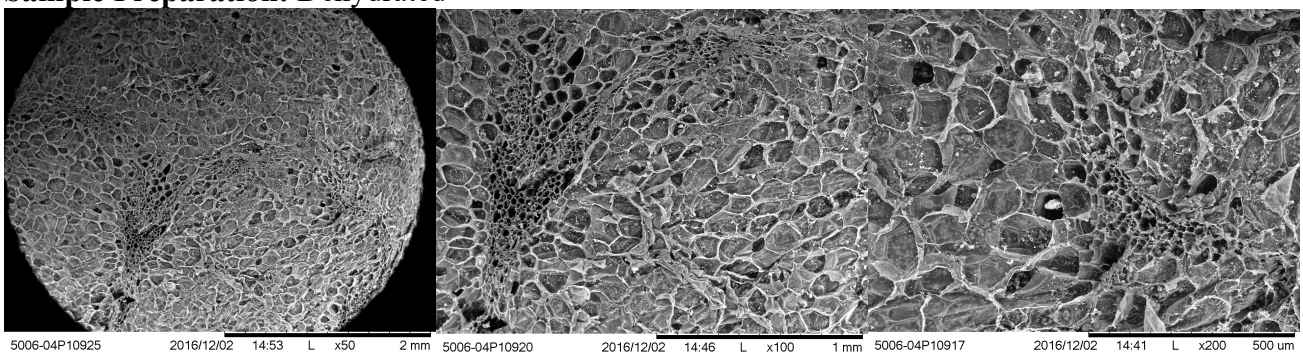
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Vascular Tissue

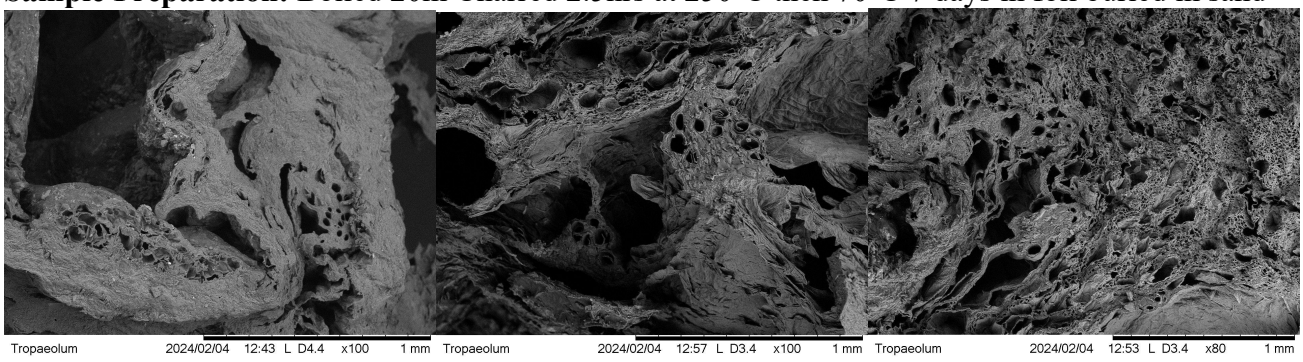
Sample Preparation: Stained



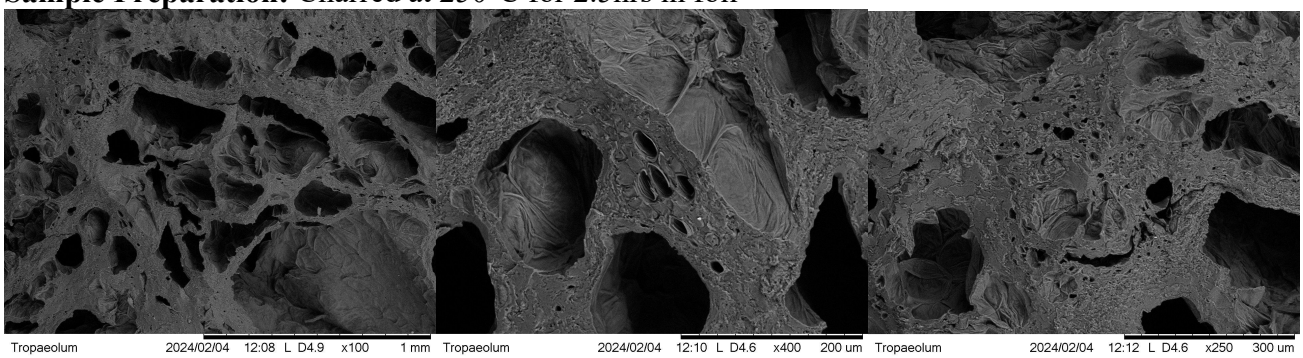
Sample Preparation: Dehydrated



Sample Preparation: Boiled 20m Charred 2.5hrs at 250°C then 70°C 7 days in foil buried in sand



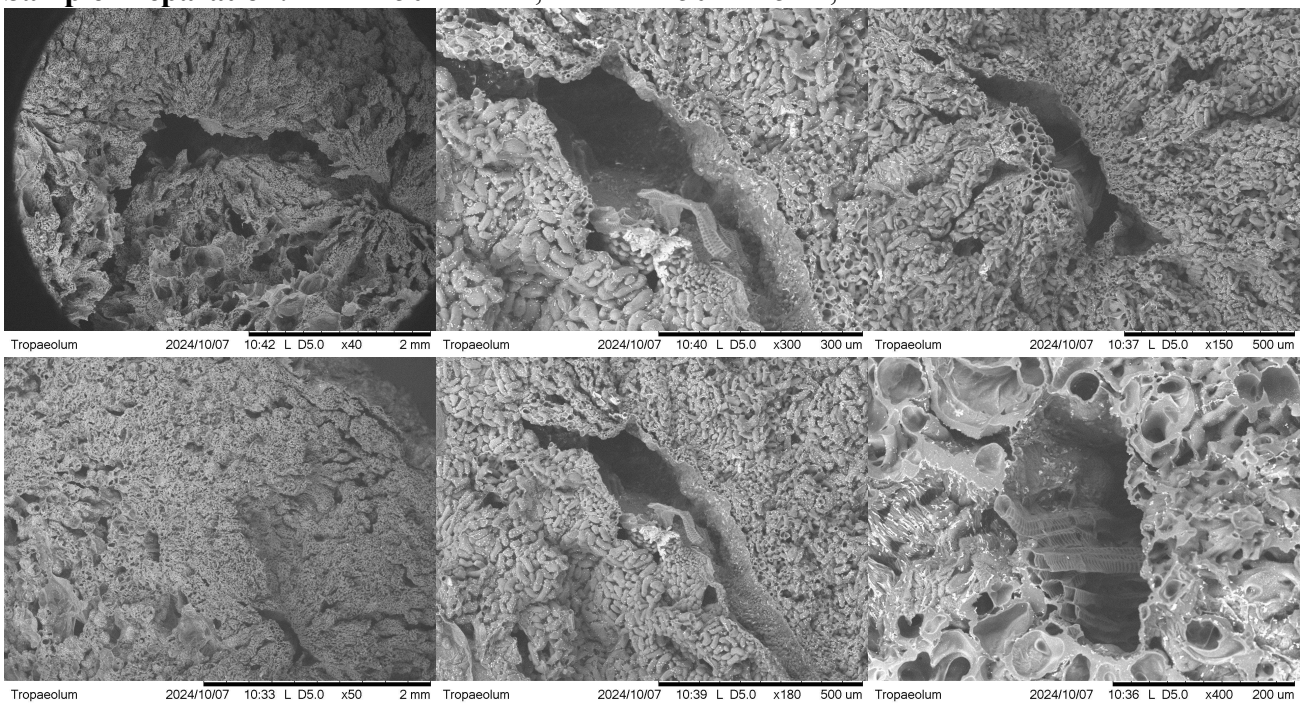
Sample Preparation: Charred at 250°C for 2.5hrs in foil



