RIT

Comparative assessment of biochar produced at laboratory and commercial scales

Yvan D. Hernandez-Charpak
Madan M. Manipati
Carlos A. Diaz
Thomas A. Trabold

Rochester Institute of Technology
Rochester, New York

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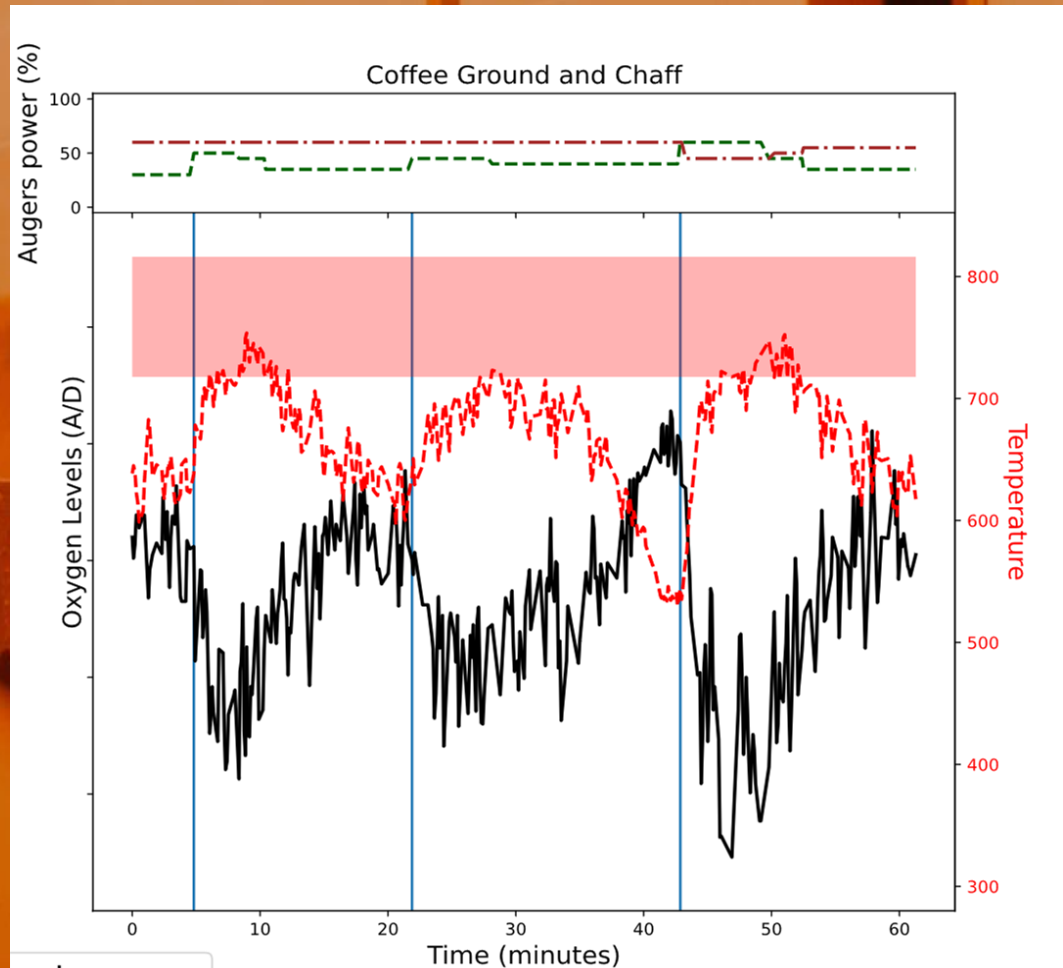
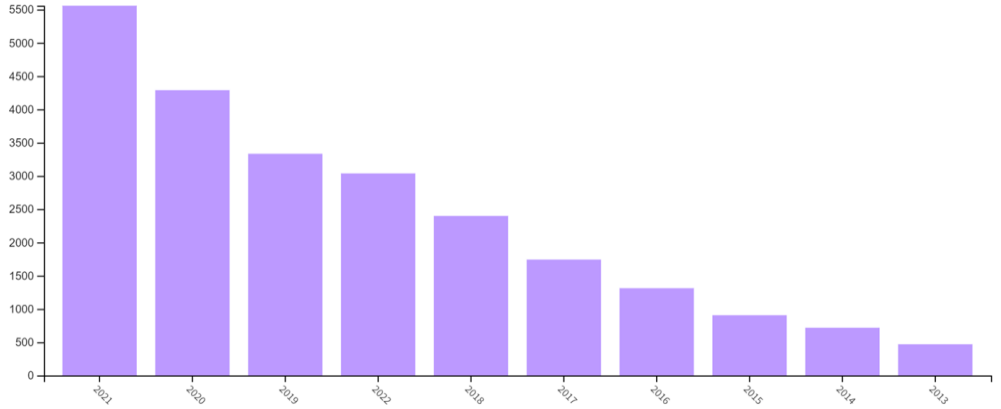
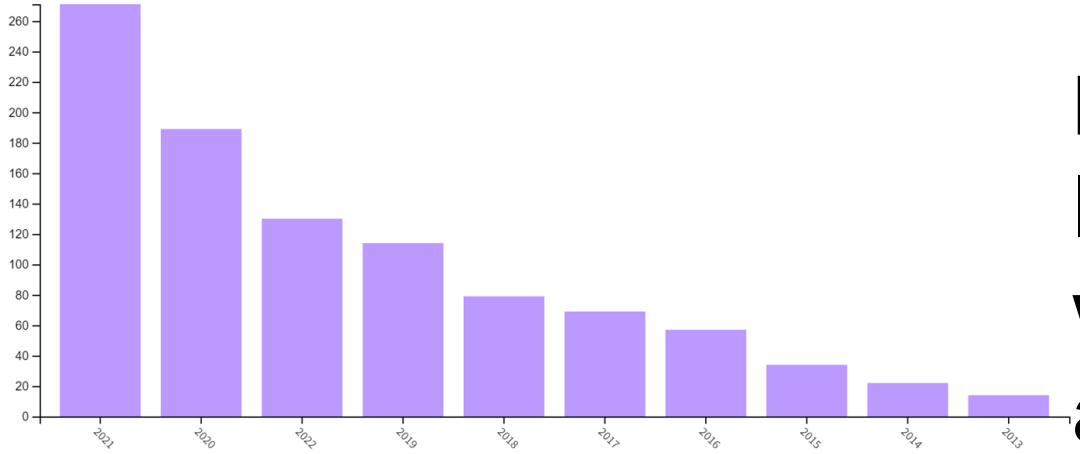


Motivation

More and more biochar knowledge and characterization (55k articles with ‘biochar’ last year)





But most of the work is made at a laboratory scale, only 260 articles when added keywords ‘production’ and ‘industrial’

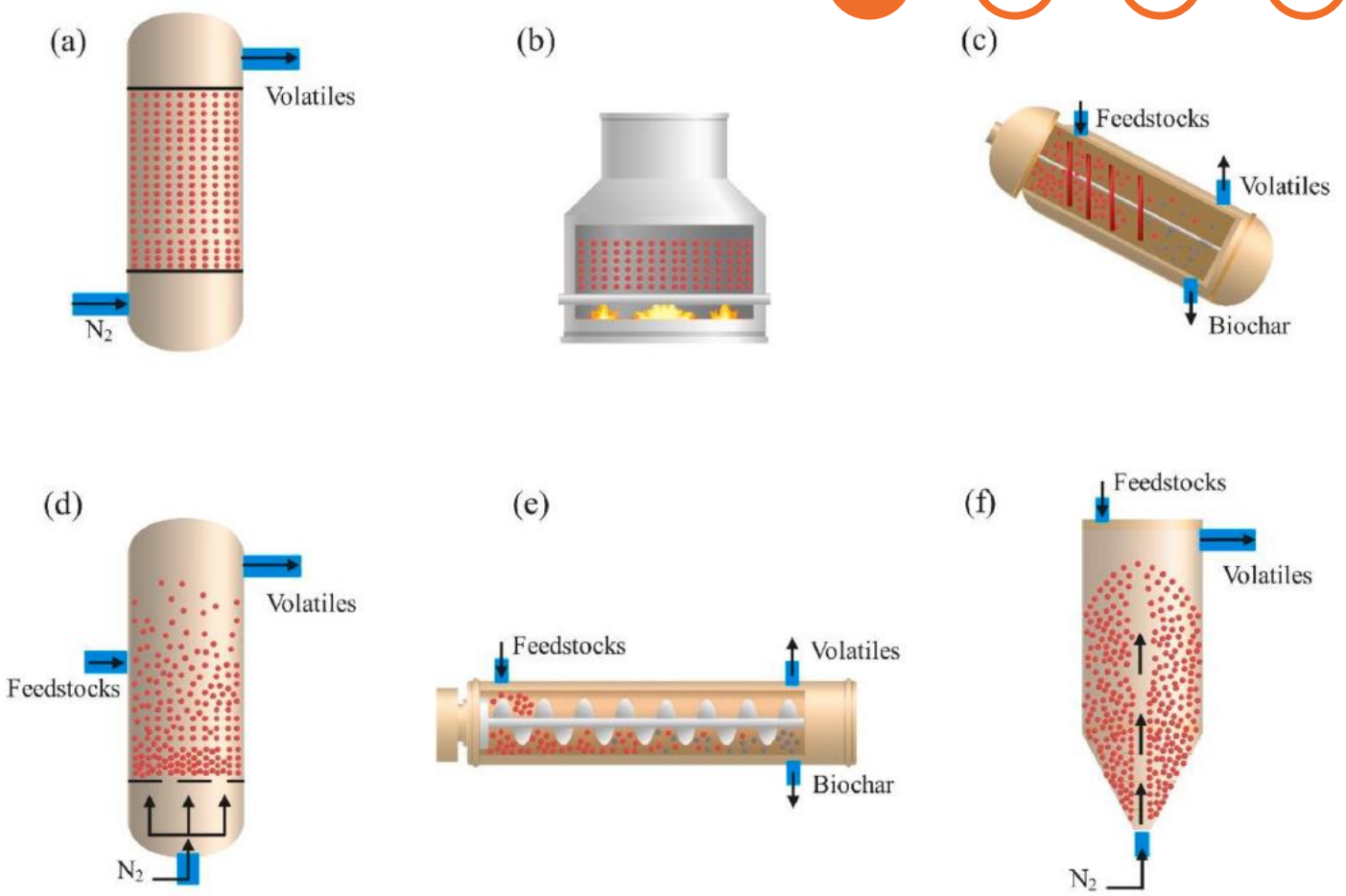
How different is biochar when produced at commercial scale?

