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Physical properties of charred pellets after two months of storage

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Physical properties of Torrefied material measured after two months of storage

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Background

- All biomass samples were torrefied at 275^{o}C and for 30 min prior to pelleting.
- The torrefied pellets were stored for almost 2 months during the period January 2015 to early March 2015. Bulk density and individual pellet density of torrefied pellets after the two-month storage were measured.
- Other measured properties include:
  - Color
  - Hardgrove Index for grindability
  - Hygroscopicity
  - Water immersion test

Physical properties of torrefied pellets

Table 1. Average pellet dimensions, mass, individual pellet density, and bulk density of torrefied pellets

Species	Average Length (mm)	Average Diameter (mm)	Average Single Pellet Mass (g)	Bulk Density (kg/m^3)	Pellet Density (g/cm^3)
Canola Straw	27.5	6.4	1.04	619	1.17
Willow	28.8	6.4	1.02	542	1.10
Bagasse	29.8	6.4	1.13	622	1.18
Wheat Straw	28.3	6.2	0.94	505	1.10
Switch grass	23.8	6.5	0.79	537	1.00
Miscanthus	25.3	6.4	0.83	475	1.01

Pellet dimensions were measured manually

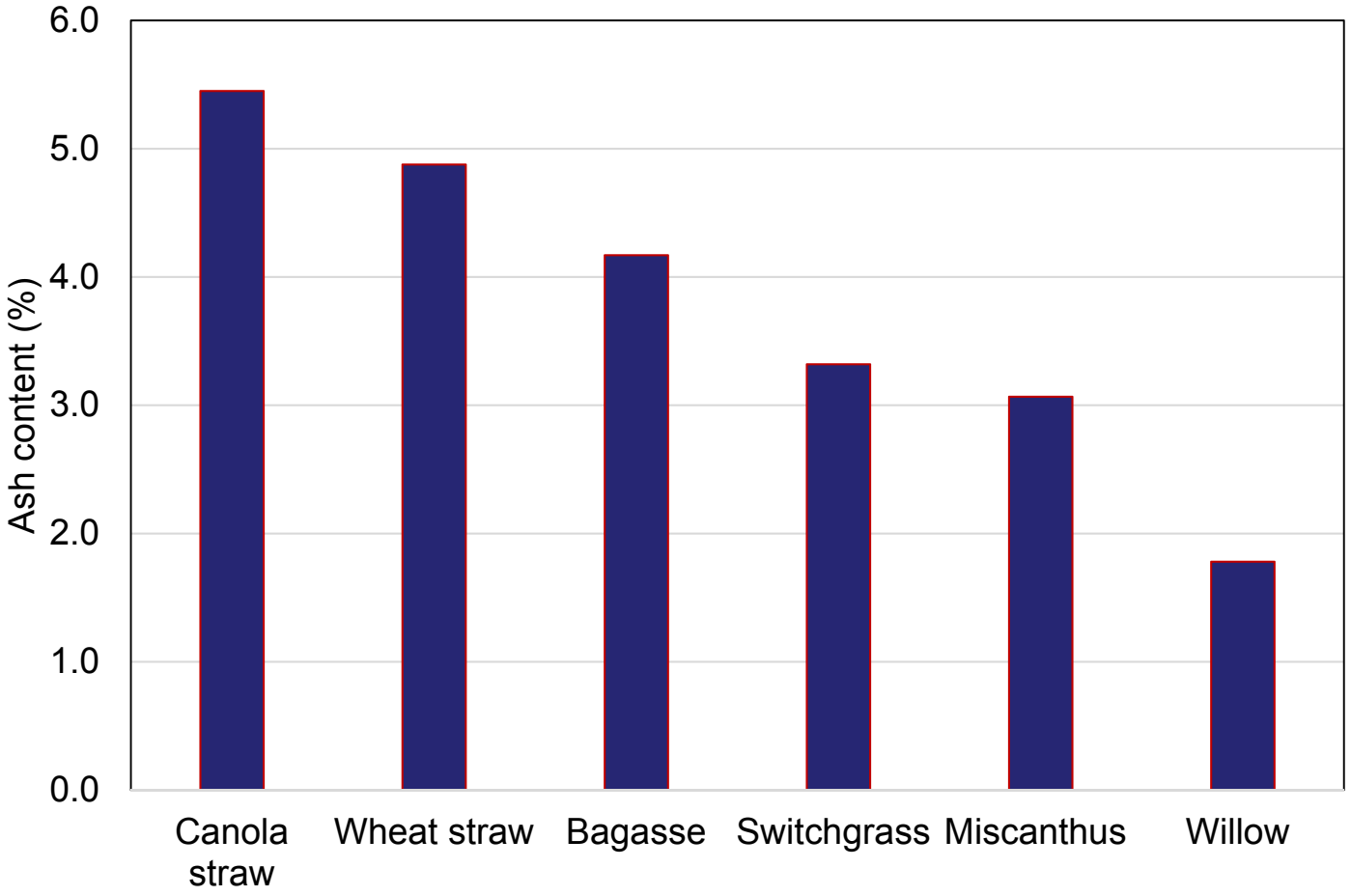
Bulk density of torrefied pellets was determined according to ASABE Standard S269.4 (ASABE Standards, 2007).

