



12th ECCRIA

The European Conference on Fuel and Energy Research and its Applications



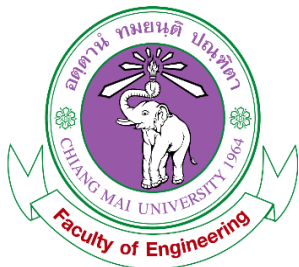
5-7 September 2018,
Cardiff University,
Cardiff, UK.

Torrefaction of Maize Residue Pellets:

Effects of operating conditions on products' yields, composition, grindability, and moisture uptake ability

Thossaporn Onsree and Nakorn Tippayawong

Chiang Mai University, Thailand.



Sustainable and Renewable Energy Laboratory
Department of Mechanical Engineering,
Faculty of Engineering, Chiangmai University



Presentation Overview

Outline

Introduction

Methodology

Results

Conclusion

Introduction

- Biomass residues & Its Upgrading Processes

Objectives

Methodologies

- Experiment Setup & Analyses
(Product distribution & yields, Elemental composition, Grindability test, Moisture uptake ability)

Results and Discussion

Conclusion



Maize Production & Residues

Outline

Introduction

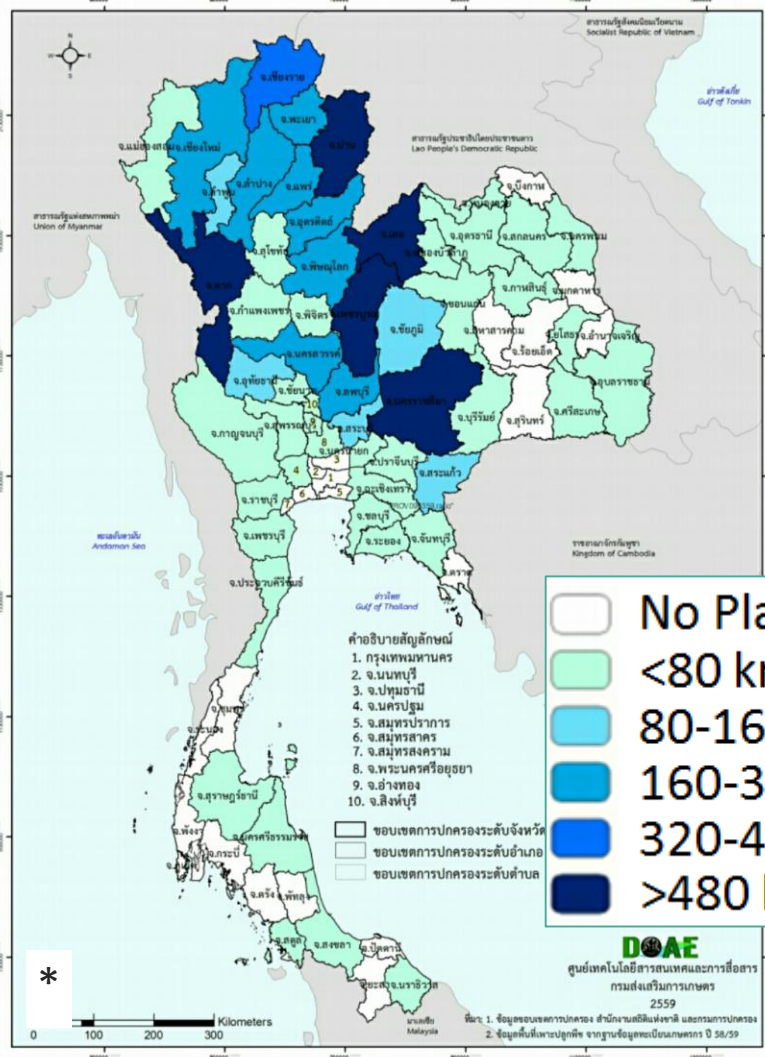
Methodology

Results

Conclusion



Foc
An



on



A map of maize planting areas in Thailand.

~ 65,000 TJ/year

f:



Residues



Simple Upgrading of Agro-residues

Outline

Introduction

Methodology

Results

Conclusion

Densification

Cylinder
Biomass
Rollers
Pellets
Holes



Raw Biomass

9–12 MJ/kg

200–250 kg/m³



Pellets

15–18 MJ/kg

550–750 kg/m³



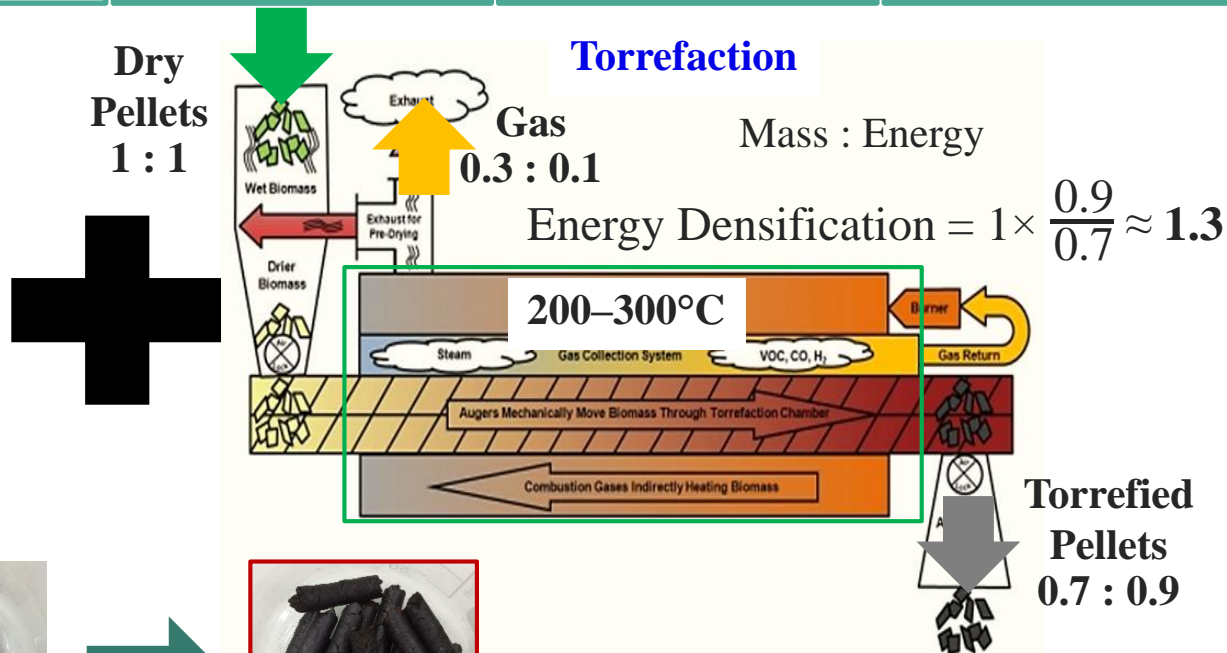
Torrefied Pellet

20–24 MJ/kg

750–850 kg/m³

Hydrophobic

Preserved/Homogeneous



Superior Fuel Properties:

