KNU IFS 2018

Annual International Symposium of Institute of Forest Science

KNU IFS 2018

2018. 9. 6. ~ 7.

College of Forest Science and Environmental Sciences
Kangwon National University
Chuncheon
Republic of Korea

KNU

KNU IFS

IFS2018

▣ Session 12. Research activities on the utilization of woody biomass in Korea, China, and Indonesia

- Venue: Room 104 (Building No.1), College of Forest and Environmental Sciences

Time	Title	Authors	Moderator
15:40 ~ 16:00	Development of mass reduction and heating value prediction model for optimizing torrefaction process for wood pellet	**Sun-Yong Park**, Kwang-Cheol Oh, Chung-Geon Lee, La-Hoon Cho, In-Seon Jeong, Min-Jun Kim, Seok-Jun Kim, Young-Kwang Jeon, Dae-Hyun Kim	
16:00 ~ 16:20	Environmentally friendly and high performance of bamboo fiber reinforced composites	**Yue Qi**, Wen-Ji Yu, Ding-Hua Ren, Yang-Lun Yu, Rong-Xian Zhu, Ya-Hui Zhang, Ya-Mei Zhang, Yu-Xiang Huang	
16:20 ~ 16:40	Optimum Conditions for Manufacturing of Wood Fiber Insulation Boards	**Min Lee**, Jae-hyuk Jang, Sang-min Lee	Professor Nam Hun Kim & Dr. Sang Seon Park
16:40 ~ 17:00	New technology of termite control for wooden structure	**Sae-Min Yoon**, Jung-Eun Park, Won-Joung Hwang, Yong-Seok Choi, Dong-Won Son, Jin-Young Chung	
17:00 ~ 17:20	Peatland restoration for local community based bioenergy production in Indonesia	**Soo-Min Lee**, Han-Seob Joeng, Don-Ho Lee, Himlal Baral	
17:20 ~ 17:40	Torrefaction of Wood Pellets using Counter Flow Multi-Baffle (COMB) Technology	**Wahyu Hidayat**, Udin Hasanudin, Dewi Agustina Iryani, Agus Haryant, Amrul, Si-Hyun Lee, Sang-Do Kim	
17:40 ~ 18:00	Design and performance test of a modified charcoal kiln for thermal therapy	**Nam Hun Kim**, Yun Ki Kim, Ah Ran Kim, Hee Soo Lee, Wae Jung Kim, Byantara darsan Purusatama	

Torrefaction of Wood Pellets using Counter Flow Multi-Baffle (COMB) Technology

Wahyu Hidayat[1,*], Udin Hasanudin[1], Dewi Agustina Iryani[2], Agus Haryanto[1], Amrul[2], Sihyun Lee[3] and Sangdo Kim[3]

[1]Faculty of Agriculture, University of Lampung, Bandar Lampung 35145, Indonesia,

[2]Faculty of Engineering, University of Lampung, Bandar Lampung 35145, Indonesia,

[3]Climate Change Research Division, Korean Institute of Energy Research, Daejon, 34129, Republic of Korea

*Corresponding Author(s): Wahyu Hidayat (wahyu.hidayat@fp.unila.ac.id)

Abstract

Jabon (*Anthocephalus cadamba*) is a promosing fast growing wood species that is widely planted in community forests and industrial plantation forests but the wood has a relatively low density, durability, and mechanical properties which limited its application as structural timbers. One of the alternative utilizations of jabon wood is by converting into wood pellet for bioenergy. The aim of this study was to improve the properties of wood pellets from jabon through rapid torrefaction using Counter-Flow Multi Baffle (COMB) reactor, a pilot plant for torrefaction of biomass with a capacity of 20 kg/h that has a main advantage of performing torrefaction within a short period of time. Wood pellets were classified according to its length and then torrefied at 300°C with a residence time of 3 min. Torrefied pellets (black pellets) were succesfully produced. The initial moisture content of the long and short pellets of 12.76% and 12.47% decreased up to 2.85% and 2.61% after torrefaction. Water immersion test for 1 min, 5 min, 30 min, 1 h, 6 h, 12 h, and 24 h showed that the raw pellets (control) fully disintegrated after 30 min, while black pellets showed no significant disintegration even after 24 h test which is an advantage for long period storage of pellets. The initial calorific values of long and short pellets of 17.69 MJ/kg and 17.35 MJ/kg increased up to 31.79 MJ/kg and 32.02 MJ/kg after torrefaction. The results proposed that rapid torrefaction using COMB could provide a great improvement in bioenergetic properties of wood pellets from fast growing species as jabon wood.