Individual pellet density is the mass of an individual pellet divided by its volume

Pellet bulk density of regular pellet is 650-700 kg/m^3

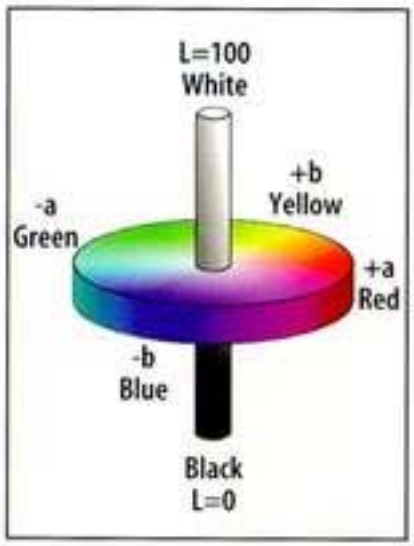
Pellet density of regular pellets (not torrefied) is 1.25-1.35 g/cm^3

Ash content measured in the untreated biomass prior to torrefaction



Ash content in regular pellets is normally less than 1%. The ash content in material tested exceeded 1%.

Torrefied pellet color index



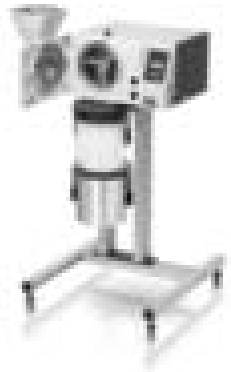
Lab model

Table 3. L*a*b* color coordinates measured for the torrefied pellets

Species	CIE-LAB Color Parameters		
	Lightness, L*	red/greenness, a*	yellow/blueness, b*
Bagasse	21.2	3.0	5.5
Miscanthus	20.7	3.9	7.1
Wheat Straw	20.3	3.9	7.1
Canola Straw	20.2	2.6	4.8
Willow	18.5	2.4	4.0
Switch grass	17.7	2.8	4.9