- Transport & Handling
- Grindability
- Combustion, Pyrolysis & Gasification



Objective


Outline

Introduction

Methodology

Results

Conclusion



To investigate effects of torrefaction conditions on characteristics of treated biomass pellets

- Product distribution & yields (Solid, Liquid, & Gas)
- Elemental composition (C, H, O, N, S - Cl, K)
- Grindability (Energy consumption & Size distribution)
- Moisture uptake ability

Experiment Setup

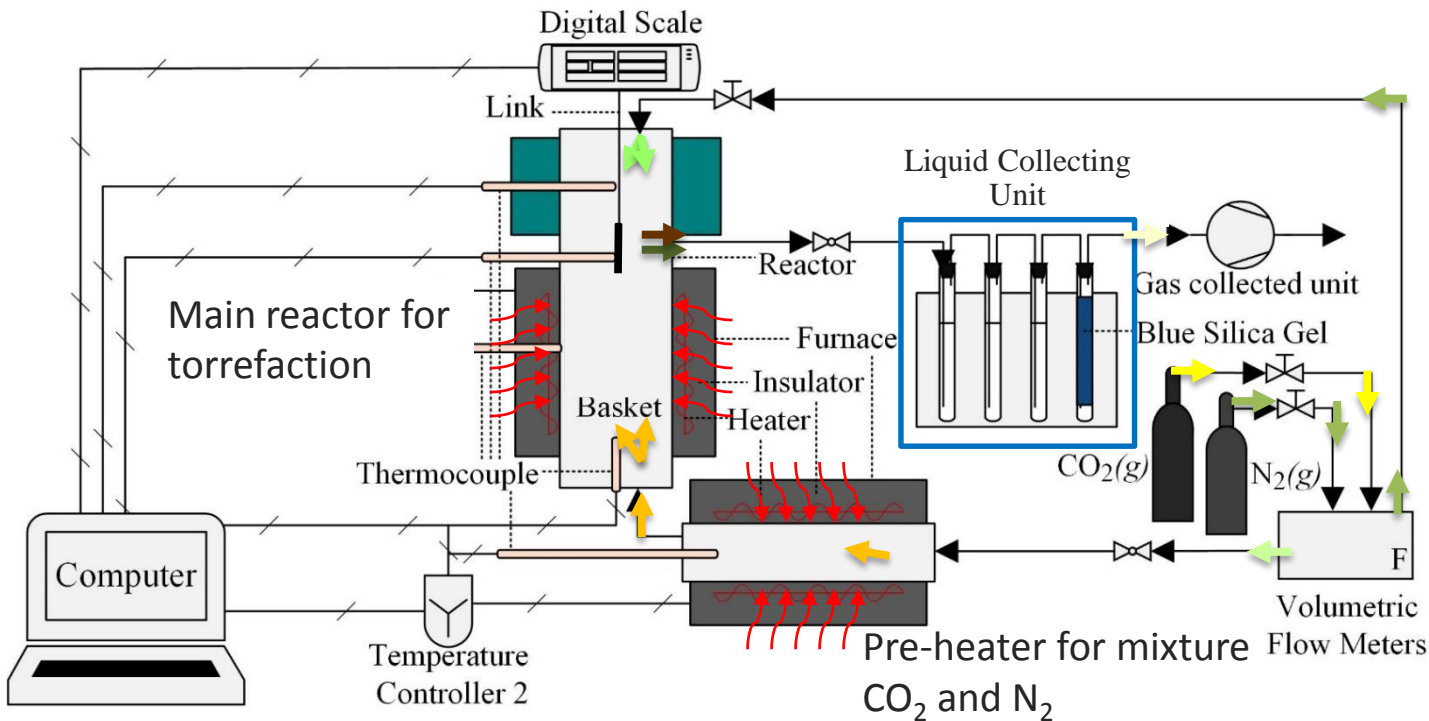
Outline

Introduction

Methodology

Results

Conclusion



Feed sample



MC: ~10 % wb

Pellet Size:

$\phi = 8.1 \pm 0.2 \text{ mm}$

$l = 30.0 \pm 1.1 \text{ mm}$

Operating Conditions;

Temperature: 220, 260, & 300 °C

Residence time: 10, 20, 30, & 40 min

Simulated flue gas: CO₂ = 0, 6, 12, & 18 % (with N₂ balance)