(Web of Science, 2022)

Biochar at scale

- Multiple technologies are proven ready for industrial application

- Biochar production at industrial scale depends on the pyrolysis method



(X. Zhu et al., 2022)

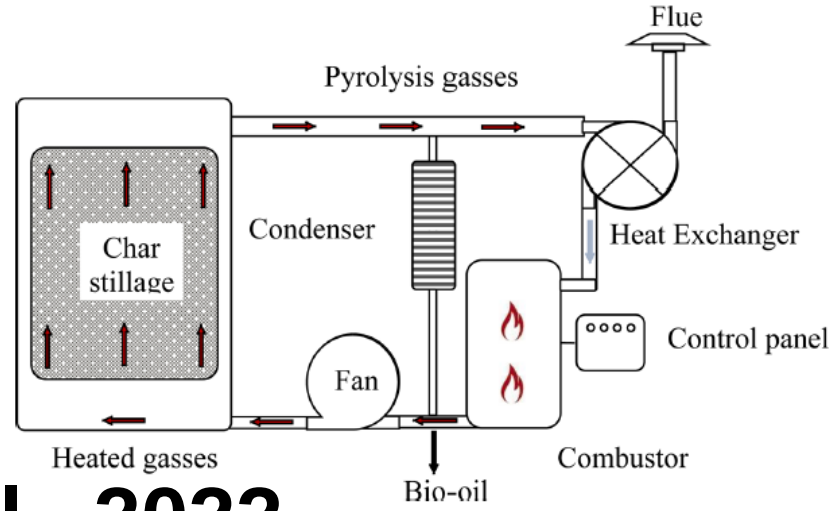
- **Objective:**

Compare laboratory biochar with a **commercial-scale auger** system produced biochar

Background

Mašeka et al., 2018

- Compared BC from a fixed bed reactor, a laboratory auger reactor and a rotary kiln
- Volatile matter (VM) as proxy.
- BC appear to be consistent through out methods, but key properties are missing like H:C, O:C, surface area, etc.



James et al., 2022

- Lab and commercial batch reactors
- Large-scale BC underperformed in efficient zinc removal.
- Important remark is the pyrolysis temperatures and high oxygen content (200C, 270C and 340C)

Methodology

Biochar production methods

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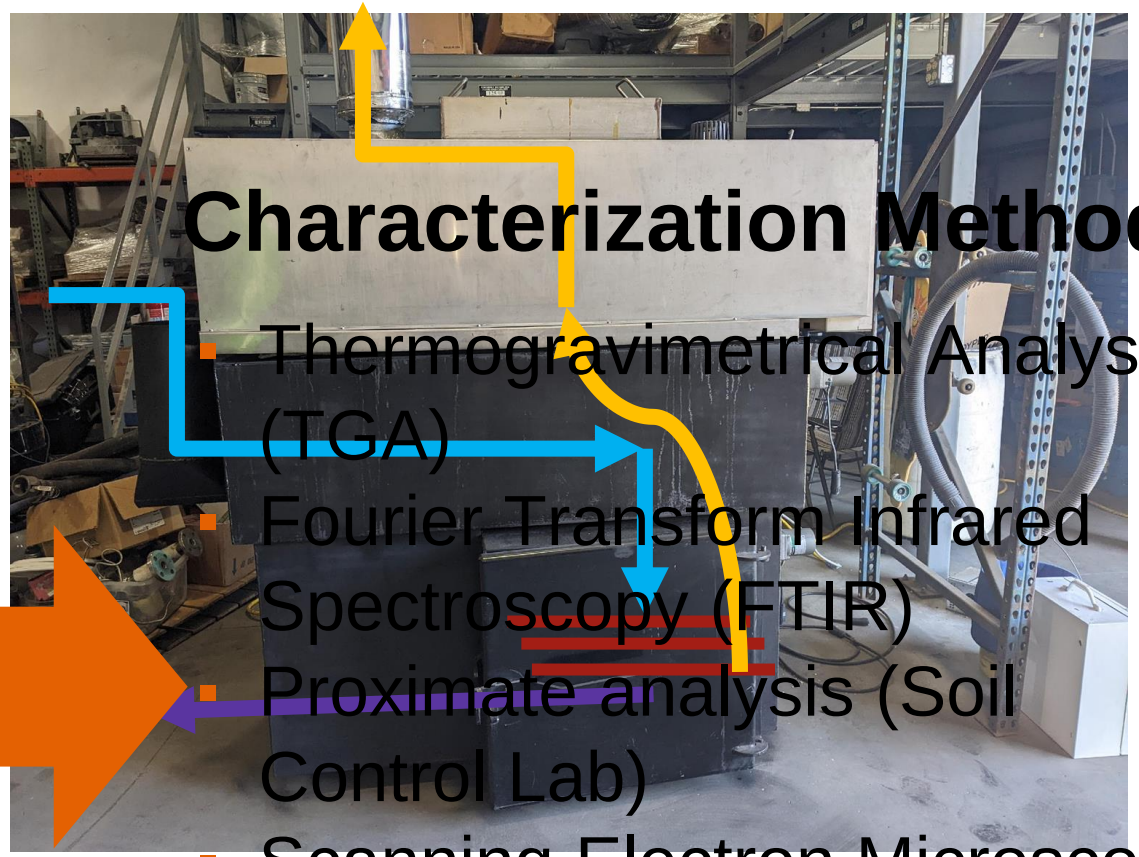
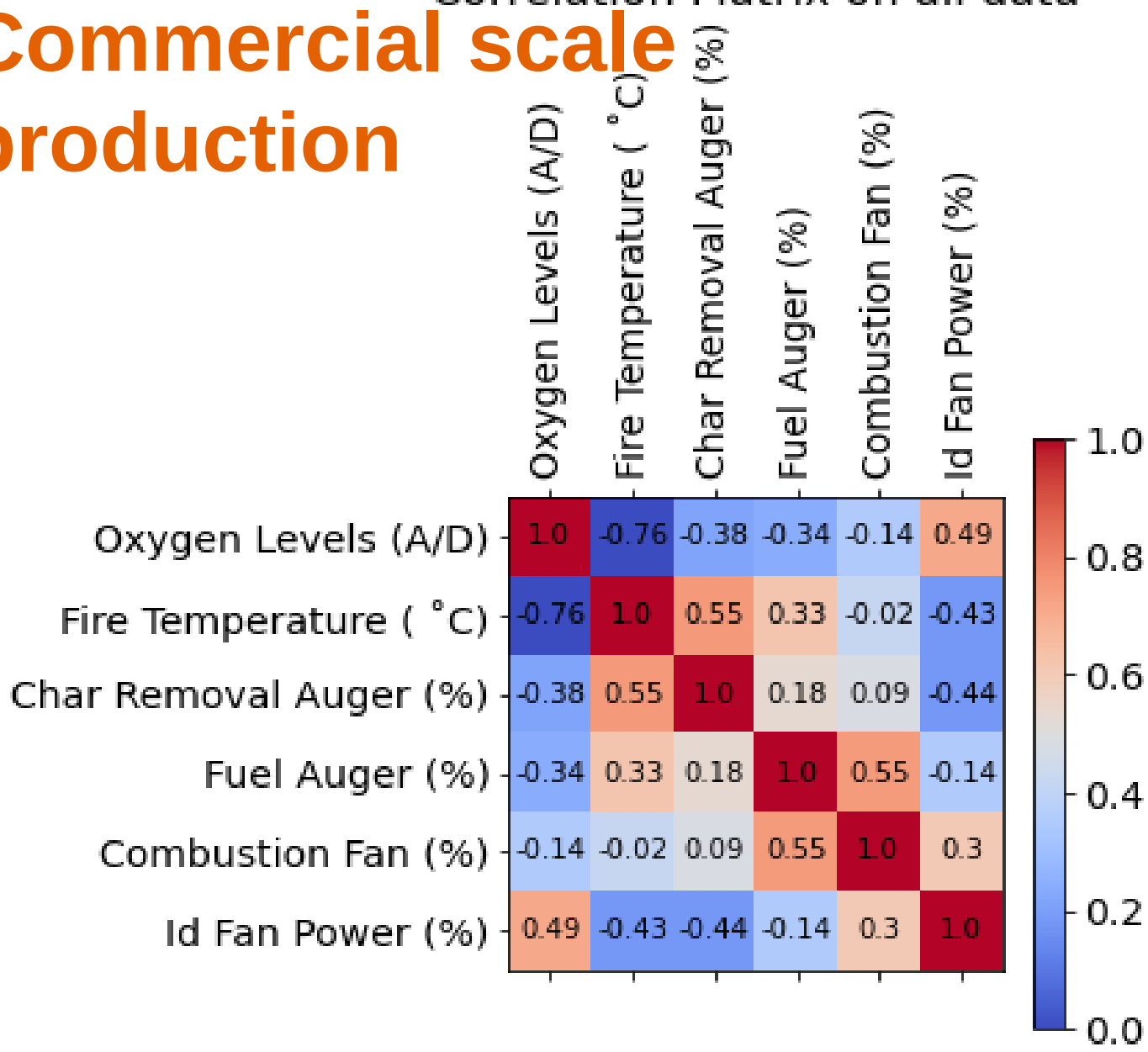
PP (97:3)