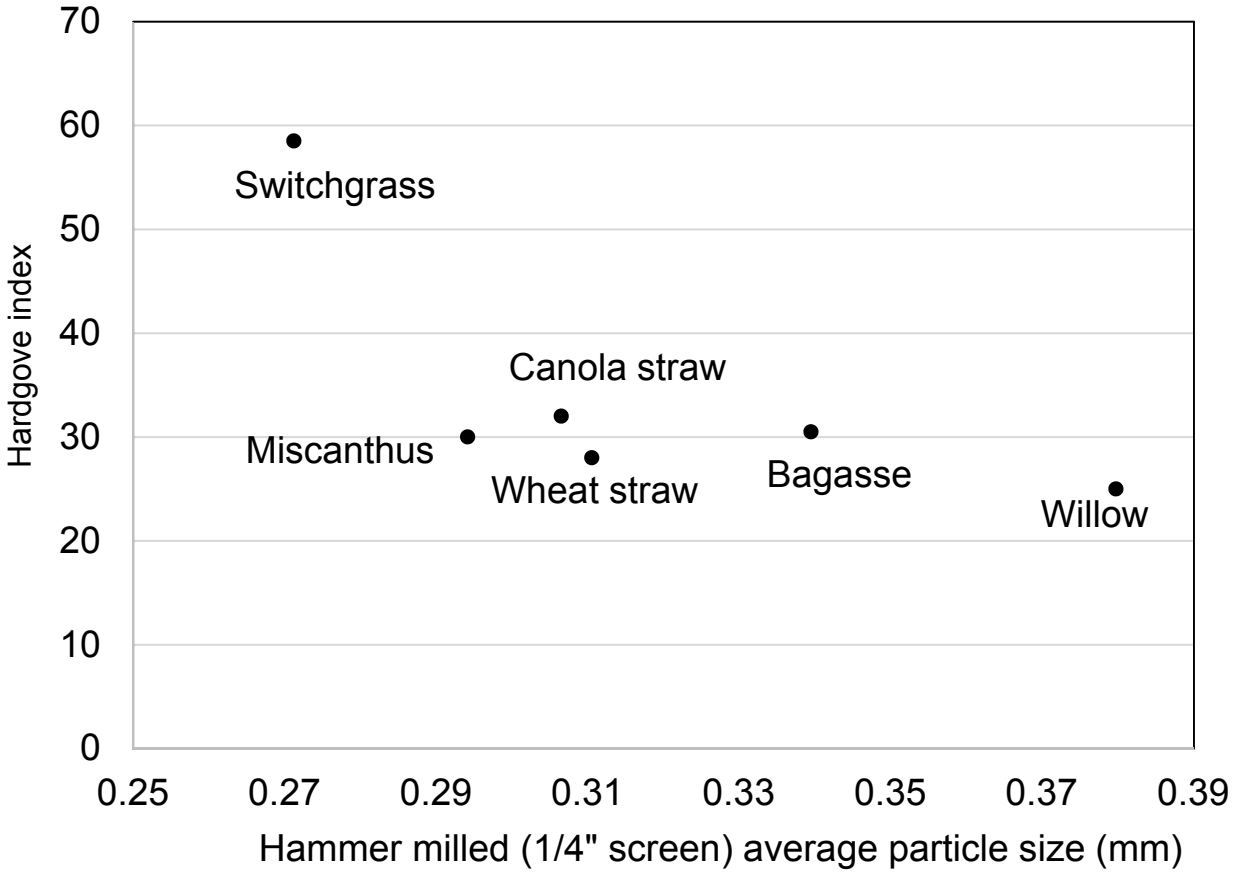
L* values are arranged from large (white) to dark black, bagasse the lightest to switchgrass the darkest. The scale on a* and b* are from -50 to +50. Wheat straw and miscanthus had slightly higher b* parameters of 7.1, making them yellowish brown.

Grindability



Hammer mill

Hargrove



Larger particle size is associated with smaller Hargrove index.

Hygroscopicity (moisture adsorption from humid air)

Pellets from untreated canola straw

Pellets made from torrefied canola straw no binder

Pellets made from torrefied canola straw with 5% binder

Pellets made from canola straw after 20 hours in humidity chamber, pellets made from untreated biomass (left), pellets made from torrefied biomass 0% binder (middle), pellets made from biomass with 5% binder (right).