Moisture Uptake Test

Outline

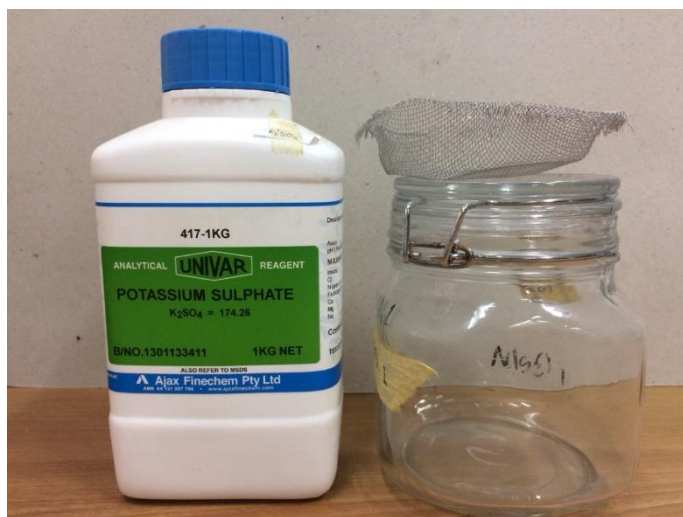
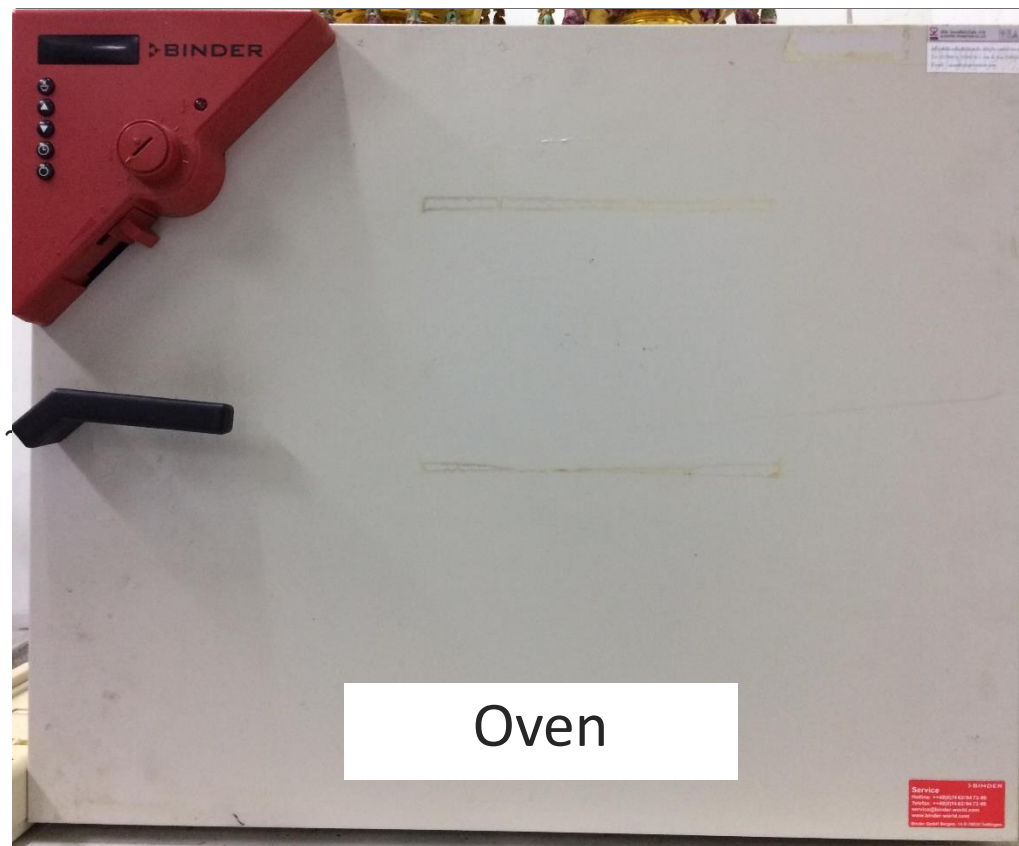
Introduction

Methodology

Results

Conclusion

Salt*	Relative humidity (%RH)		
	20 °C	30 °C	35 °C
Potassium sulphate	97.20	96.60	94.80



Before test: all samples were dried at 103 °C for 24 h ([EN14774-1](#))

During the test: all samples were weighed at every 1, 2, 3, 6, 12, and 24 h

Grindability Test

Outline

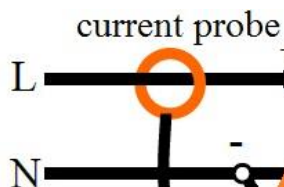
Introduction

Methodology

Results

Conclusion

A commercial coffee grinder
(Fiorenzato M.C, F5, Italia)



C. analyzer
(0 ± 1%)
M
(5 0.7%)



1st

2nd

3rd

Size Distribution

Grindability Test

Outline

Introduction

Methodology

Results

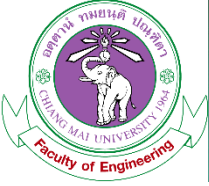
Conclusion

U.S.A. STANDARD SIEVES ASTM SPECIFICATION E-11

Sieve Designation			
Standard		Alternative	
2 mm		NO.	10
1.7 mm		NO.	12
1.4 mm		NO.	14
1.18 mm		NO.	16
1 mm		NO.	18
850 μm		NO.	20
710 μm		NO.	25
600 μm		NO.	30
500 μm		NO.	35
425 μm		NO.	40
355 μm		NO.	45
300 μm		NO.	50
250 μm		NO.	60
212 μm		NO.	70
180 μm		NO.	80
150 μm		NO.	100
125 μm		NO.	120
106 μm		NO.	140
90 μm		NO.	170
75 μm		NO.	200