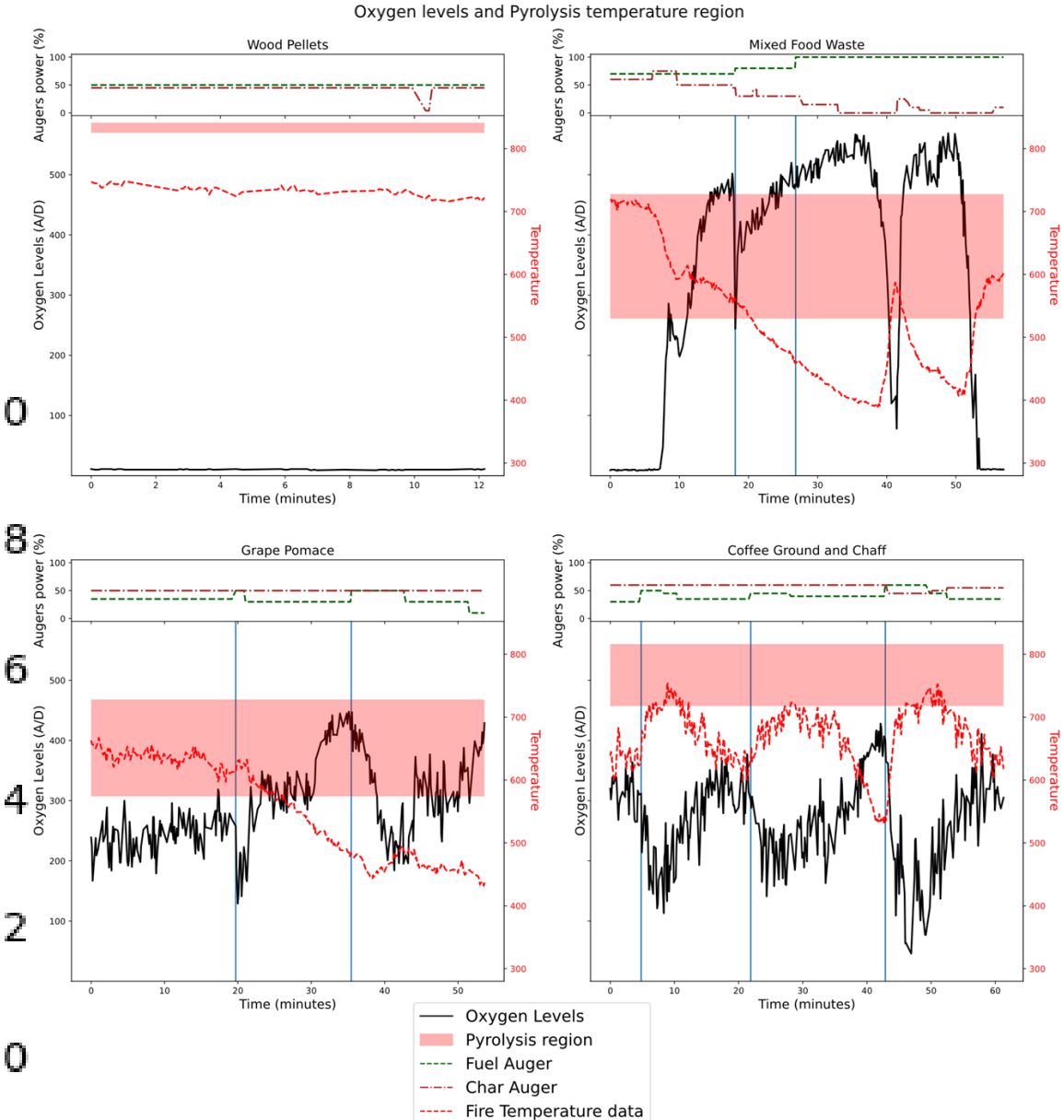


Characterization Methods

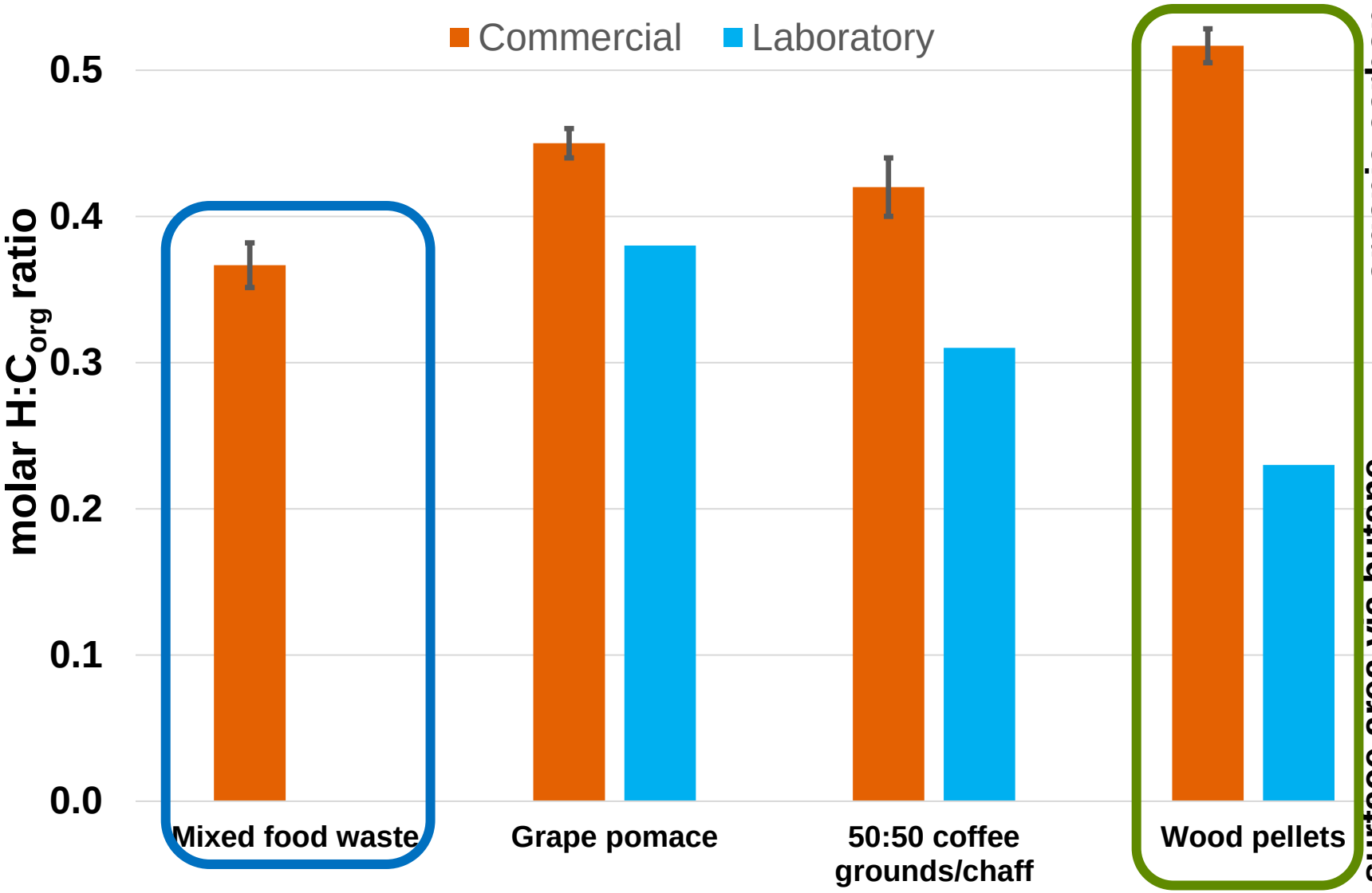
- Thermogravimetrical Analysis (TGA)
- Fourier Transform Infrared Spectroscopy (FTIR)
- Proximate analysis (Soil Control Lab)
- Scanning Electron Microscopy (SEM)