Hygroscopicity (moisture adsorption from humid air)

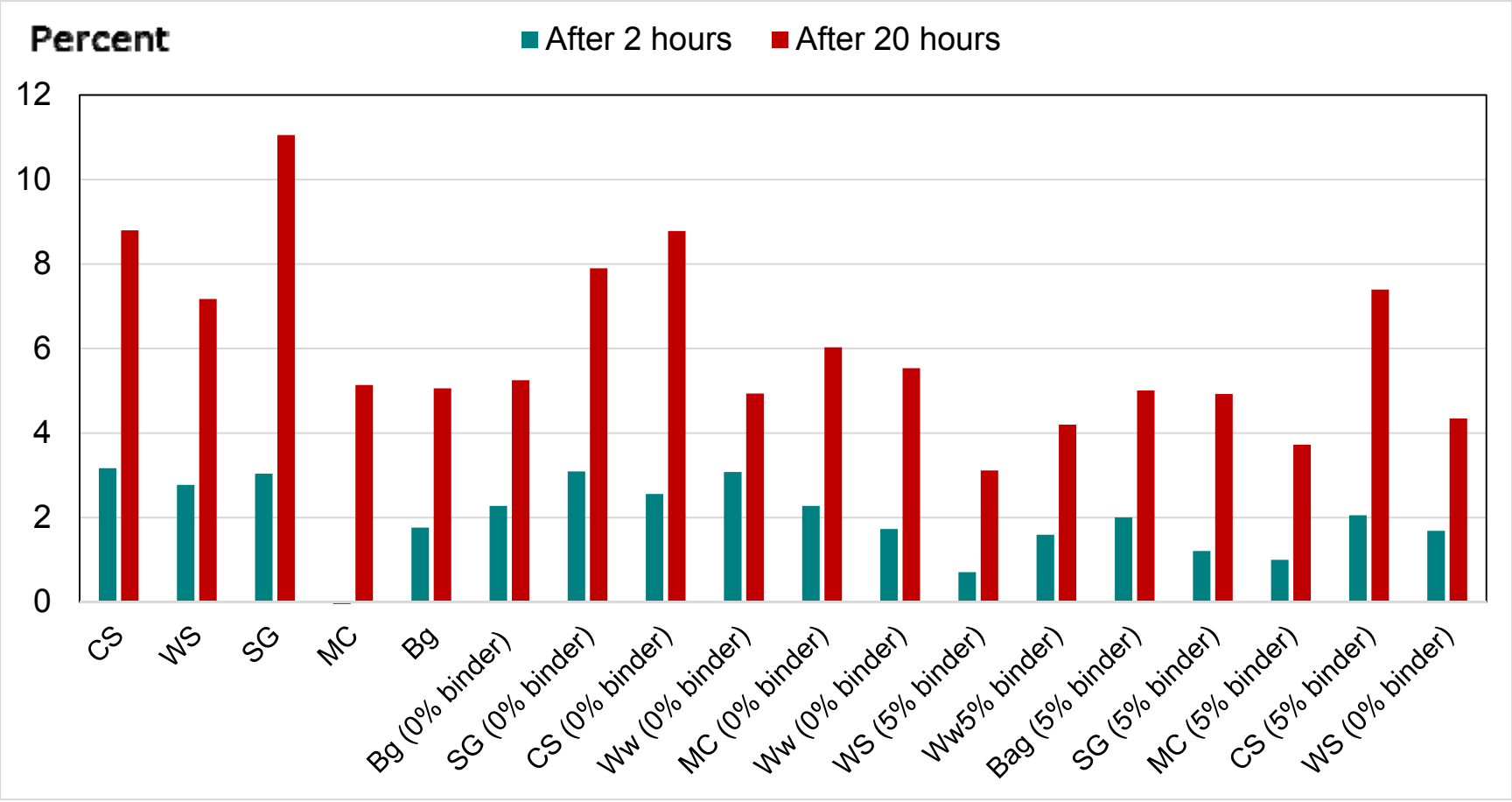


Figure 9. Moisture adsorption time after 2 and 20 hours respectively for pellets made from raw untreated material (the first 5 sets of bar graphs on the left) and torrefied pellets with 0% or 5% binder placed in humid chamber set at 30°C and 90% RH.