Keywords: *Anthocephalus cadamba;* Black pellet; Torrefaction; Wood pellet

Annual International Symposium
of Institute of Forest Science (KNUIFS 2018)

Chuncheon, 6-7 September 2018

Torrefaction of Wood Pellets using Counter Flow Multi-Baffle (COMB) Technology

Wahyu Hidayat[1], Udin Hasanudin[1], Dewi Agustina Iryani[2], Agus Haryanto[1], Amrul[2], Sangdo Kim[3], Sihyun Lee[3]

[1]Faculty of Agriculture, University of Lampung, Bandar Lampung 35145, Indonesia
[2]Faculty of Engineering, University of Lampung, Bandar Lampung 35145, Indonesia
[3]Climate Change Research Division, Korean Institute of Energy Research, Daejon, 34129, Republic of Korea

E-mail: wahyu.hidayat@fp.unila.ac.id

CONTENTS

Chapter 01

Introduction

Chapter 02

Chapter 03

Chapter 04

Social Forestry

Government target (2015-2019): allocating **12.7 million hectares** of state forest areas to be managed by communities through social forestry schemes.

Abundant forest biomass potential

- The use of forest biomass for energy is relatively small and restricted to domestic firewood and some small industrial plants.
- Indonesia is developing production of a modern bioenergy such as wood pellets derived from wood residues, but it was only 40 thousand tons in 2013 (FAO, 2016). About 37 thousand tons of that production were exported mostly to South Korea (94.4%) followed by Japan (2.2%), and European countries (<1%).

Biomass from Community Forests

Jabon *(Anthocephalus cadamba)*

1. Widely planted in community forests & industrial plantation forests
2. Rapid growth & harvested in short rotations: 5-7 years
3. Production: 20-23 m^3/ha/year

Timber quality

1. Low density
2. Low durability
3. low mechanical properties
4. Limited its application as structural timbers.

Forest industry sectors should be encouraged to adapt to the use of the species from planted forests and develop suitable conversion technologies for production of value-added product.

Wood Pellet: low-cost and eco-friendly bioenergy

Objective

The aim of this study was to improve the properties of wood pellets from jabon (*Anthocephalus cadamba*) through rapid torrefaction using Counter-Flow Multi Baffle (COMB) reactor.

White Pellet

Black Pellet

Chapter 01

Chapter 02

Materials & Method

Chapter 03

Chapter 04

Materials

Wood pellet from sawdust of jabon wood: sawmill waste

Chemical and bioenergy properties of jabon

Parameter	Value
Cellulose[1]	52.4 %
Pentosan[1]	16.2 %
Lignin[1]	25.4 %
Silica[1]	0.1 %
Extractives dissolve in[1]	
- Alcohol-benzene	4.7 %
- Cold water	1.6 %
- Hot water	3.1 %
- NaOH 1%	18.4 %
Ash contents[2]	1.3 %
pH[2]	5.0
Heating Value[2]	19.15 MJ/kg (4,578 cal/g)

Note: [1]Martawijaya *et al.*, 1989; [2]Wood Physics Laboratory, KNU.