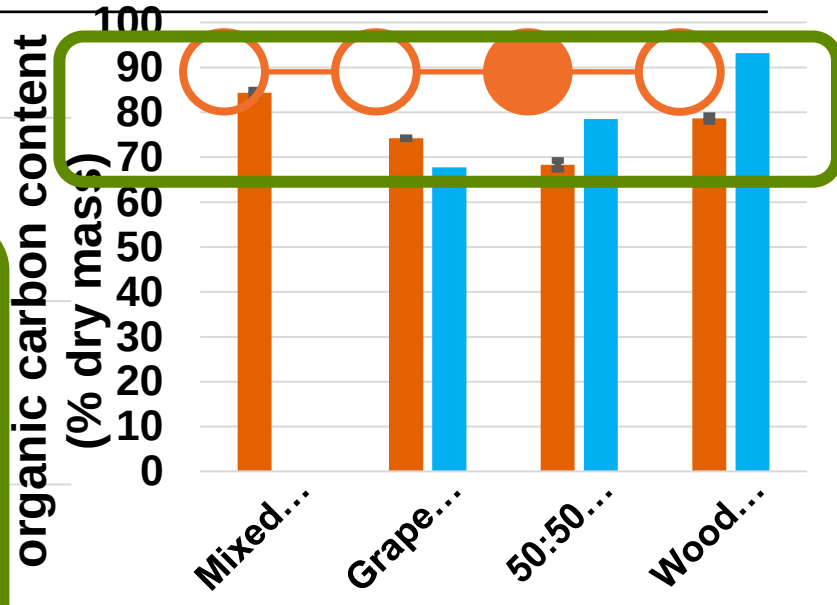
Commercial scale production

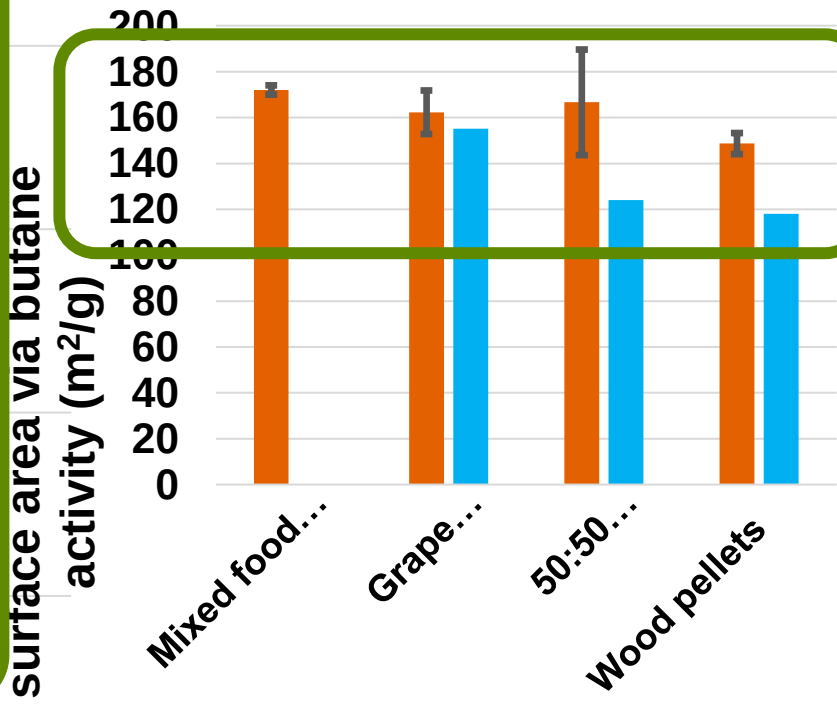


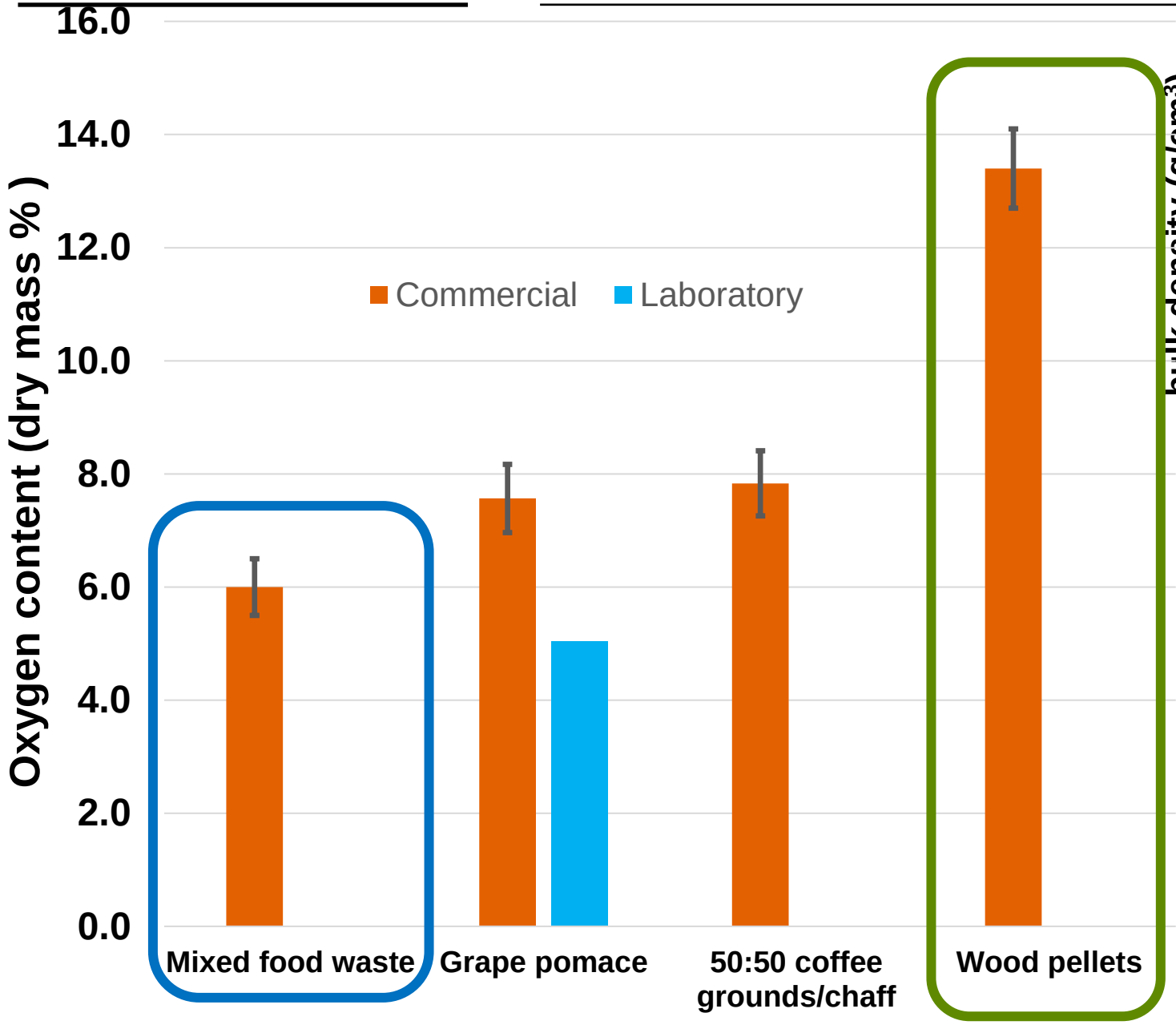


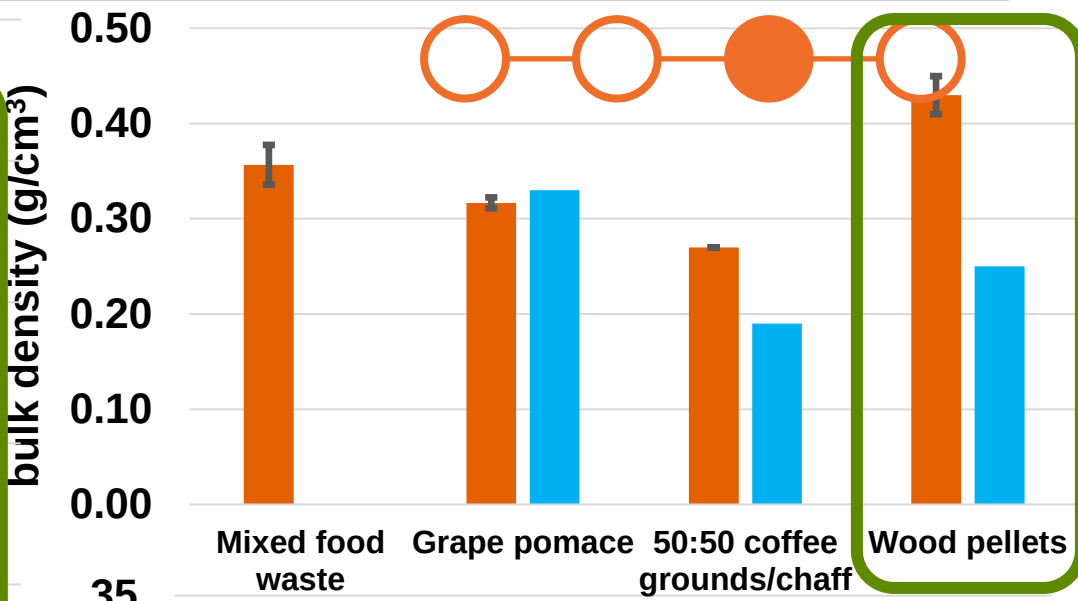
Soil Control lab Analysis

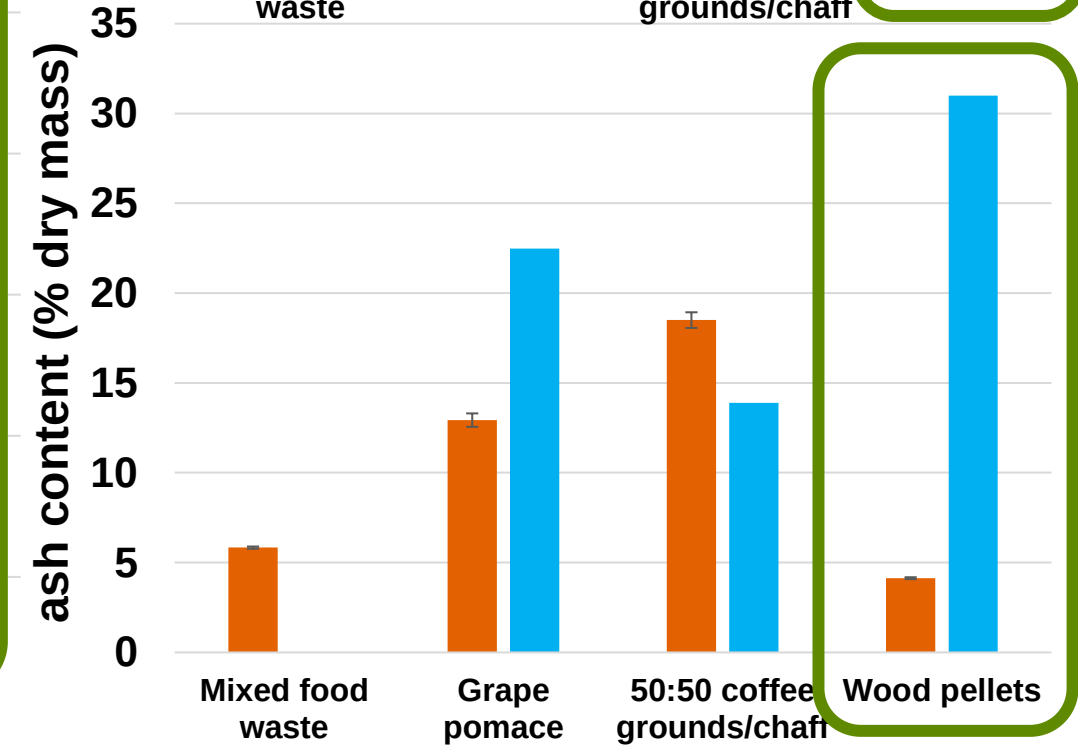