Size Distribution



Outline

Introduction

Methodology

Results

Conclusion

Results and Discussion

Appearances of Torrified Pellets

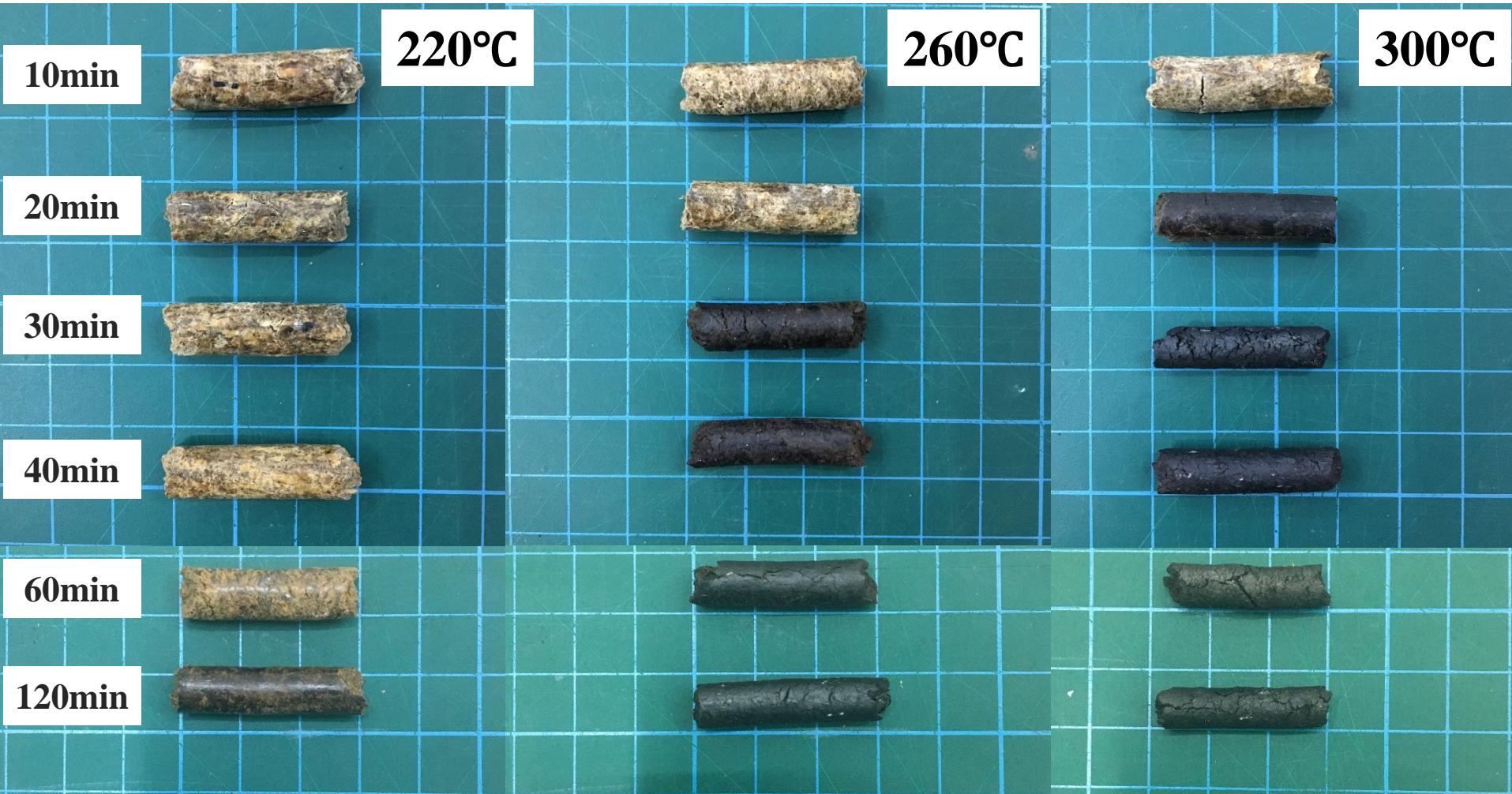
Outline

Introduction

Methodology

Results

Conclusion



Solid Yields

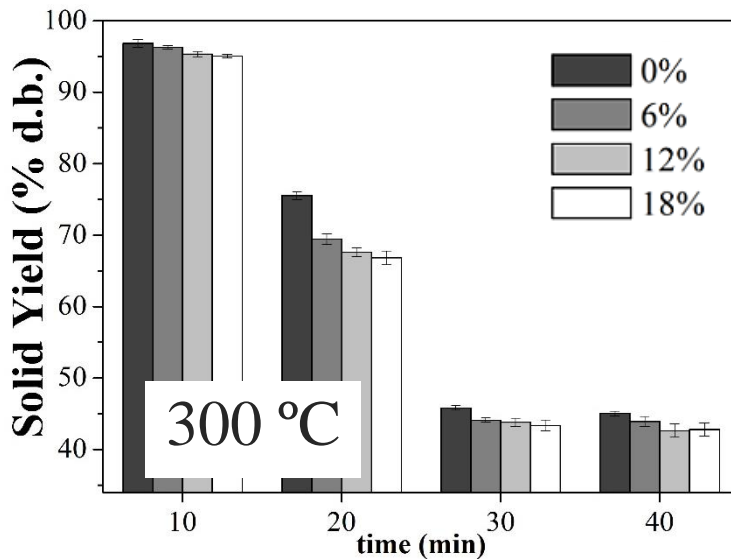
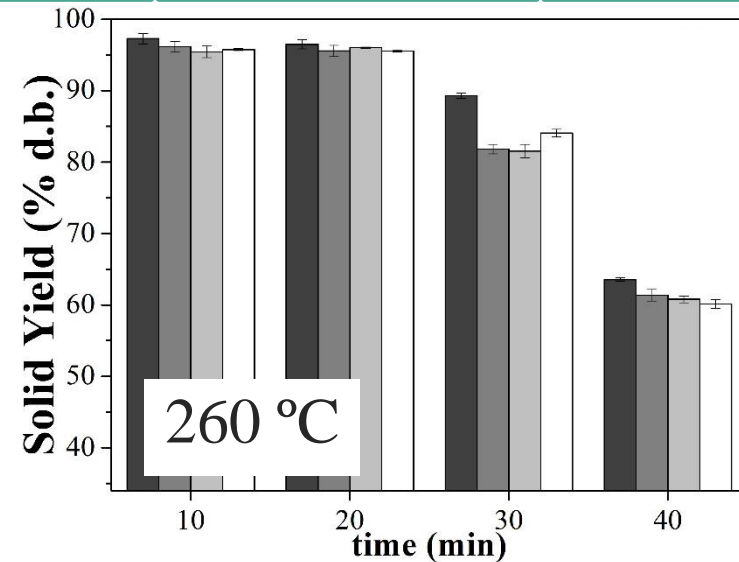
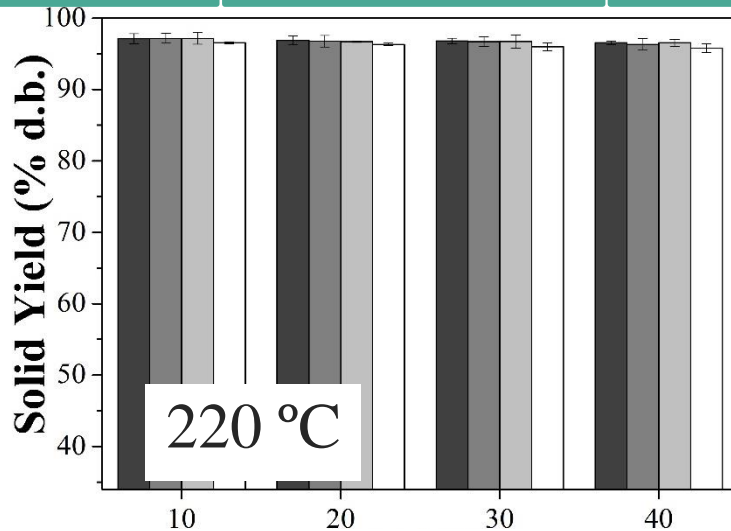
Outline

Introduction

Methodology

Results

Conclusion



Significantly lowering in **SOLID Yield** if:

- Increasing **Temperature & Time**
- Presence of CO₂ did not affect much

Product Distribution & Yields

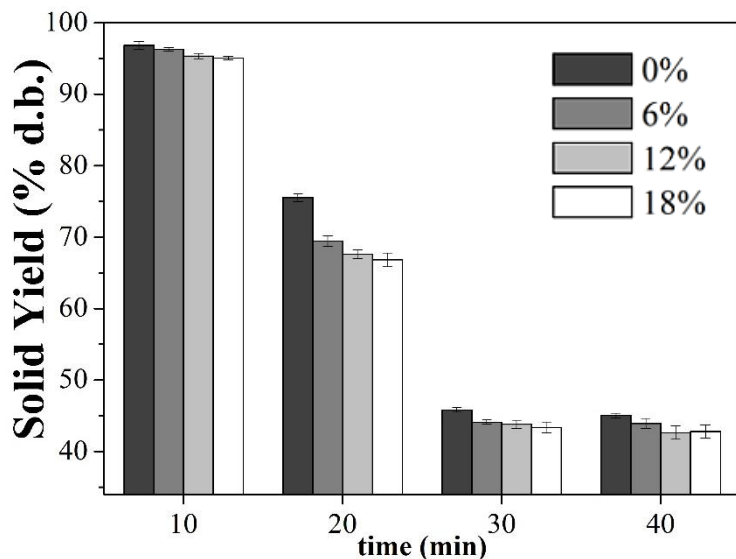
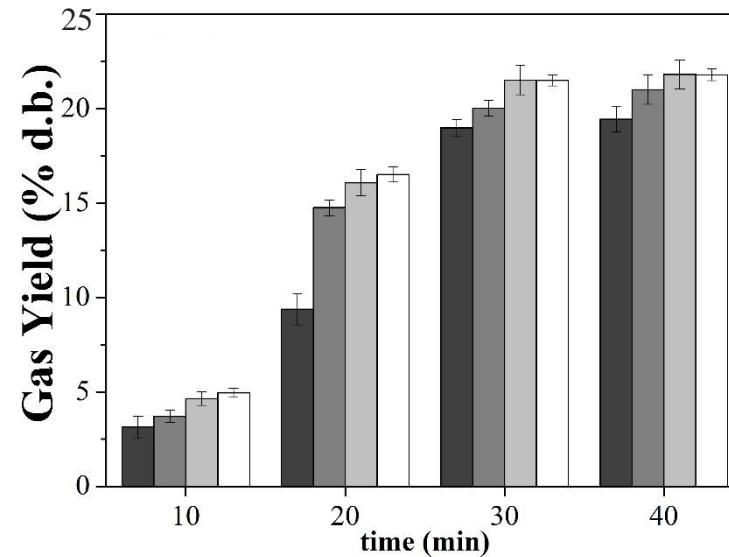
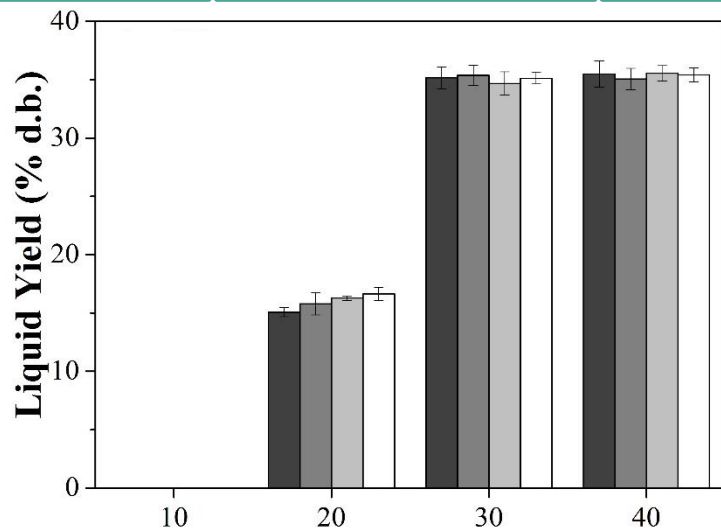
Outline

Introduction

Methodology

Results

Conclusion



300 °C



Elemental Composition & HHV

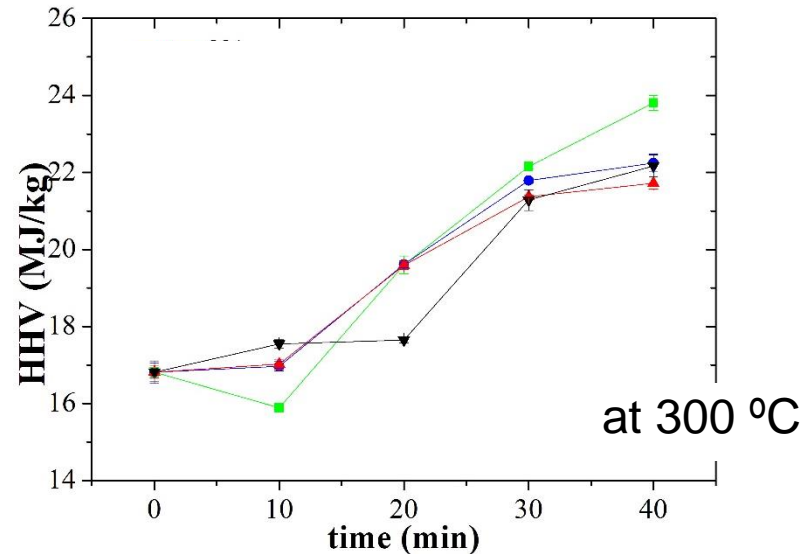
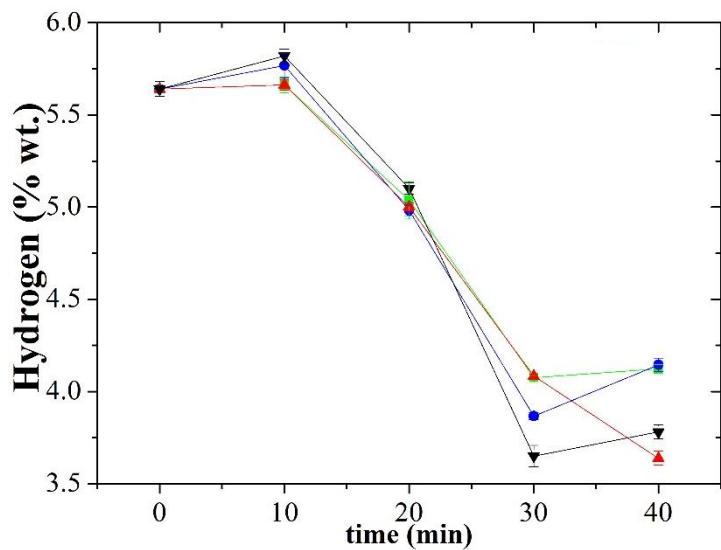
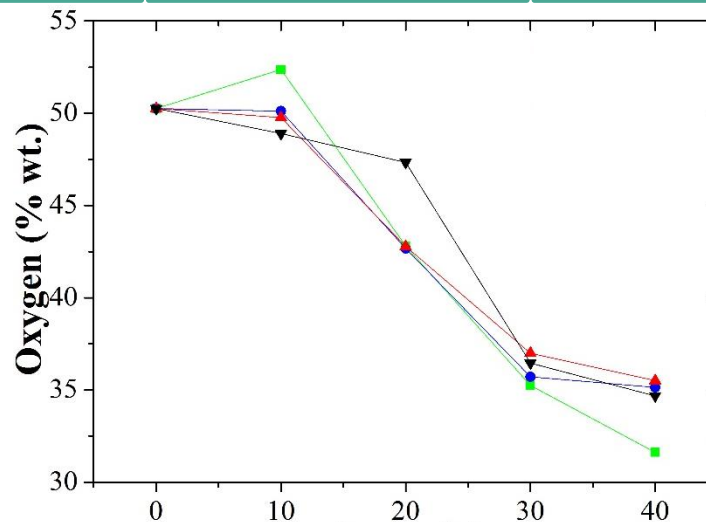
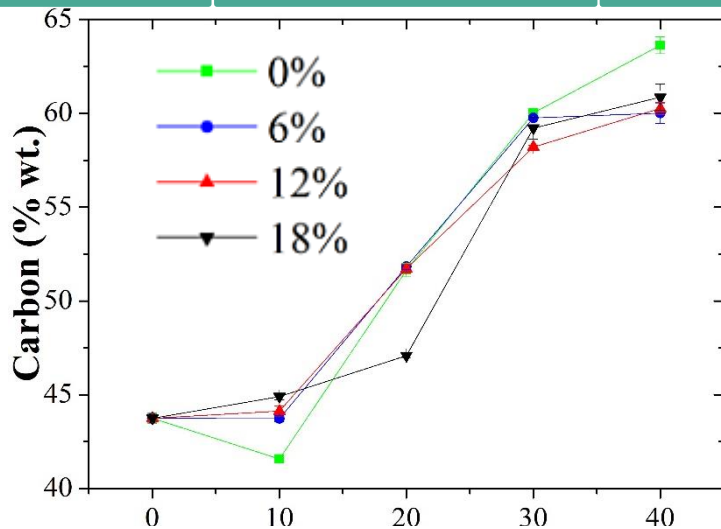
Outline