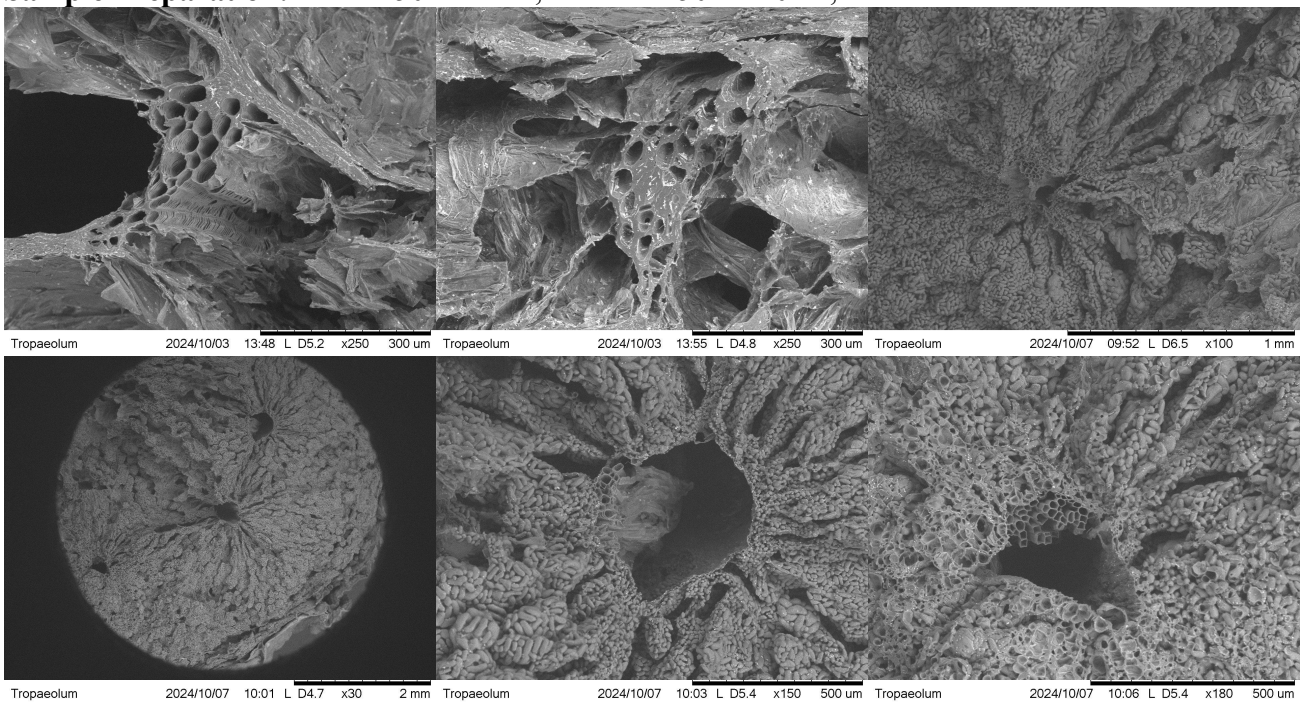
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Vascular Tissue Continued

Sample Preparation: Dried 150°F 12hrs, Charred 250°C 1.5hrs, in foil



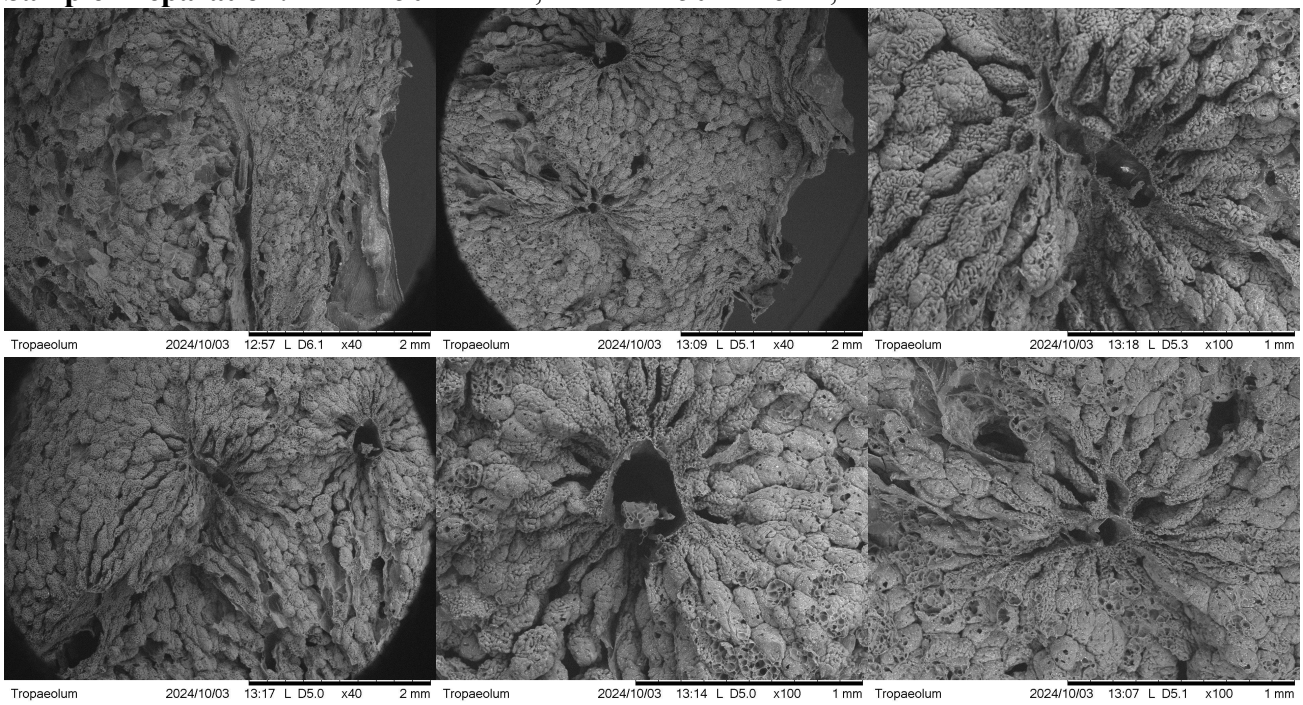
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.0hrs, in foil