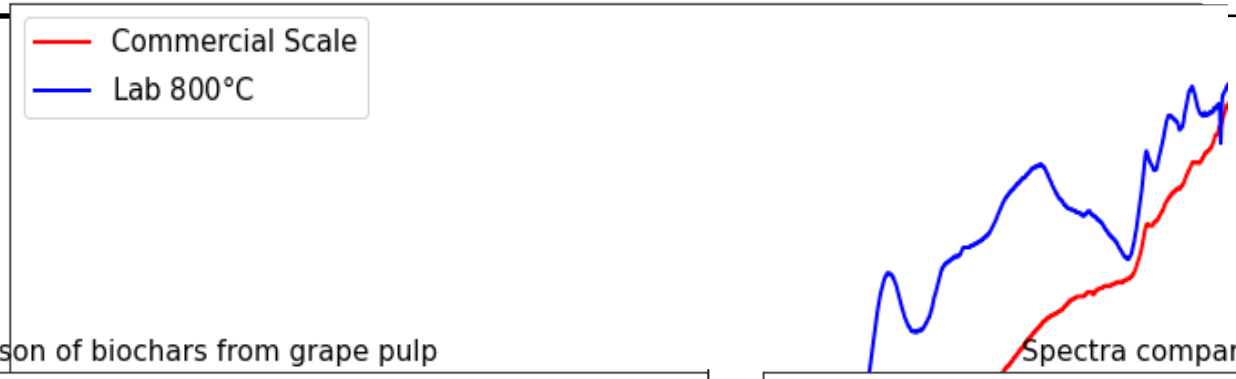


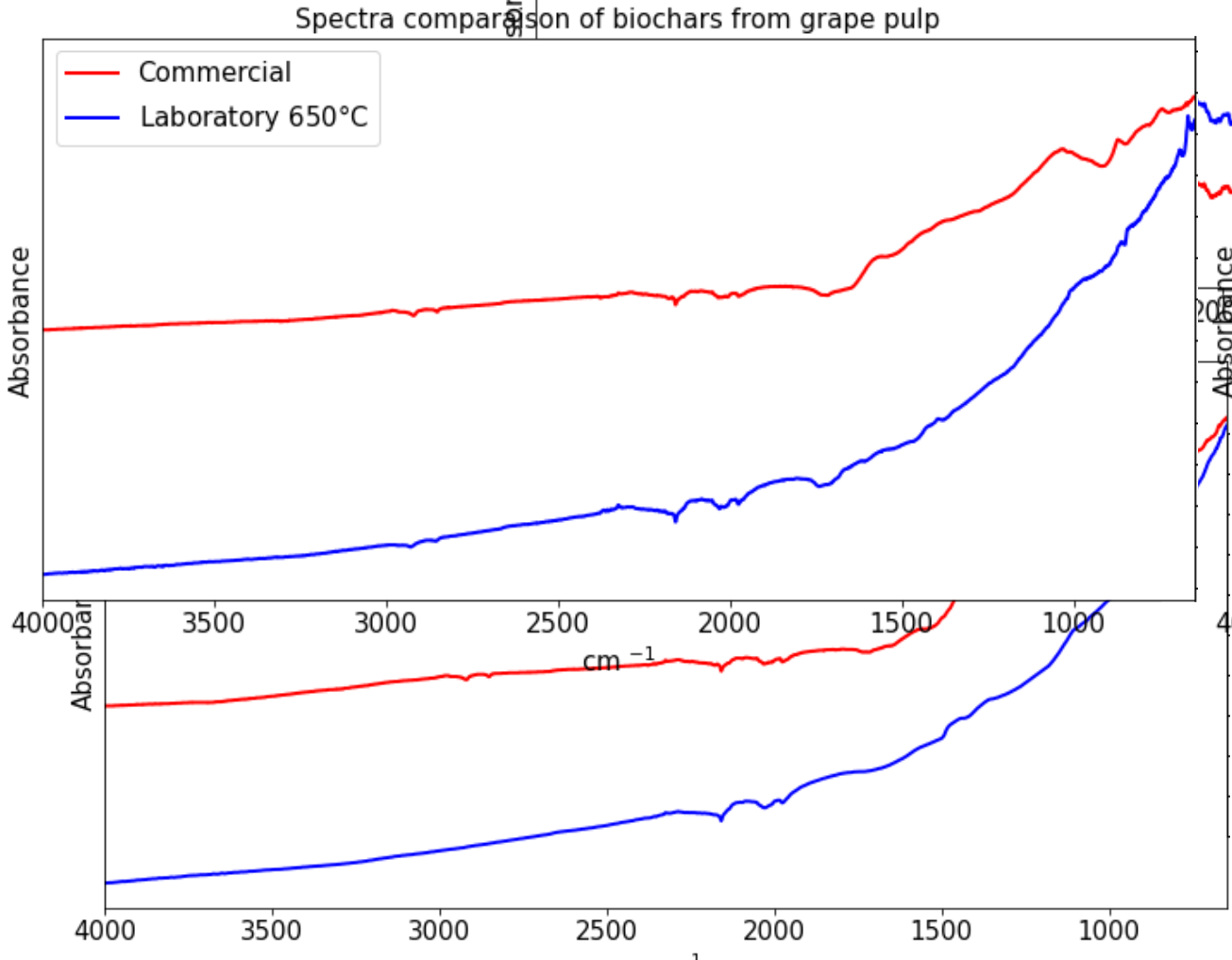

Oxygen content (dry mass %)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Commercial
Laboratory
Mixed food waste
Grape pomace
50:50 coffee grounds/chaff
Wood pellets