Introduction

Methodology

Results

Conclusion



Elemental composition was analyzed by CHNS/O analyzer, Flash 2000, ThermoScientific.



S, Cl, K contents

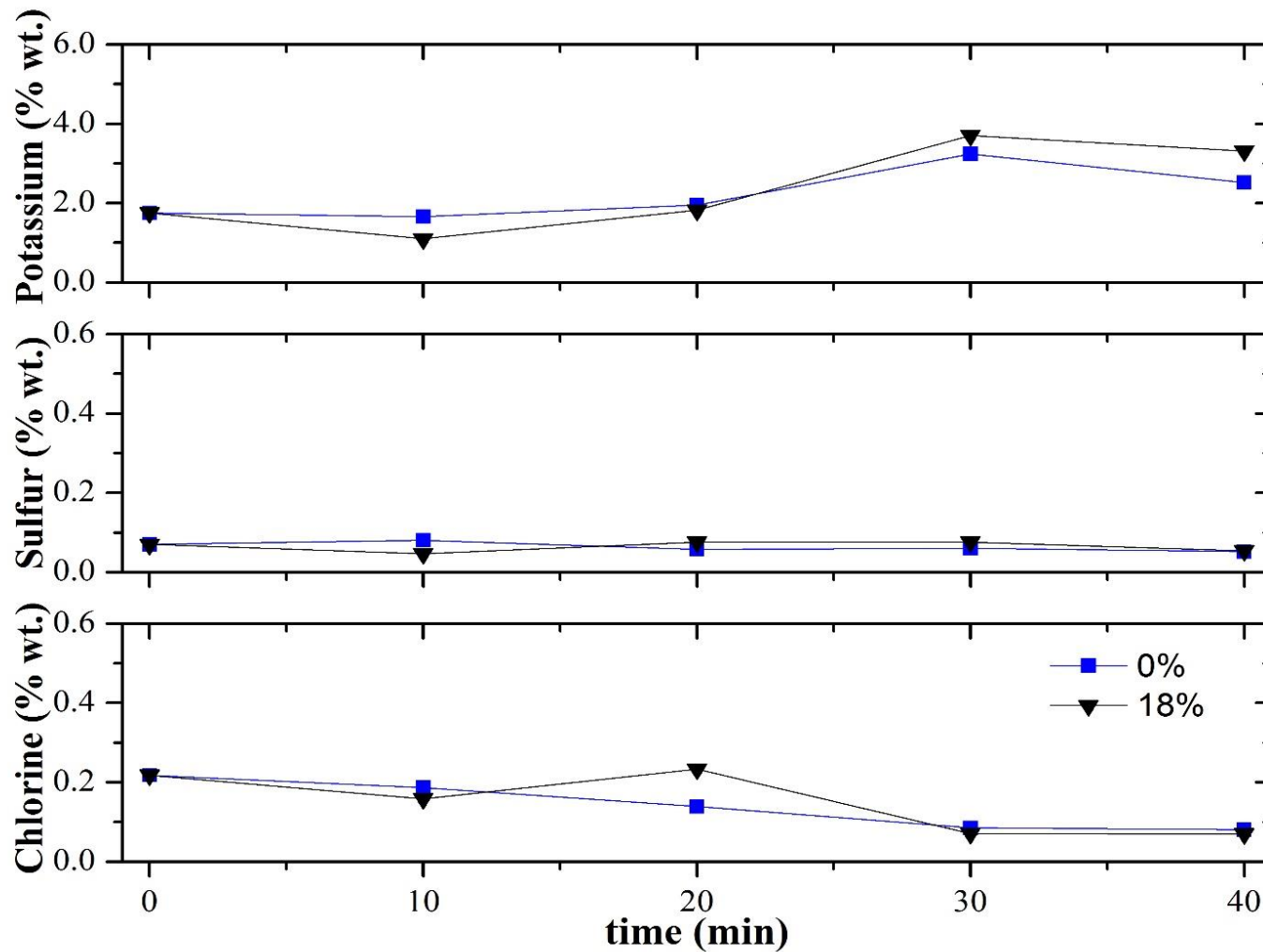
Outline

Introduction

Methodology

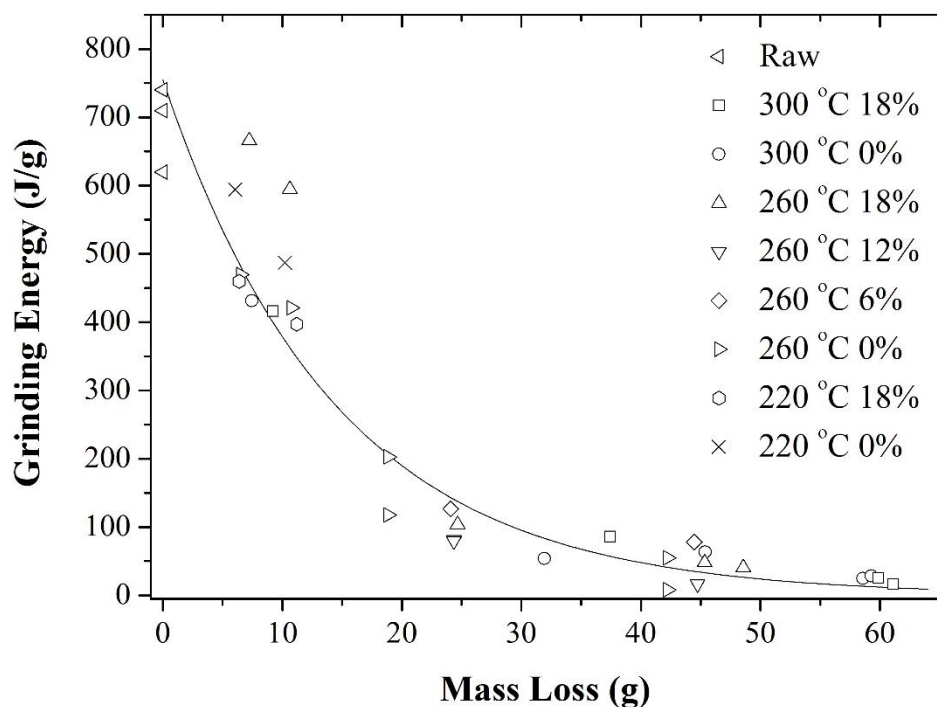
Results

Conclusion

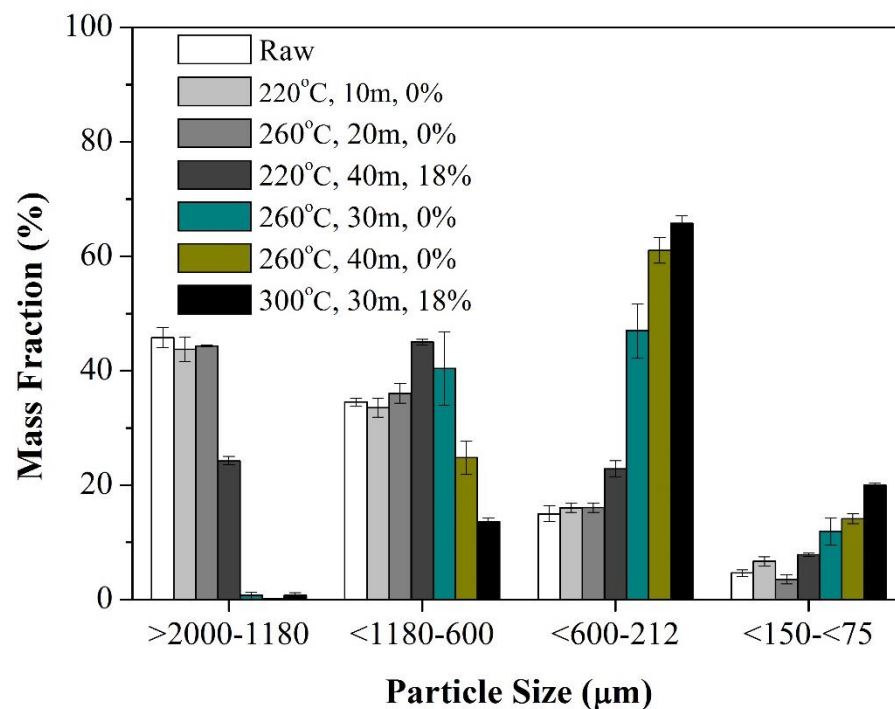


at 300 °C

Grinding Energy



Particle Size Distribution



Higher torrefaction level leads to smaller grinding energy consumption and particle size.