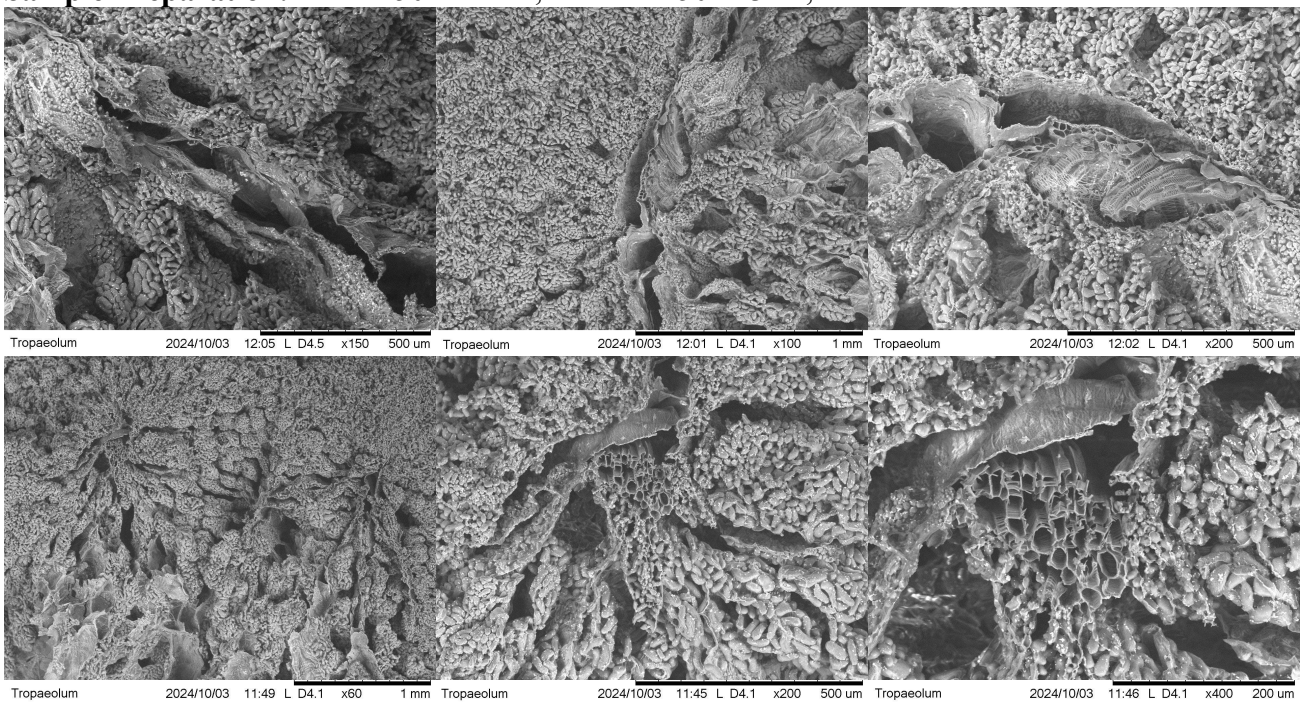
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Vascular Tissue Continued

Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.5hrs, in foil



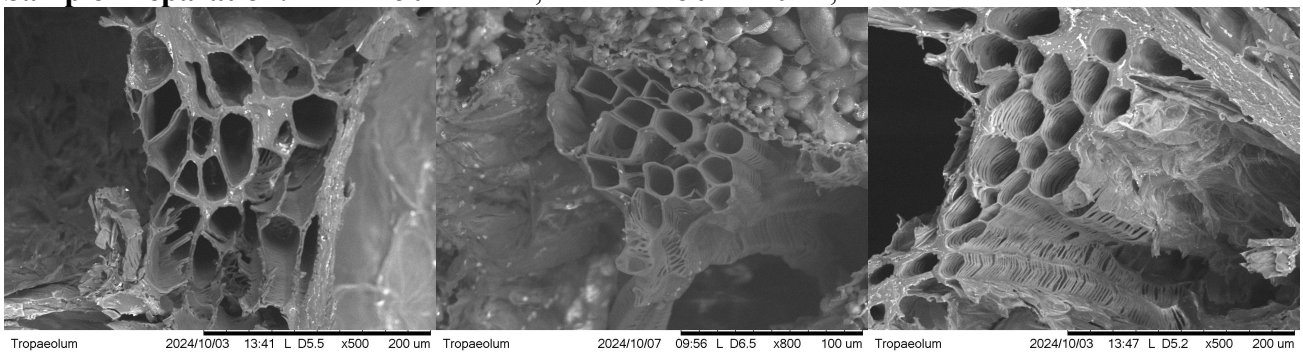
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 3hrs, in foil



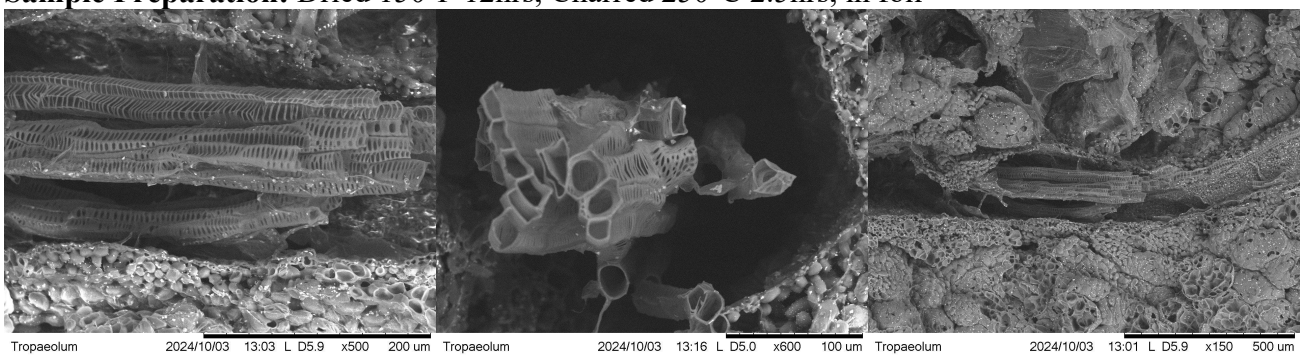
Scientific Name: *Tropaeolum tuberosum* **Common Name:** mashua **Type:** root

View: Xylem Perforation Structure: Spiral/Helical

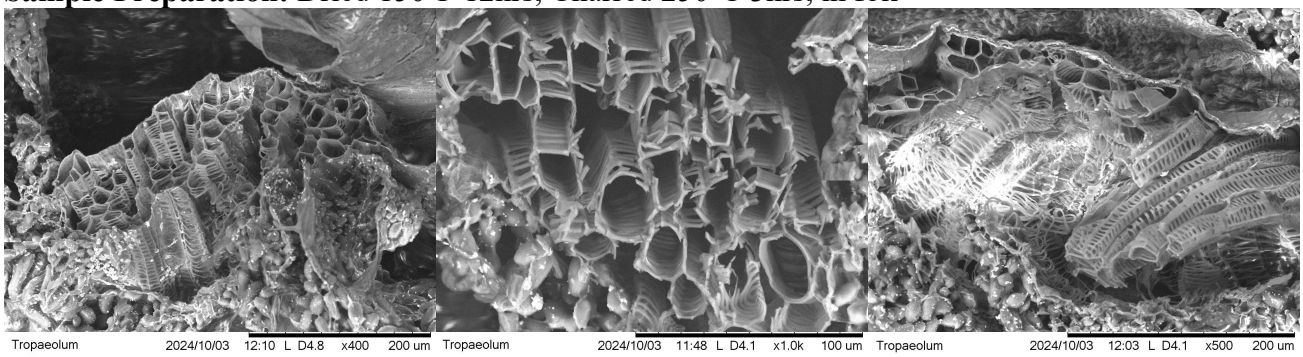
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.0hrs, in foil