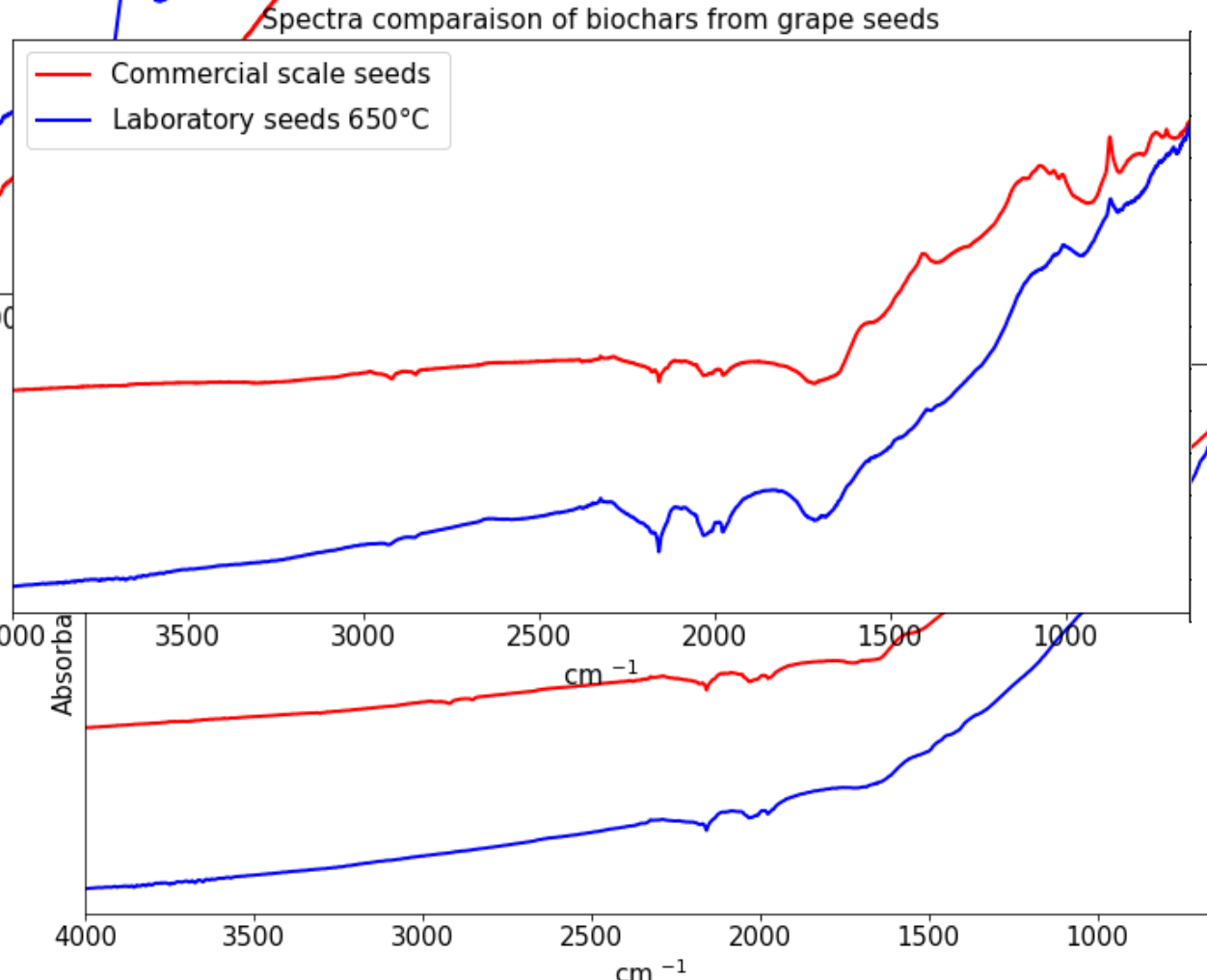

bulk density (g/cm³)
0.50
0.40
0.30
0.20
0.10
0.00
Mixed food waste
Grape pomace
50:50 coffee grounds/chaff
Wood pellets


ash content (% dry mass)
35
30
25
20
15
10
5
0
Mixed food waste
Grape pomace
50:50 coffee grounds/chaff
Wood pellets

FTIR

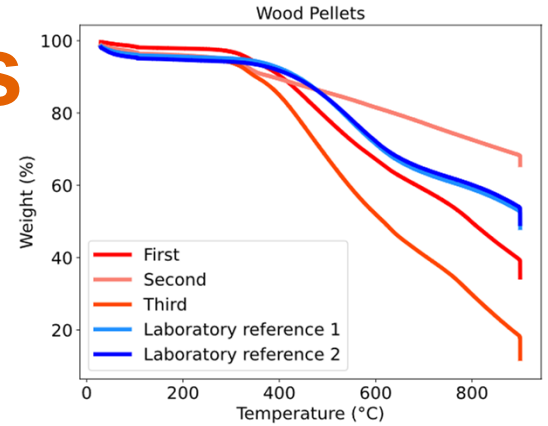

Spectra comparaison between the commercial scale WP Biochar and lab produced
Commercial Scale
Lab 800°C
Absorbance

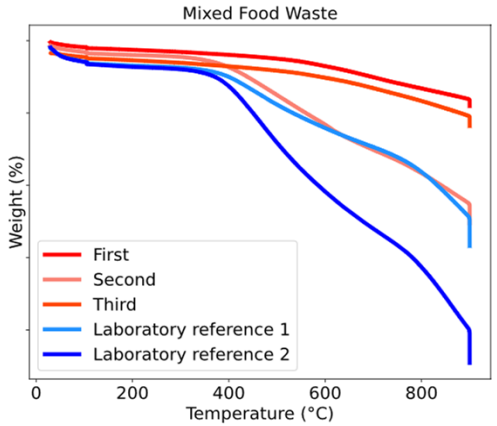

Spectra comparaison of biochars from grape pulp
Commercial
Laboratory 650°C
Absorbance
4000
3500
3000
2500
2000
1500
1000
cm −1

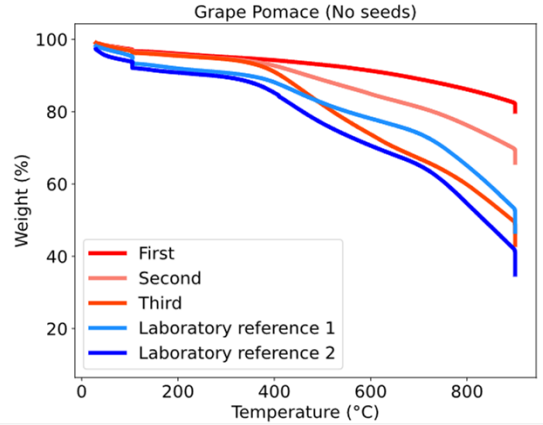

Spectra comparaison of biochars from grape seeds
Commercial scale seeds
Laboratory seeds 650°C
4000
3500
3000
2500
2000
1500
1000
cm −1

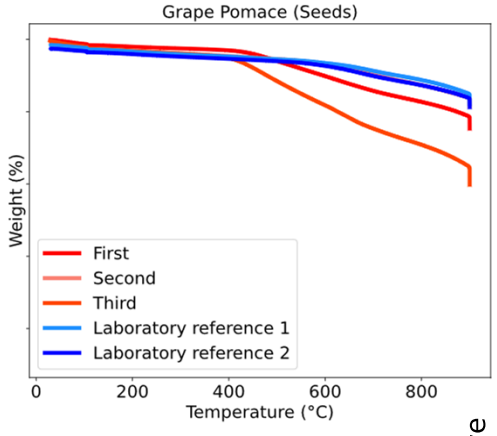
TGA profiles

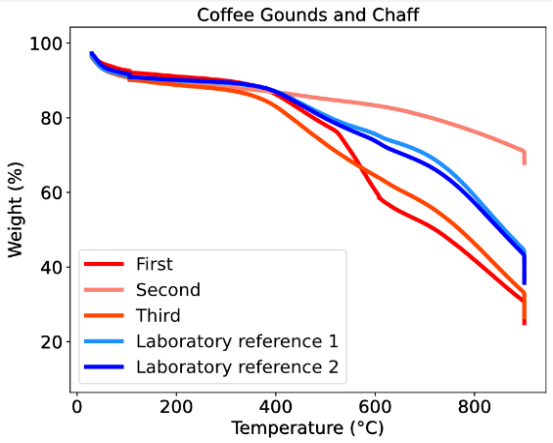
- Difference is in consistency of different levels of volatile matter
- Composition of volatiles is similar