Counter-Flow Multi Baffle (COMB) Reactor

20 KPH COMB Reactor at Forest Products Laboratory, University of Lampung

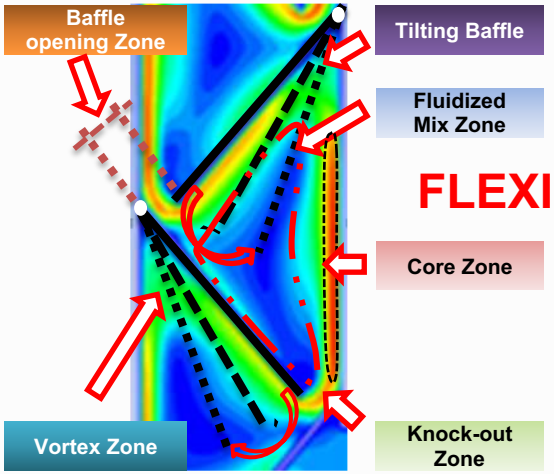
Counter-Flow Multi Baffle (COMB) Reactor

COMB Column

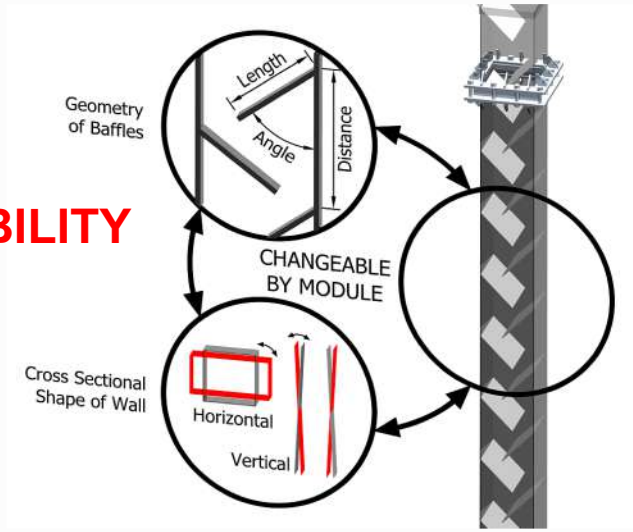
Fuel

COMB^{TM} : Counter flOw Multi-Baffle - Dryer/Pyrolyser

COMB Column



FLEXIBILITY



White Pellet

Black Pellet

- Low Gas to Solid ratio (G/S)
- Short residence time (~3min)
- Constant temperature difference (driving force) along the column
- Flexible & movable

Process Condition

Parameter	Value
Feeder frequency (Hz)	17.6
Flow rate (cm^3/min)	4.76
Column DP (mm.Aq)	302.7
Bag Filter DP (mm.Aq)	25.2
Gas cooler IN temperature (℃)	153.0
Bag filter IN temperature (℃)	46.3
ID fan inlet temperature (℃)	39.2
Column inlet temperature (℃)	334.7
Column top temperature (℃)	298.1
Column outlet temperature (℃)	237.9
Cyclone inlet temperature (℃)	203.6