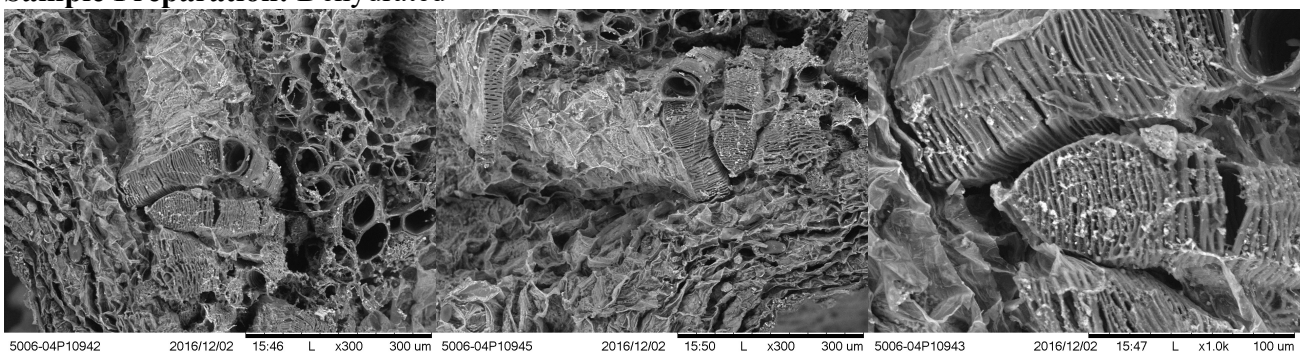
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 2.5hrs, in foil



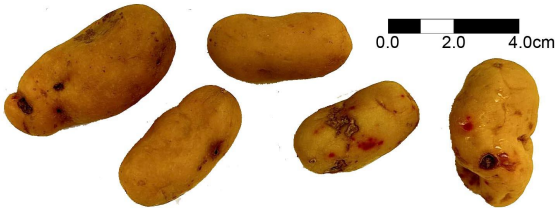
Sample Preparation: Dried 150°F 12hrs, Charred 250°C 3hrs, in foil



Sample Preparation: Dehydrated



Scientific Name: *Ullucus tuberosus*
Common Name: ulluco/papalisa
Type: Root

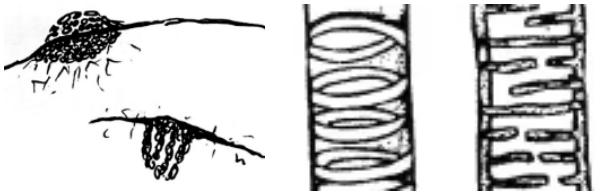


SUMMARY DESCRIPTION OF ANATOMICAL FEATURES:

Exterior Surface: Smooth/Wrinkled: Large folds and wrinkles with very little cell structure visible.

Periderm: Thin: very thin, 1 to 3 cells thick.

Vascular Tissue: Irregular: concentrated in irregular and semi-rectangular shaped bundles with 10+ xylem cells in diameter. Arranged in a transverse ring.
Xylem Perforation Structure: helical/spiral and scalariform

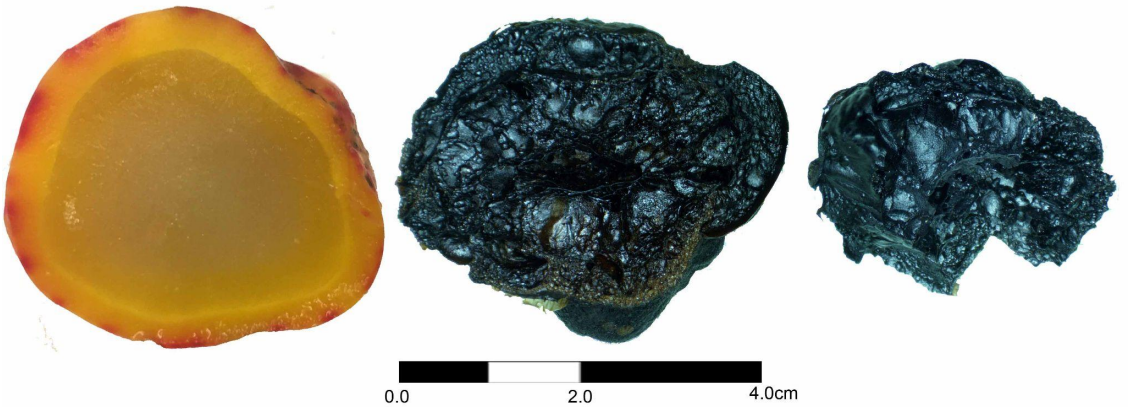


Forms of Preparation:

- Stained
- Dehydrated
- Charred 'fresh' (not dried or boiled) in foil 250°C 2.5hrs buried in sand
- Boiled 20min Charred 250°C for 2.5hrs in foil buried in sand
- Dried at 150°F for 12hrs, Charred at 250°C for 2.0hrs in foil
- Dried at 150°F for 24hrs, Charred at 250°C for 2.0hrs in foil
- Dried at 150°F for 24hrs, Charred at 250°C for 2.5hrs in foil