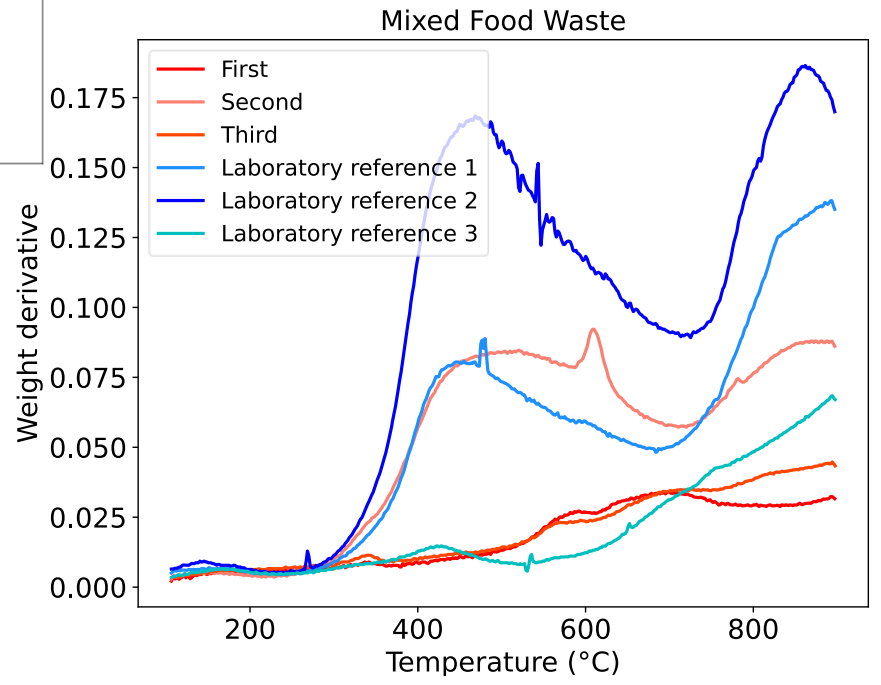






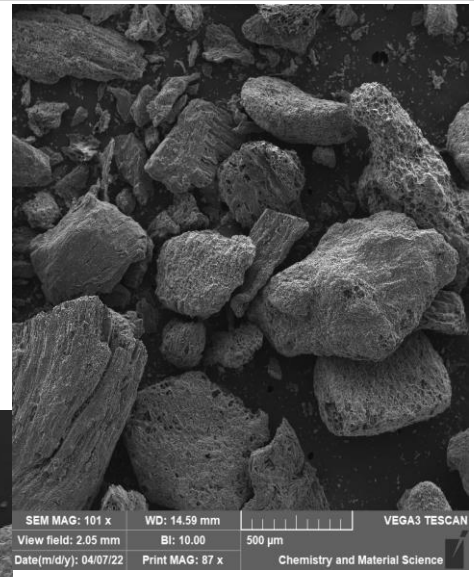


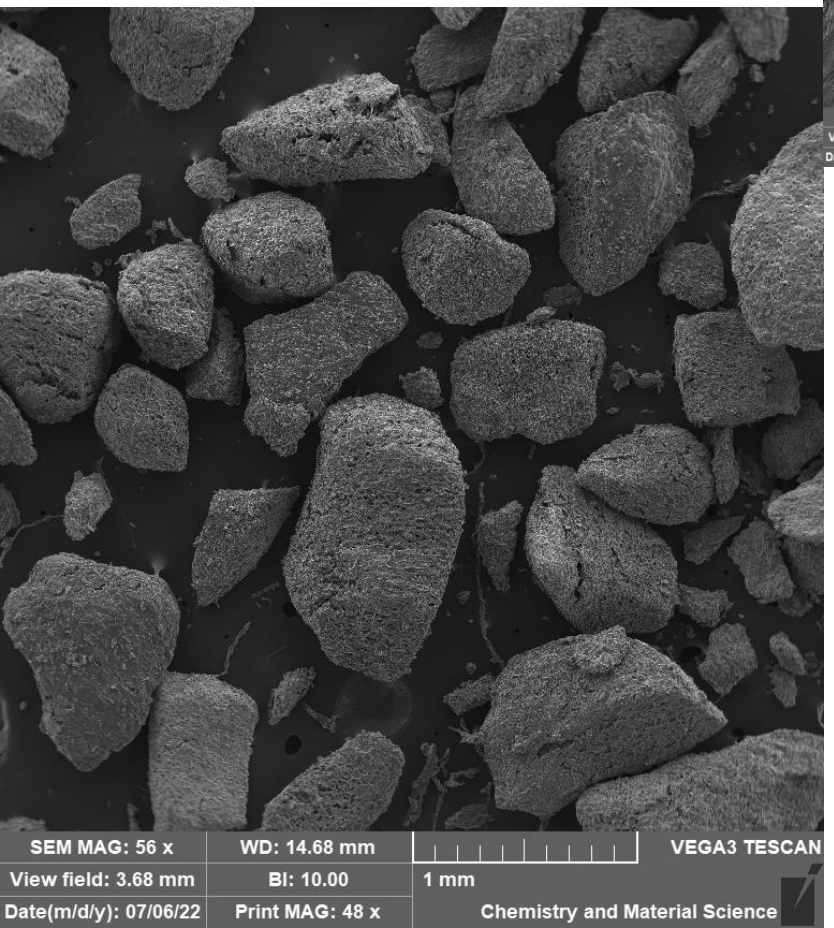




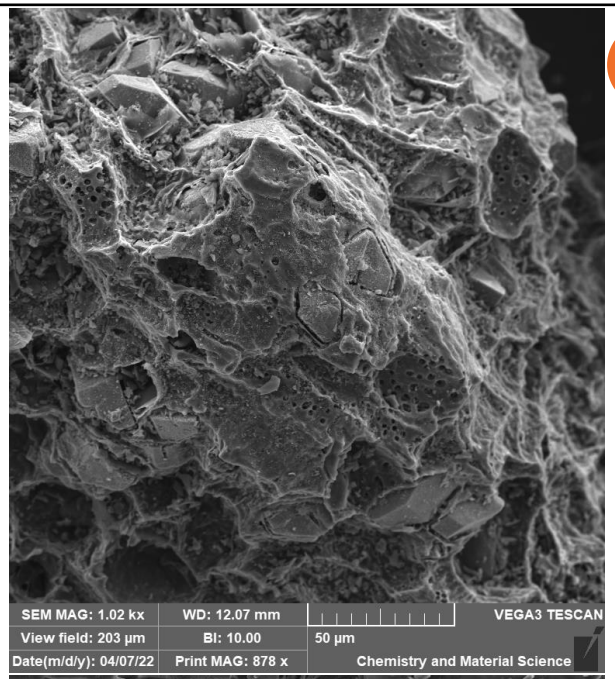
SEM

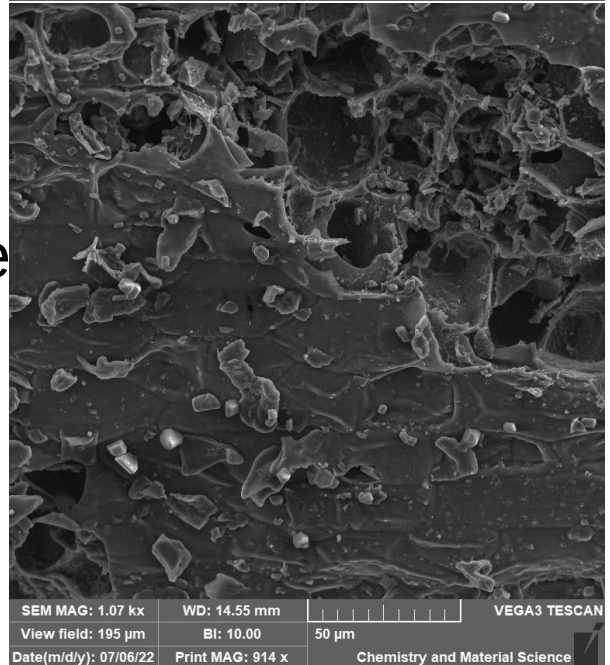
Commercial-scale





Laboratory-scale

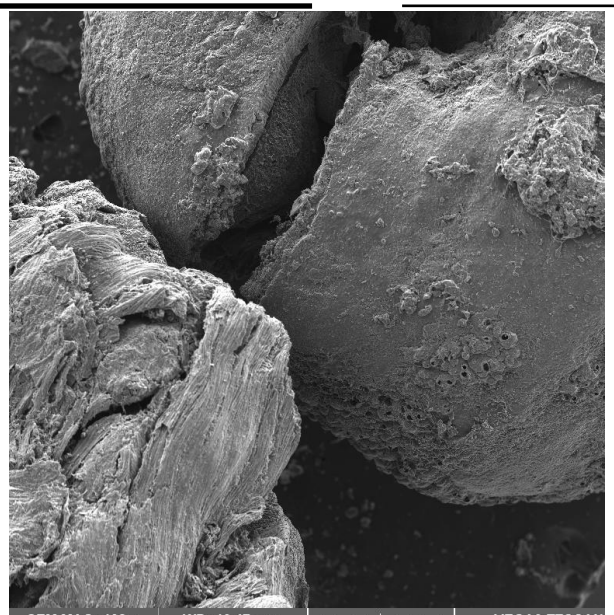


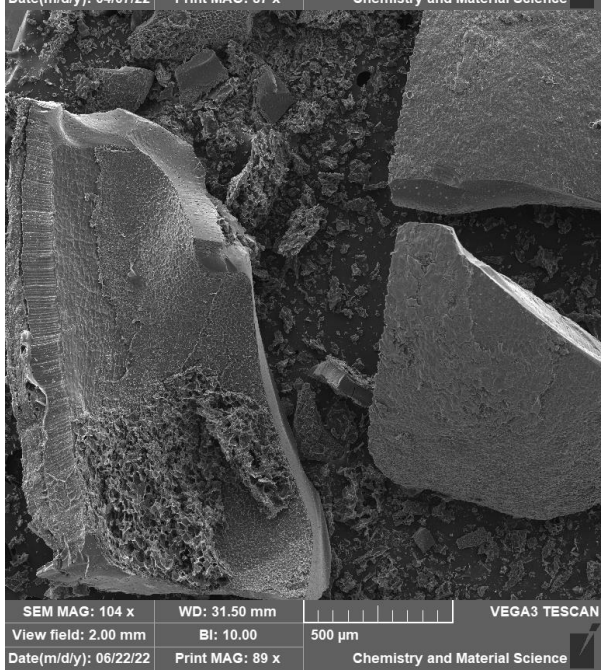


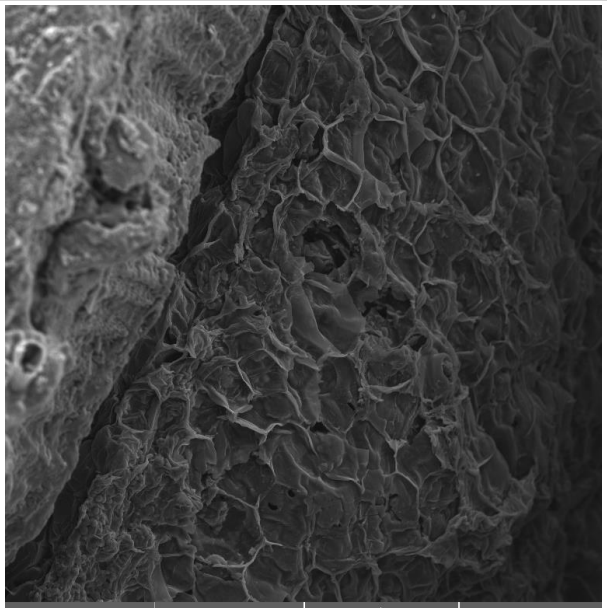
Mixed food waste

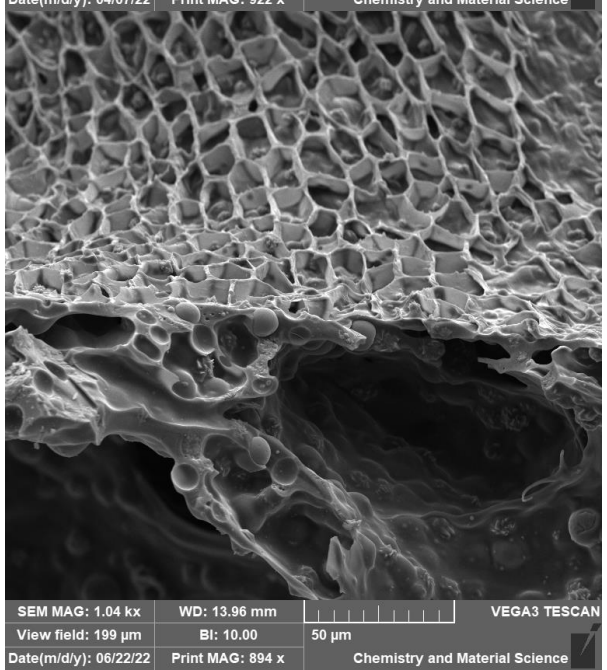
- Similar structure and morphology

SEM









Grape Pomace (seeds)

Commercial-scale

- Less defined pore walls

Laboratory-scale

- More continuous surface
- Better defined pores

Conclusions

Commercial-scale auger-based systems produce **high quality** biochar in a resilient way.

System has to be **tuned** to obtain BC properties of interest

Challenges to operate said systems are:

- High energy content materials