Moisture Uptake Ability

Outline

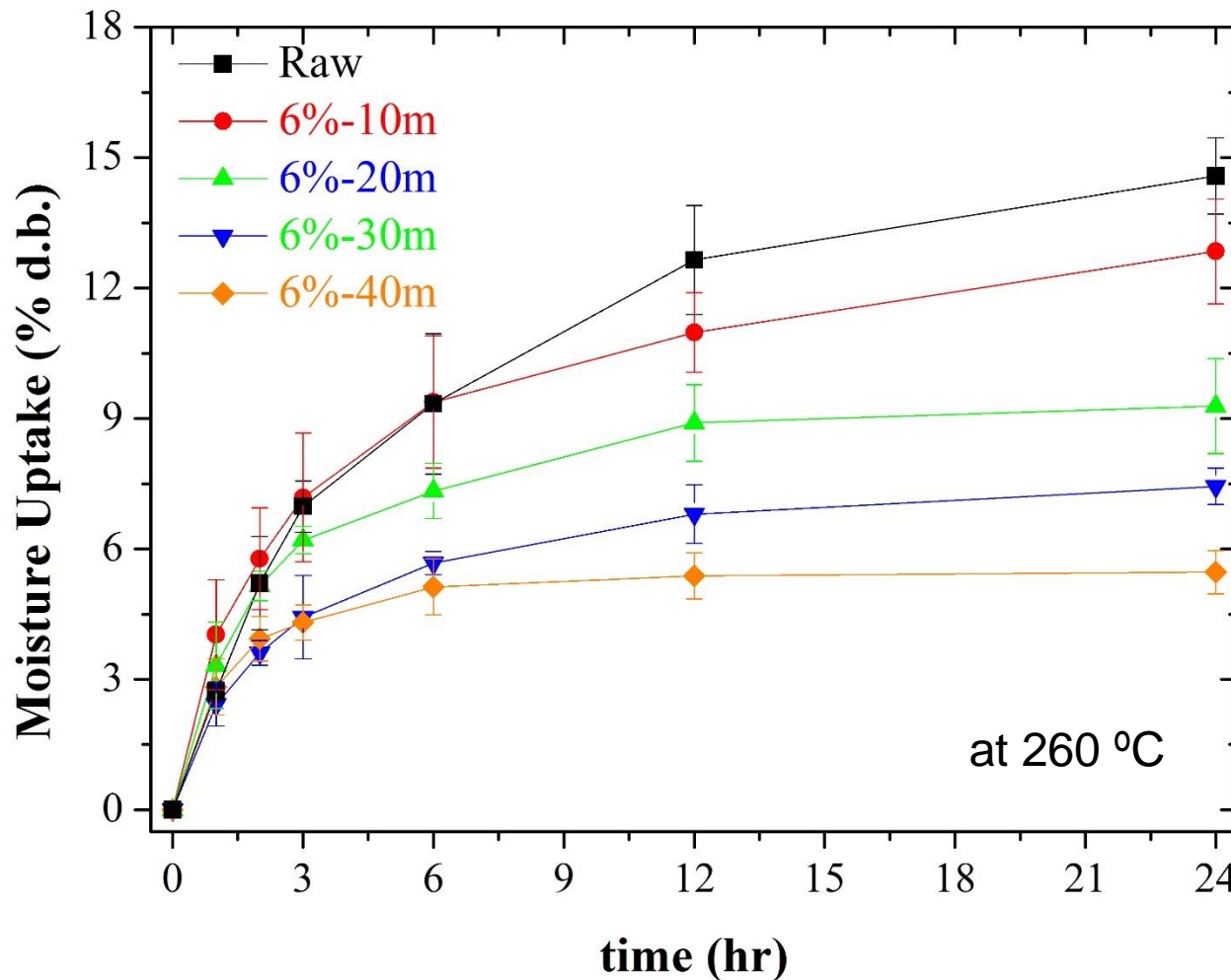
Introduction

Methodology

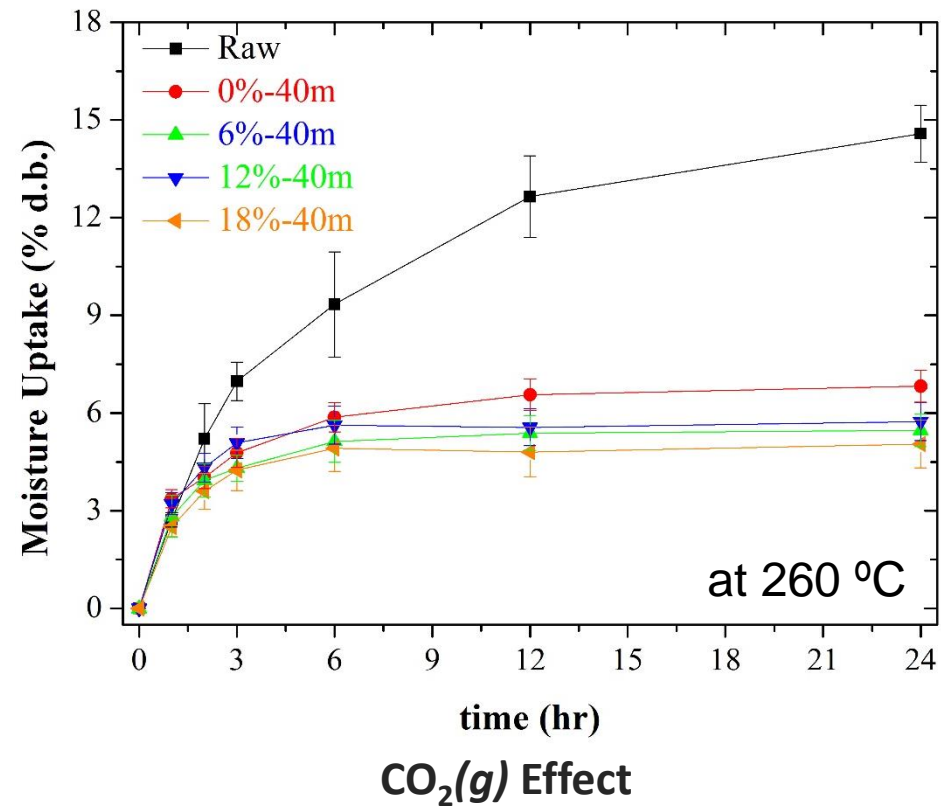
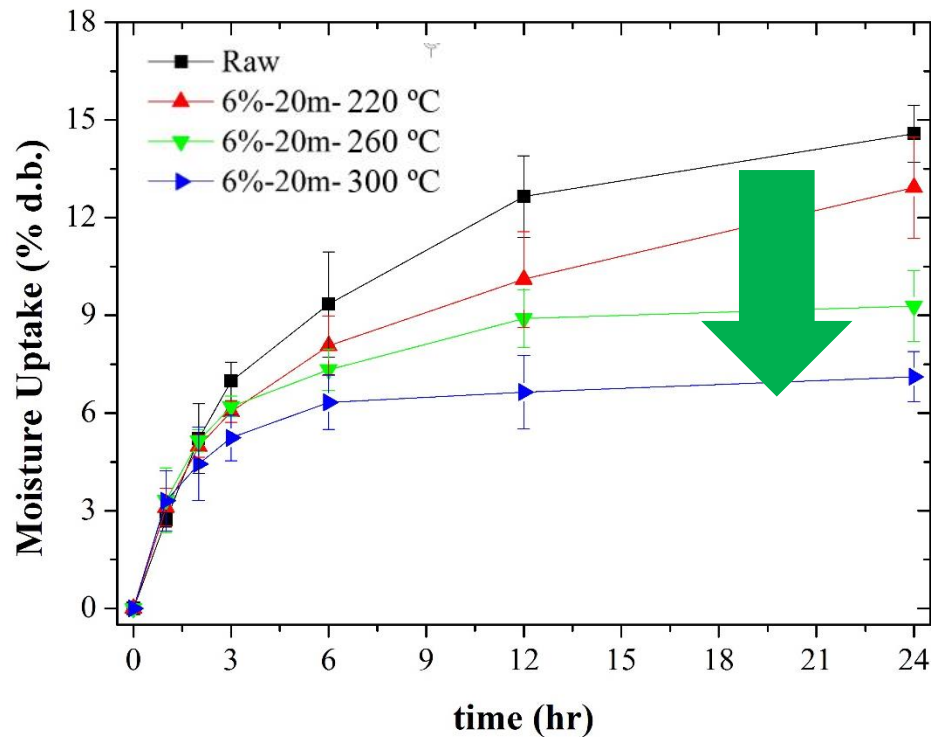
Results

Conclusion

Effects of torrefaction time on moisture uptake ability



Effects of temperature and CO₂ content on moisture uptake ability





Conclusion

Outline

Introduction

Methodology

Results

Conclusion

- Temperature and time affected considerably the **yield** and distribution of products and moisture uptake ability, but presence of CO_2 did not show statistically significant effect on yields.
- Time and presence of CO_2 appeared to have statistically significant effects on C, H, O contents as well as HHV of torrefied solids.
- Higher degree of torrefaction severity (temperature, time, CO_2 content) led to smaller grinding energy consumption and particle size distribution.



Acknowledgements

Supports from; *Chiang Mai University and Thailand Research Fund via the Research and Researcher for Industry, contract no. PHD57I0059 are acknowledged.*



Sustainable and Renewable Energy Laboratory
Department of Mechanical Engineering,
Faculty of Engineering, Chiangmai University



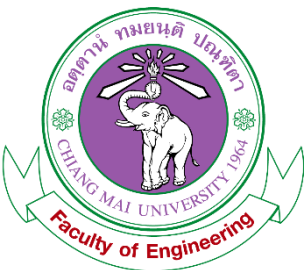


12th ECCRIA

The European Conference on Fuel and Energy Research and its Applications



THANK YOU FOR YOUR ATTENTION



Sustainable and Renewable Energy Laboratory
Department of Mechanical Engineering,
Faculty of Engineering, Chiangmai University