Transverse views: Note central area preserves poorly when charred

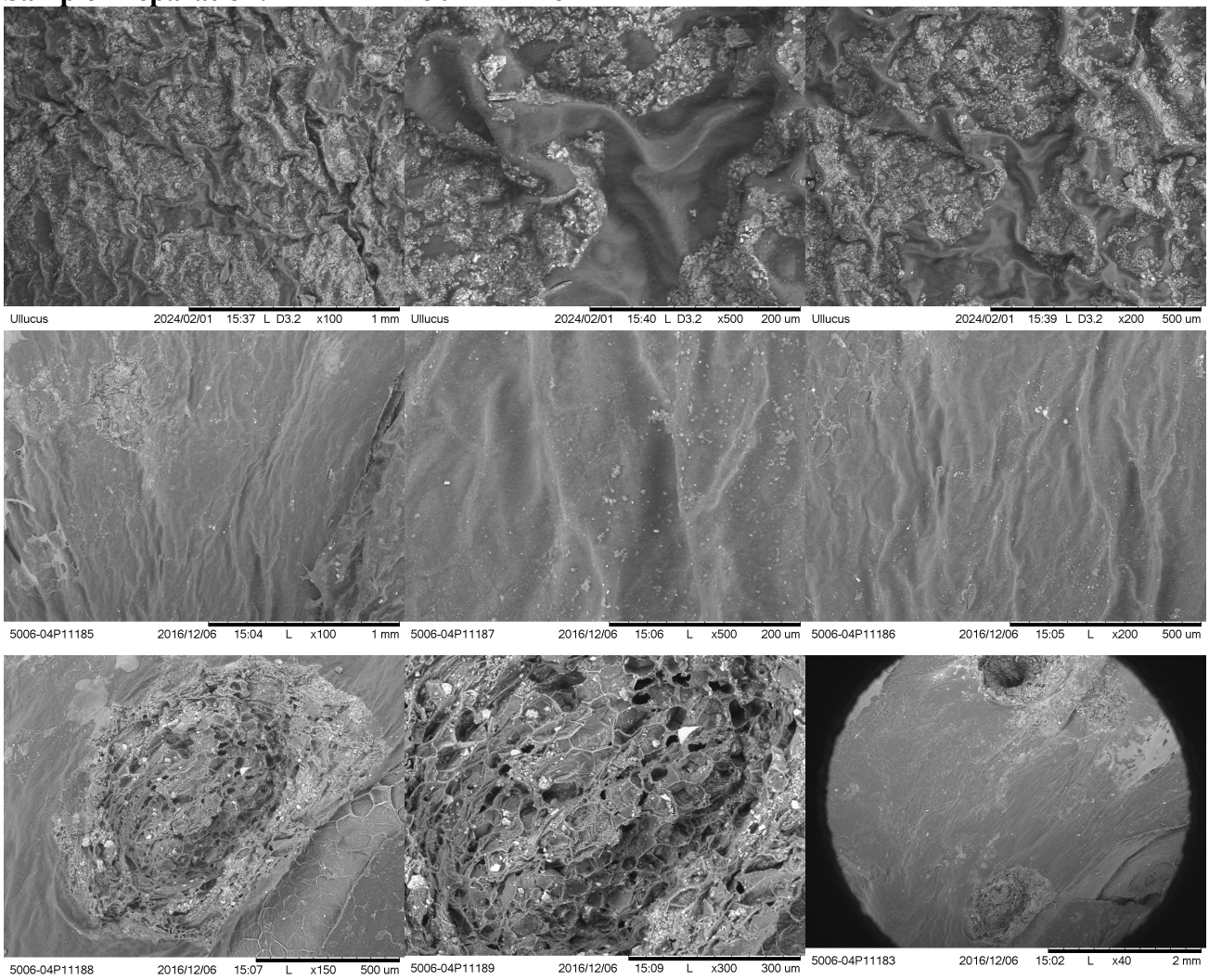
Fresh Charred Boiled and Charred



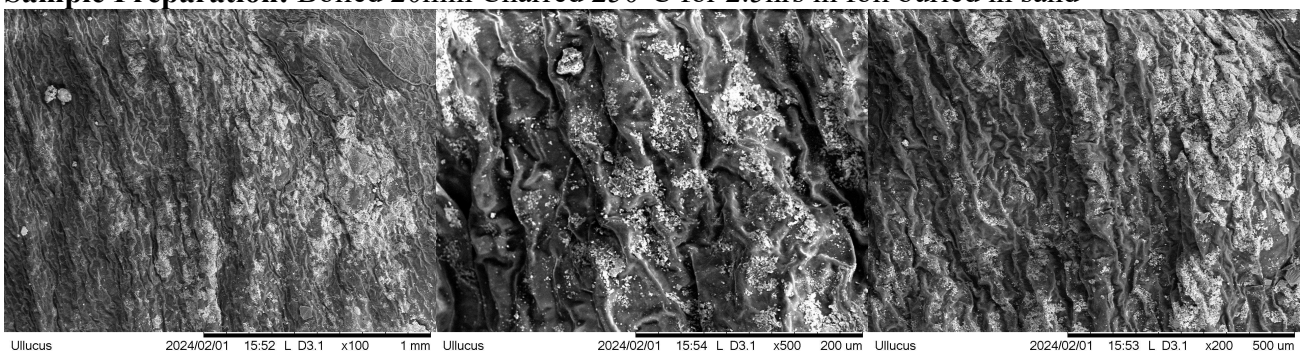
Scientific Name: *Ullucus tuberosus* **Common Name:** ulluco/papalisa **Type:** Root

View: Exterior Surface

Sample Preparation: Charred at 250°C for 2.5hrs in foil buried in sand



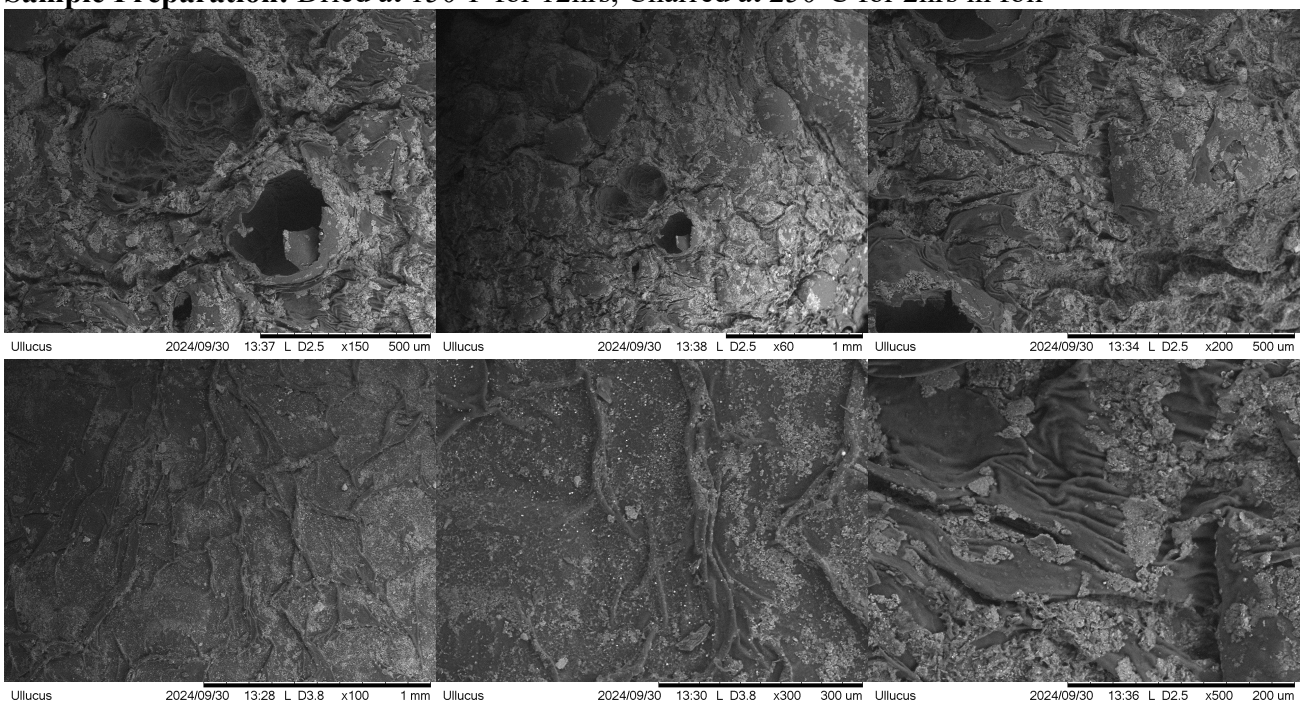
Sample Preparation: Boiled 20min Charred 250°C for 2.5hrs in foil buried in sand



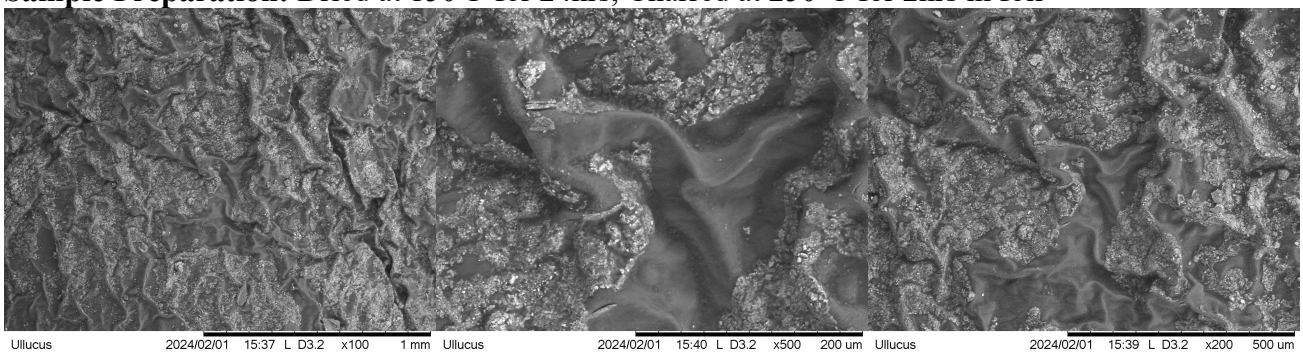
Scientific Name: *Ullucus tuberosus* **Common Name:** ulluco/papalisa **Type:** Root