- Co-pyrolysis preferred with low-energetic materials
- Post-pyrolysis fire hazards
- Oxygen presence can affect BC quality for certain applications

Differences with the laboratory produced biochar are:

- Consistently higher H:C ratios and surface area
- Laboratory samples present a more consistent thermal degradation and volatile content
- Commercial scale samples show a less organized carbon structure (faster heating rate)

References!

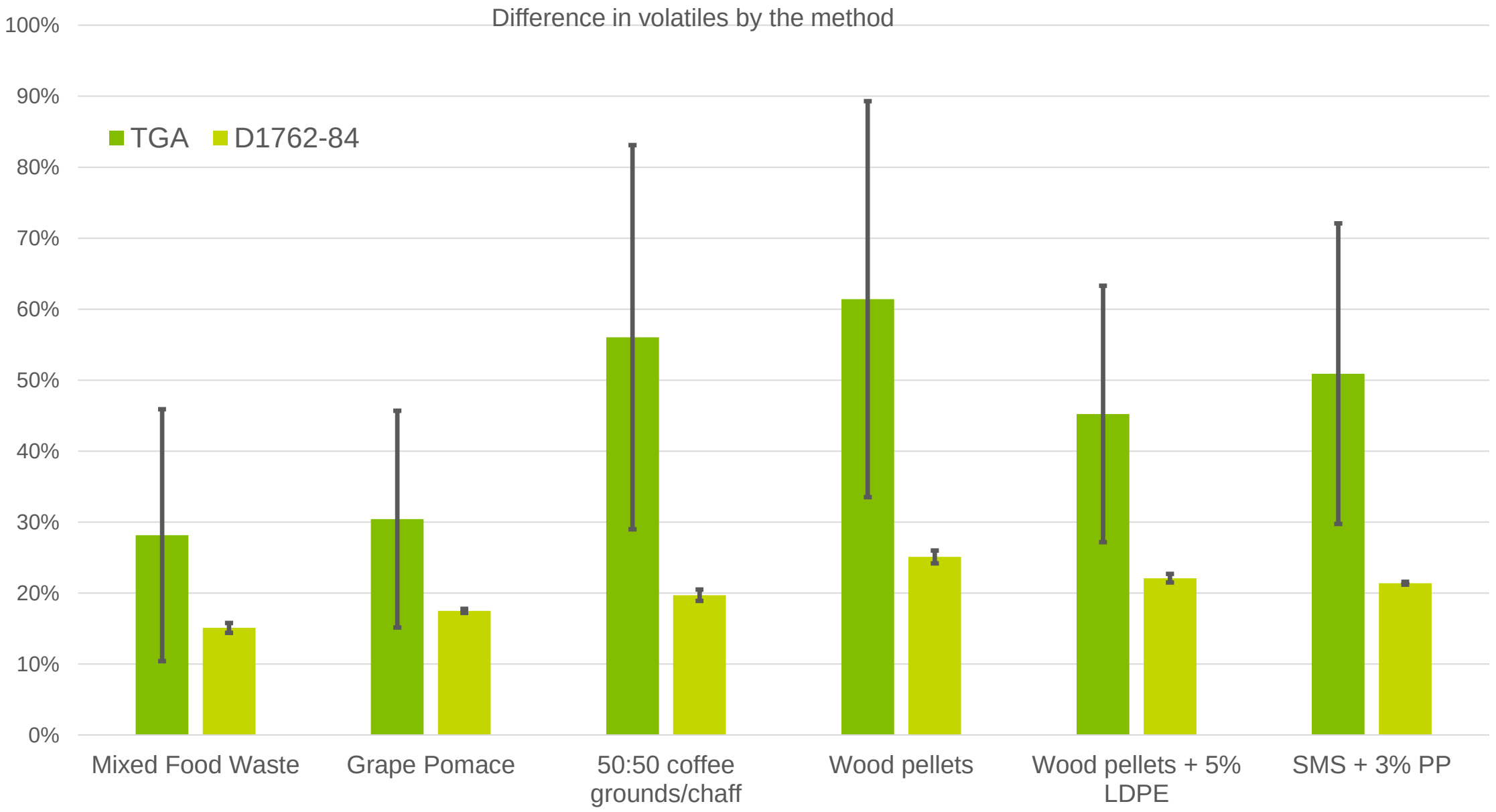
Thank you!

FOUNDATION FOR FOOD & AGRICULTURE RESEARCH

RIT | Golisano Institute for Sustainability

RIT | College of Engineering Technology

Yvan David Hernandez-Charpak
yh7993@rit.edu


Difference in volatiles by the method
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
TGA
D1762-84
Mixed Food Waste
Grape Pomace
50:50 coffee grounds/chaff
Wood pellets
Wood pellets + 5% LDPE
SMS + 3% PP