Wood Pellet Evaluation

- Moisture content
- Density
- Hygroscopic property
- Calorific value

Chapter 01

Chapter 02

Chapter 03

Results

Chapter 04

Visual appearance of the jabon wood pellet

	Raw Pellet	Brown Pellet	Black Pellet
Long			
Short			

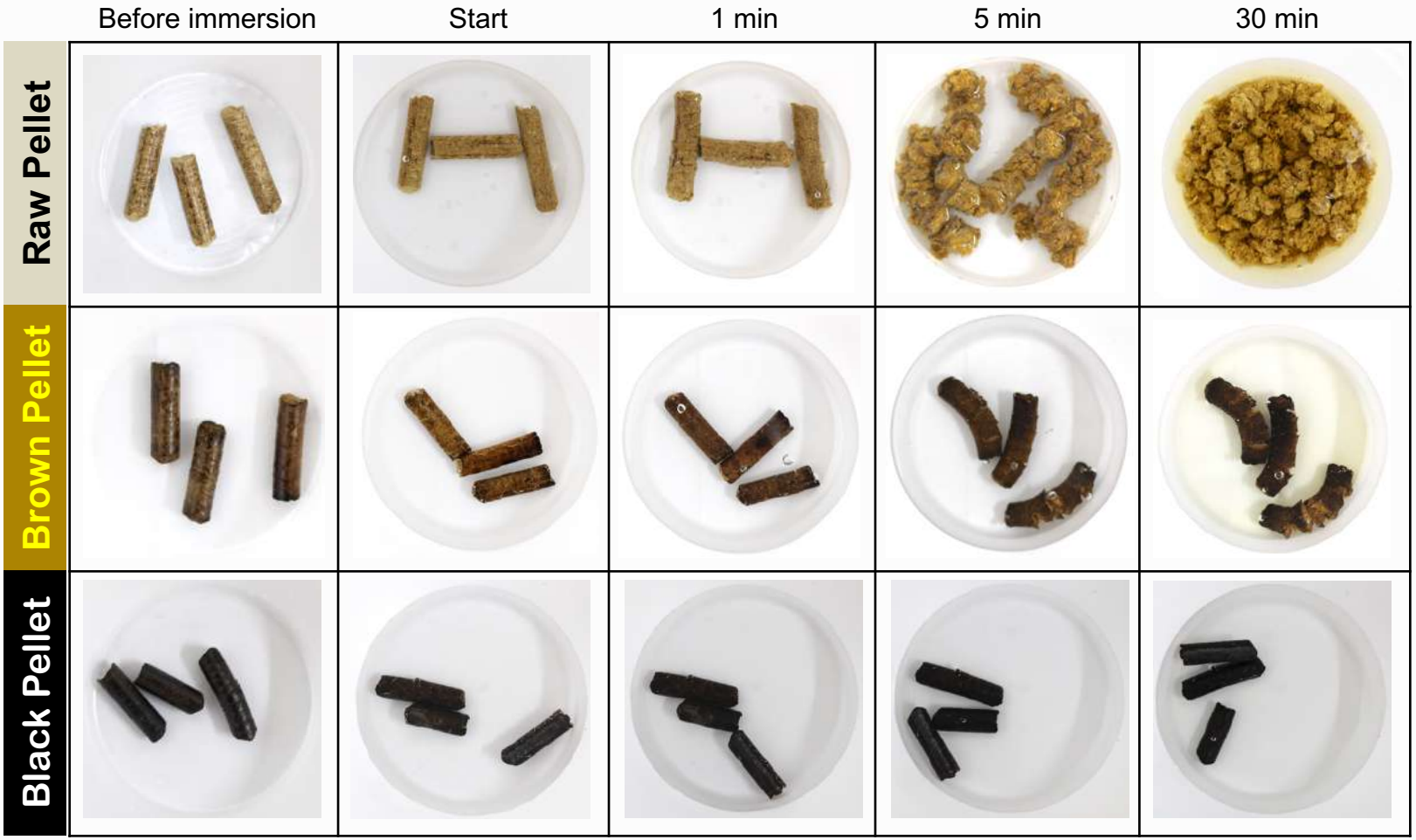
Moisture content and density

Tabel 1. Moisture content and density of jabon pellets

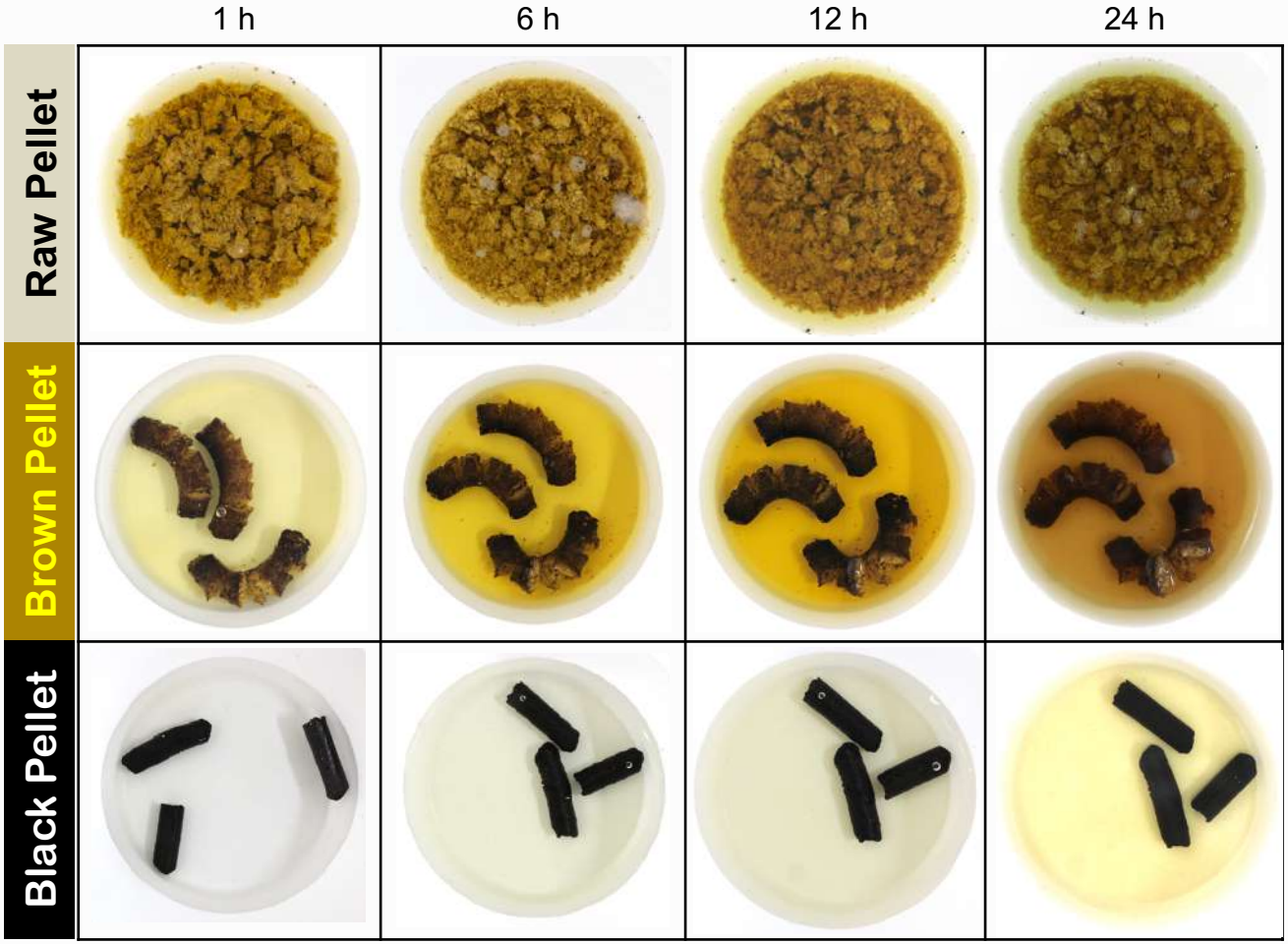
Pellet Size	Sample	Moisture content (%)	Density (g/cm^3)		Density reduction (%)	
			Air dry	Oven dry	Air dry	Oven dry
Long	Raw pellet	12.76 (1.46)	1.18 (0.03)	1.05 (0.03)	-	-
	Brown pellet	5.17 (1.56)	1.01 (0.02)	0.96 (0.02)	14.67	8.51
	Black pellet	2.85 (0.64)	0.93 (0.03)	0.91 (0.03)	21.05	13.44
Short	Raw pellet	12.47 (1.09)	1.10 (0.09)	0.97 (0.07)	-	-
	Brown pellet	4.11 (1.53)	0.97 (0.07)	0.93 (0.05)	11.88	4.82
	Black pellet	2.61 (0.45)	0.78 (0.08)	0.76 (0.08)	28.74	21.85

Notes: The means are averages of 3 replicates. Numbers in parenthesis are standard deviations.