View: Exterior Surface Continued

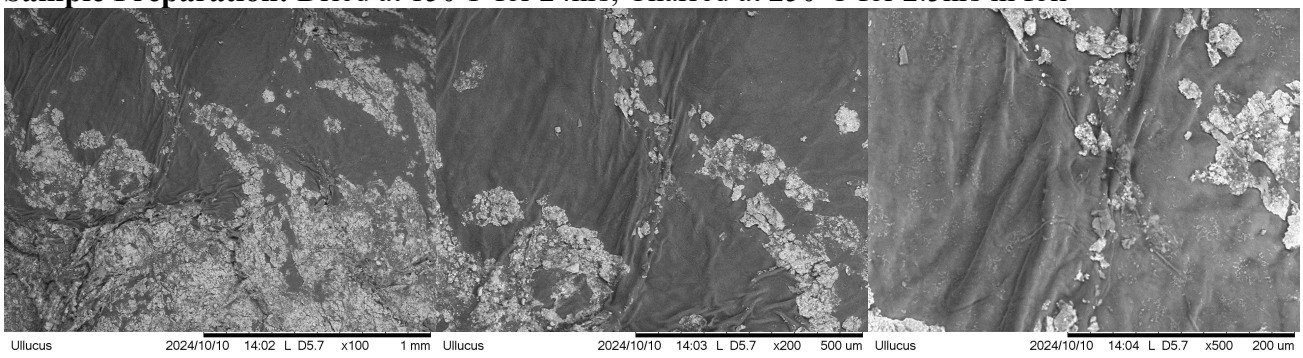
Sample Preparation: Dried at 150°F for 12hrs, Charred at 250°C for 2hrs in foil



Sample Preparation: Dried at 150°F for 24hrs, Charred at 250°C for 2hrs in foil



Sample Preparation: Dried at 150°F for 24hrs, Charred at 250°C for 2.5hrs in foil

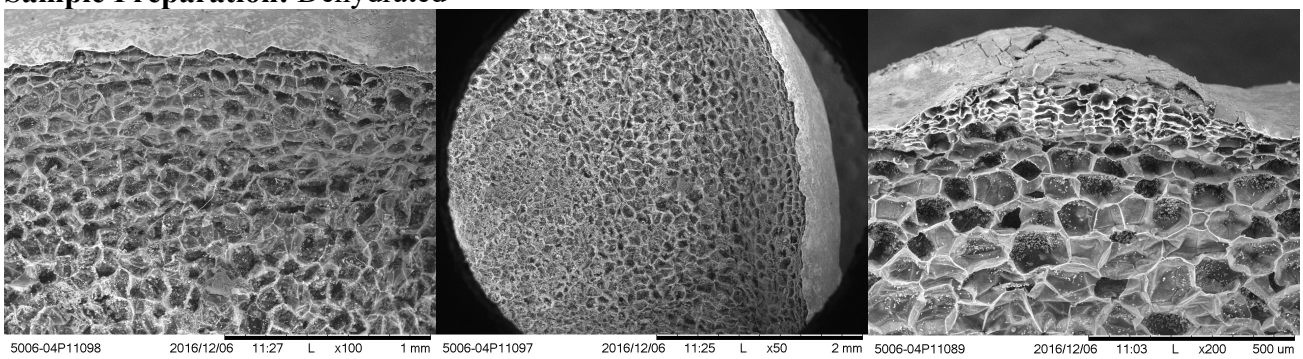


Scientific Name: *Ullucus tuberosus* **Common Name:** ulluco/papalisa **Type:** Root

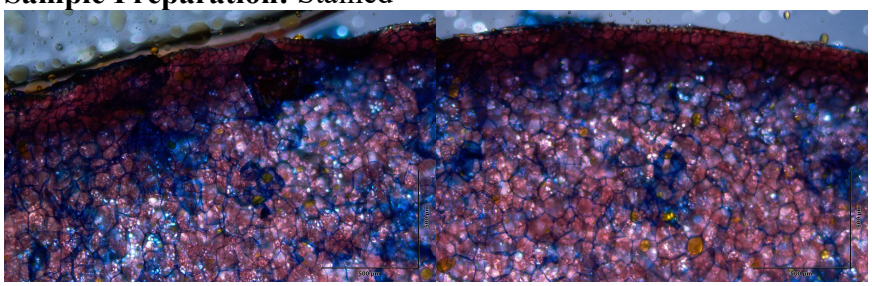
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View: Periderm

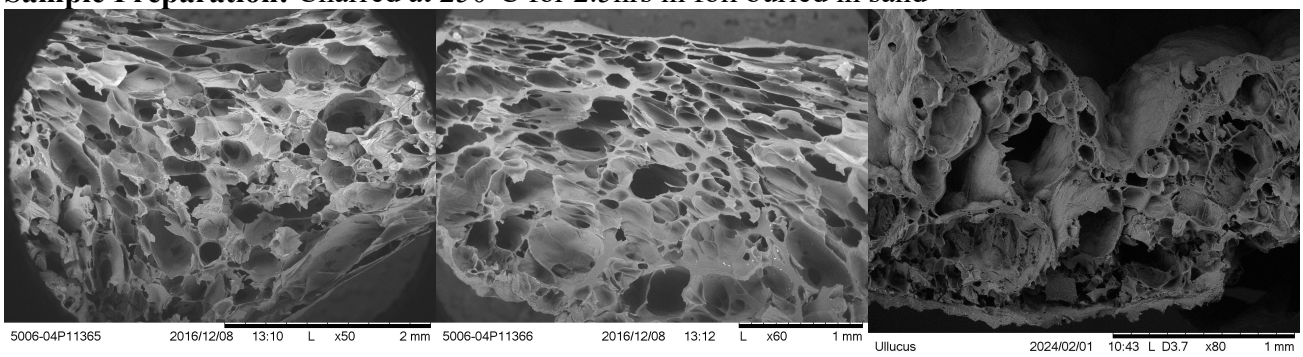
Sample Preparation: Dehydrated

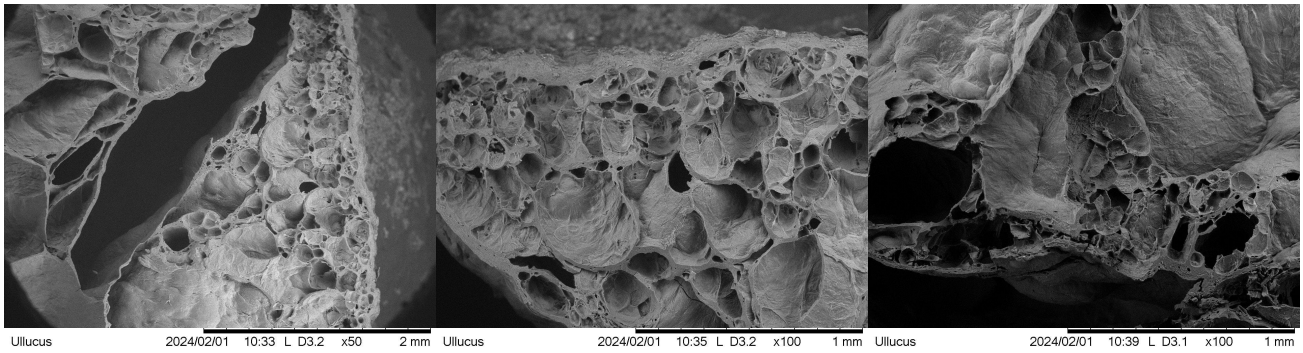


Sample Preparation: Stained



Sample Preparation: Charred at 250°C for 2.5hrs in foil buried in sand

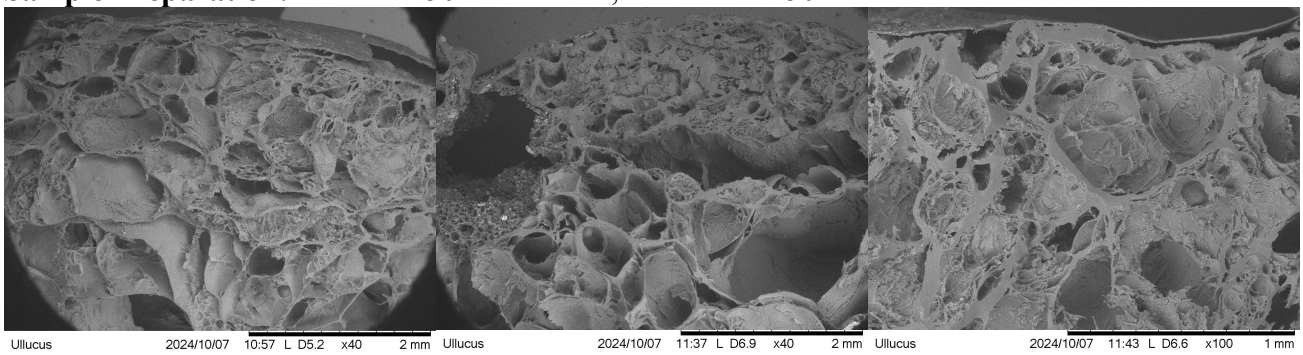




Scientific Name: *Ullucus tuberosus* **Common Name:** ulluco/papalisa **Type:** Root

View: Periderm Continued

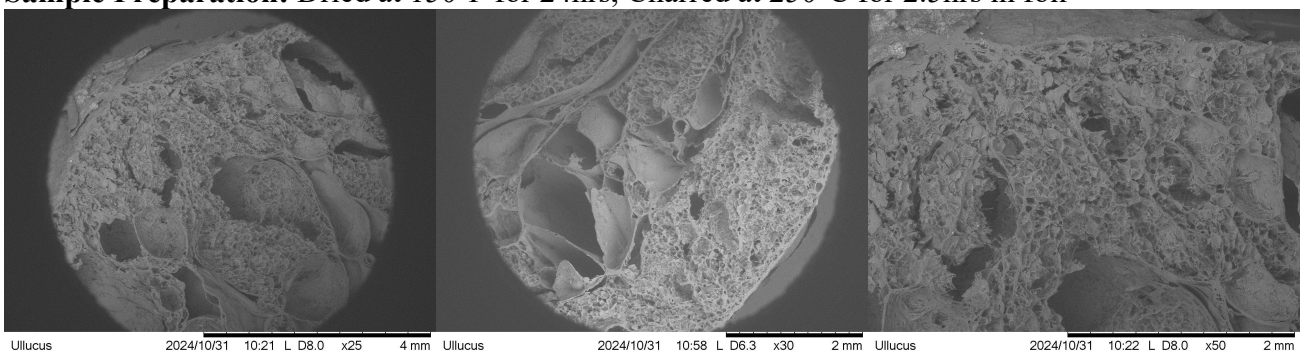
Sample Preparation: Dried at 150°F for 12hrs, Charred at 250°C for 2hrs in foil



Sample Preparation: Dried at 150°F for 24hrs, Charred at 250°C for 2hrs in foil



Sample Preparation: Dried at 150°F for 24hrs, Charred at 250°C for 2.5hrs in foil



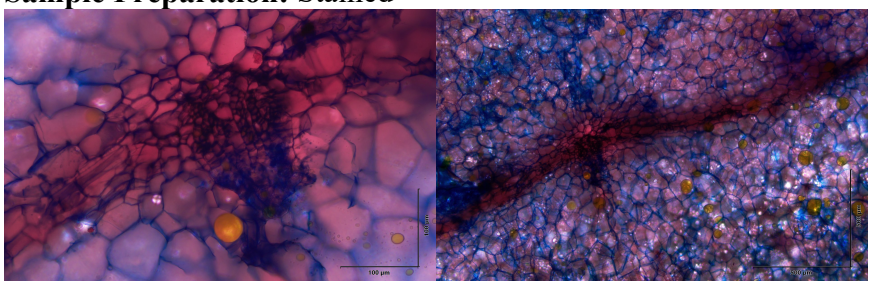
Sample Preparation: Boiled 20min Charred 250°C for 2.5hrs in foil buried in sand



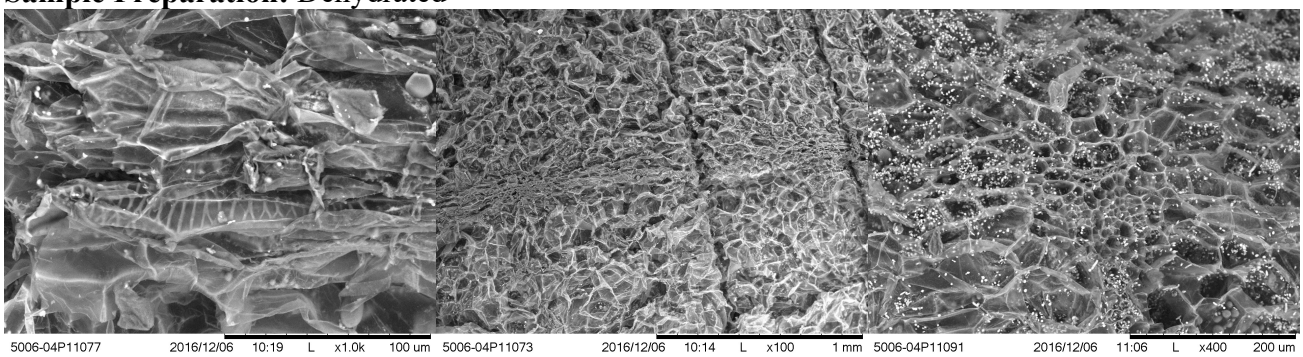
Scientific Name: *Ullucus tuberosus* **Common Name:** ulluco/papalisa **Type:** Root