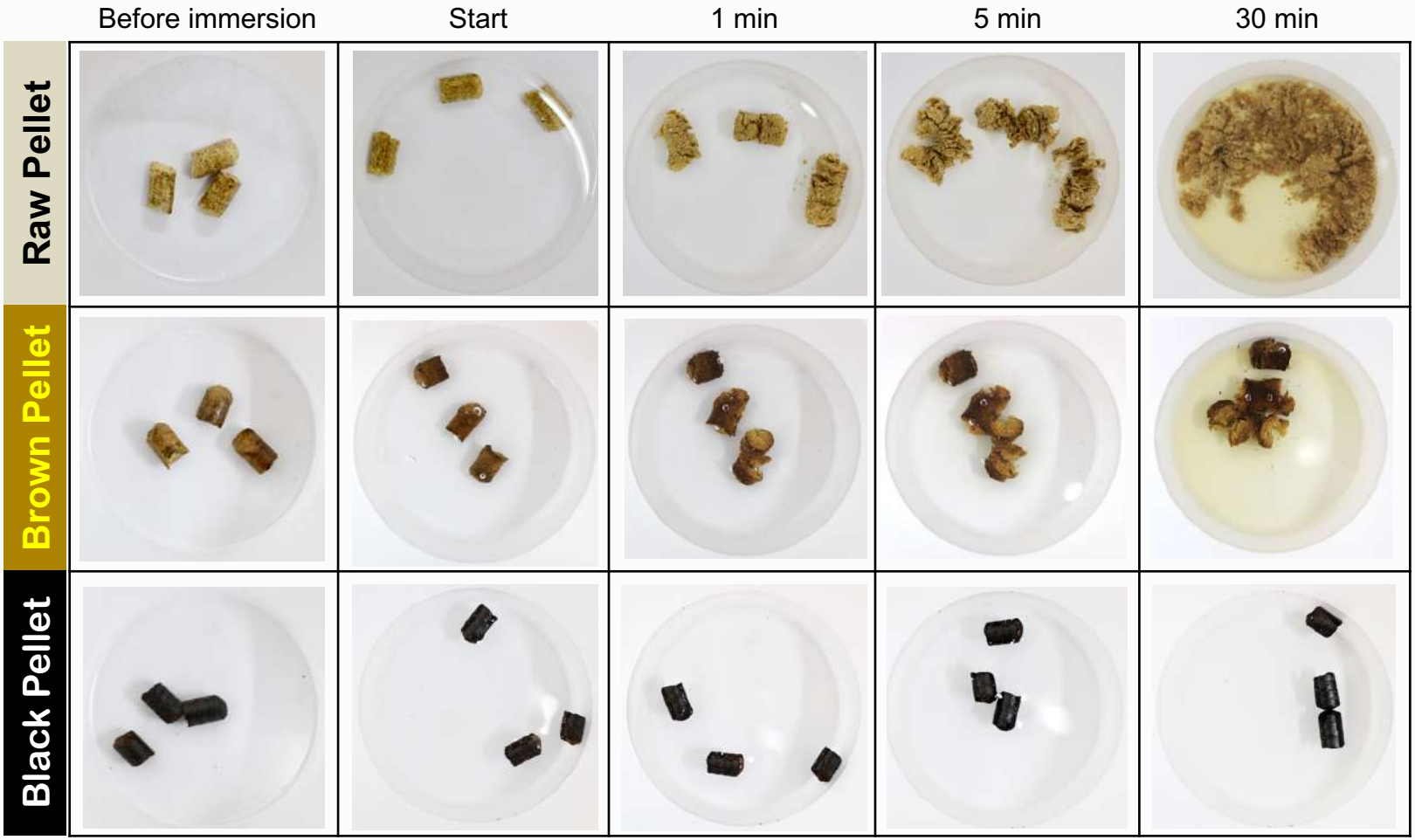
Hygroscopic property: Long pellet



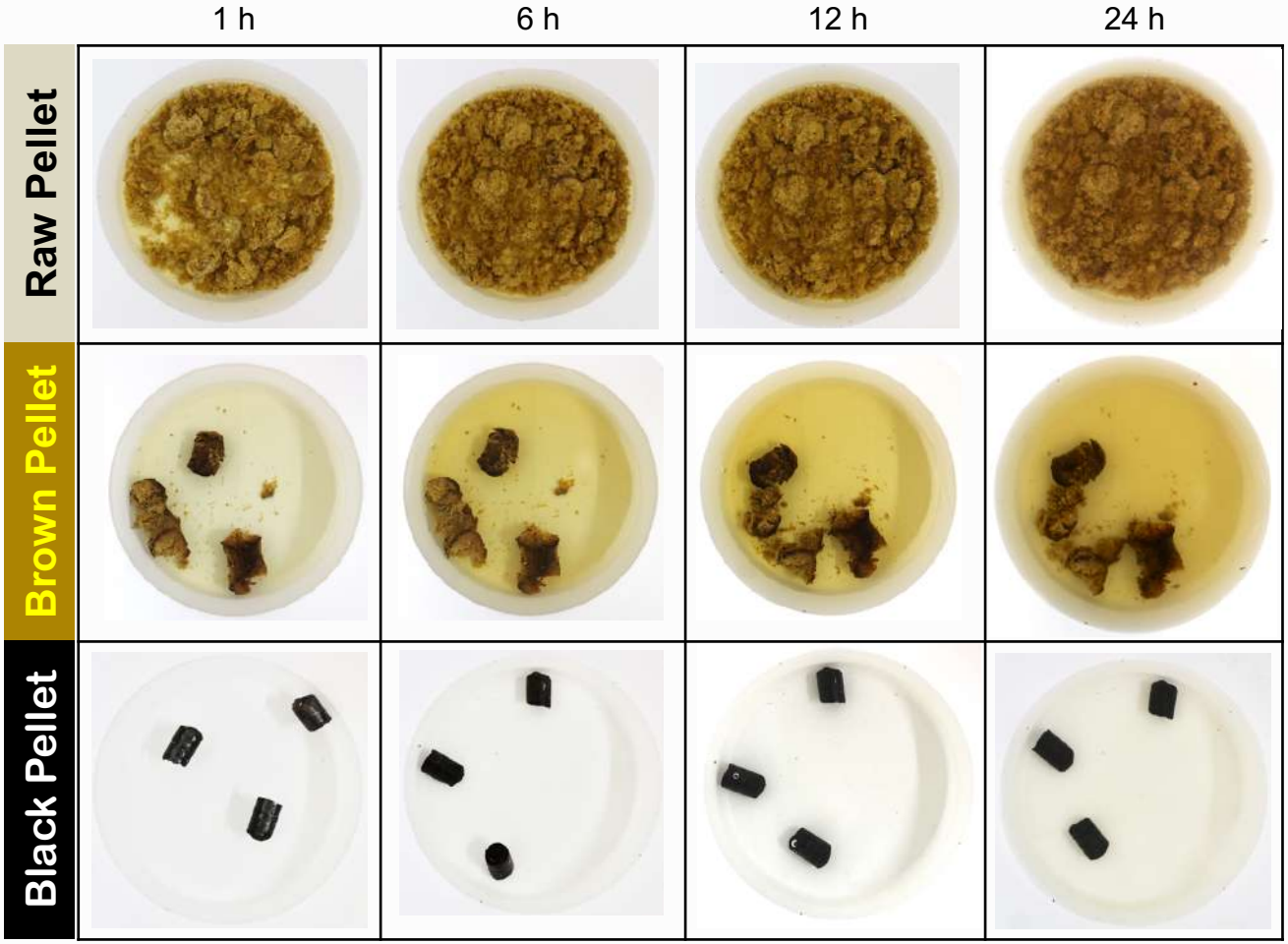
Hygroscopic property: Long pellet



Hygroscopic property: Short pellet



Hygroscopic property: Short pellet



Calorific value

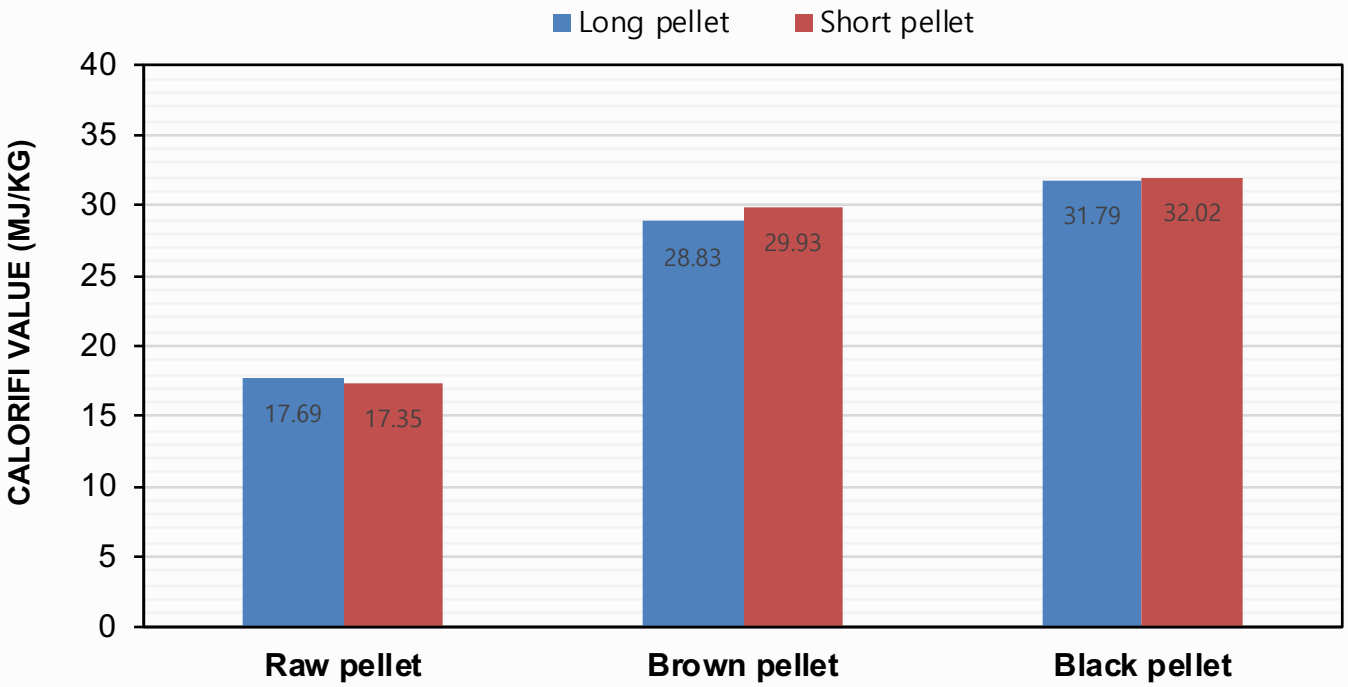


Figure 1. Calorific values of jabon pellets

Chapter 04

Conclusions

Conclusions

- The initial moisture content of the long and short pellets of 12.76% and 12.47% decreased up to 2.85% and 2.61% after torrefaction.
- The raw pellets fully disintegrated after 30 min, while black pellets showed no significant disintegration even after 24 h test which is an advantage for long period storage of pellets.
- The initial calorific values of long and short pellets of 17.69 MJ/kg and 17.35 MJ/kg increased up to 31.79 MJ/kg and 32.02 MJ/kg after torrefaction.
- The results proposed that rapid torrefaction using COMB could provide a great improvement in bioenergetic properties of wood pellets from fast growing species as jabon wood.

Thank you for your attention!

Hidayat *et al.* :

Torrefaction of Wood Pellets using Counter Flow Multi-Baffle (COMB) Technology