View: Vascular Tissue

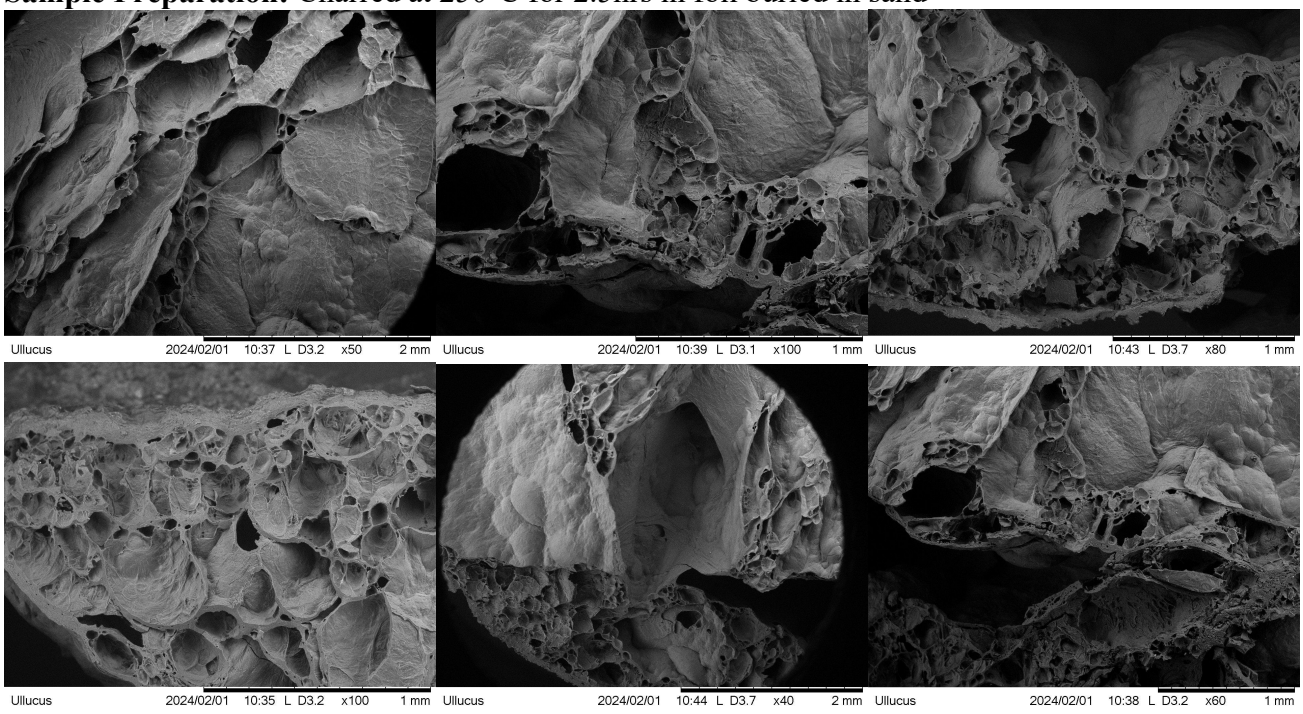
Sample Preparation: Stained



Sample Preparation: Dehydrated



Sample Preparation: Charred at 250°C for 2.5hrs in foil buried in sand



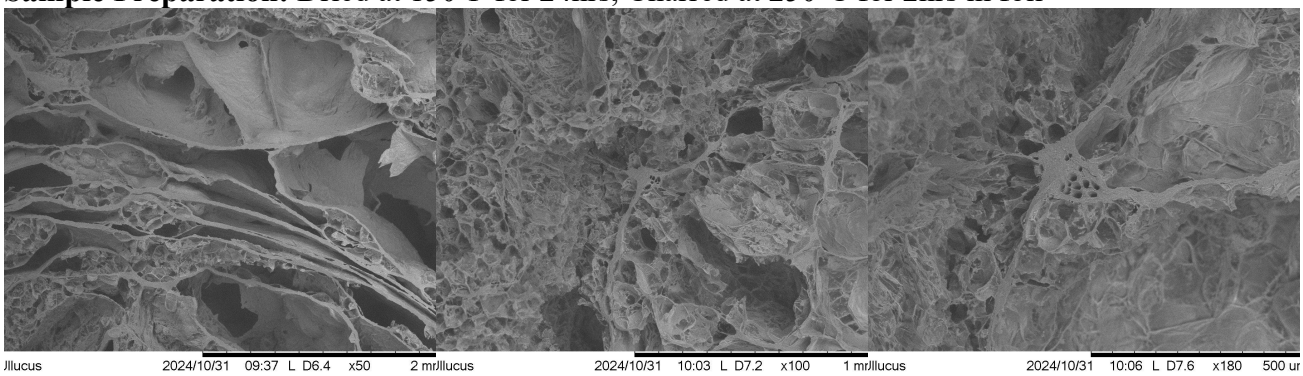
Scientific Name: *Ullucus tuberosus* **Common Name:** ulluco/papalisa **Type:** Root

View: Vascular Tissue Continued

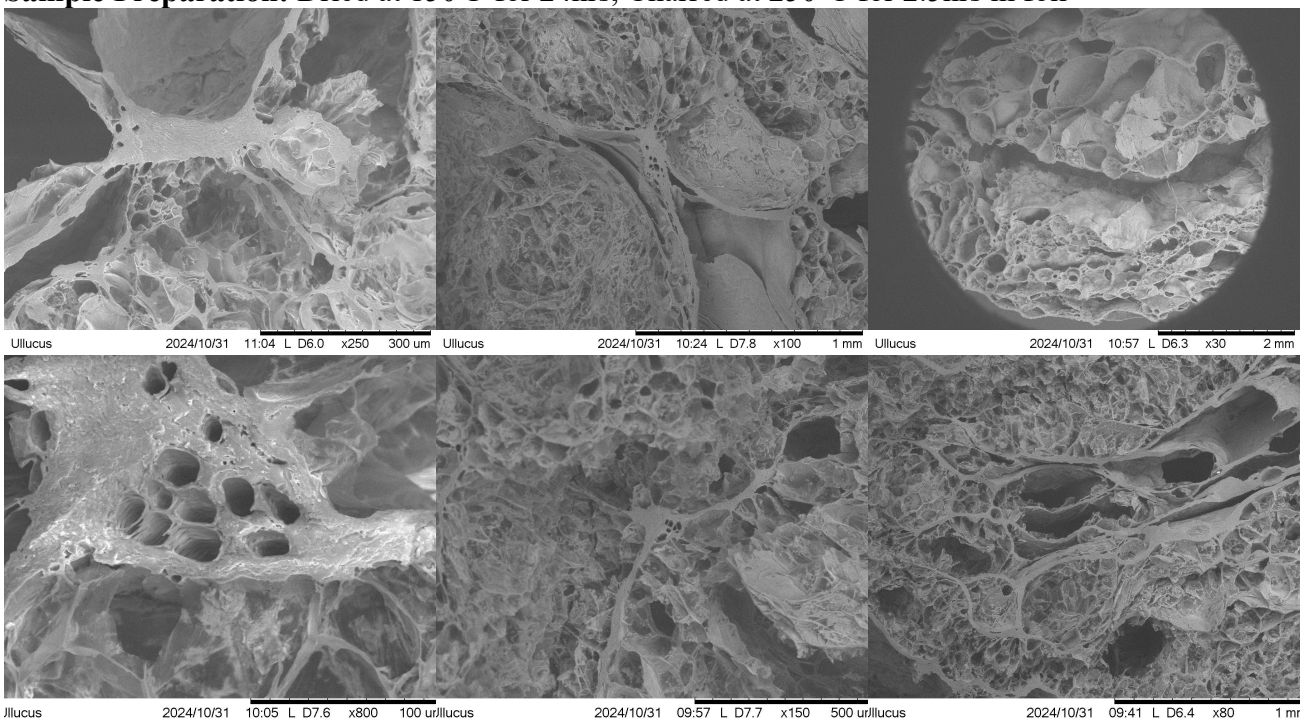
Sample Preparation: Dried at 150°F for 12hrs, Charred at 250°C for 2hrs in foil



Sample Preparation: Dried at 150°F for 24hrs, Charred at 250°C for 2hrs in foil



Sample Preparation: Dried at 150°F for 24hrs, Charred at 250°C for 2.5hrs in foil



Scientific Name: *Ullucus tuberosus* **Common Name:** ulluco/papalisa **Type:** Root

View: Xylem Pitting Structure