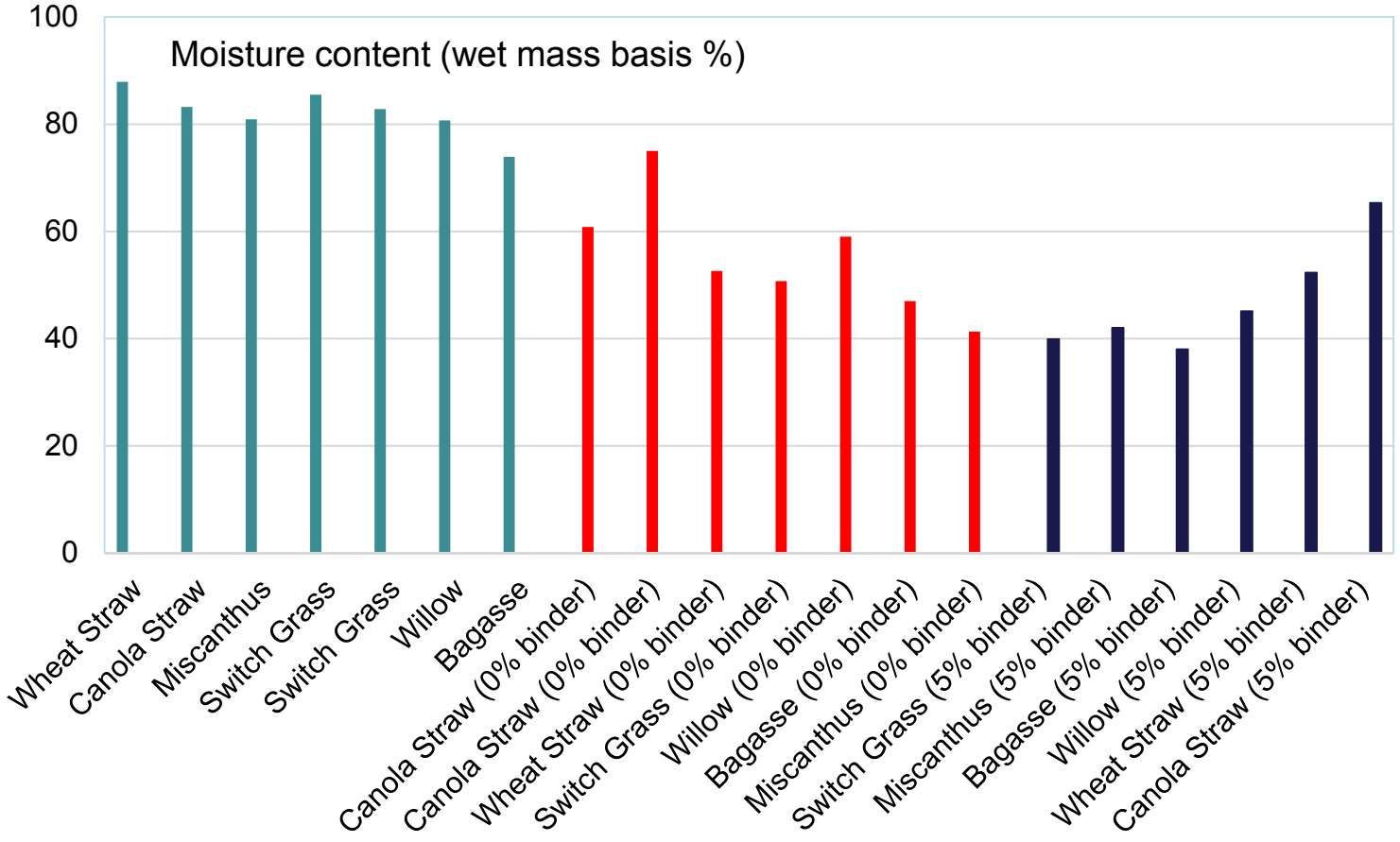
Liquid moisture adsorptivity (after 1 hour immersion in water)

Canola pellets made from raw material after immersed in water and drying

Torrefied canola pellets with no binder after immersed in water and drying

Torrefied canola pellets with 5% binder after immersed in water and drying

Liquid moisture adsorptivity
(after 1 hour immersion in water)



Moisture content of pellets after being blotted with towel paper

Summary and conclusions

- As expected torrefied pellets become hydrophobic but this hydrobicity does not prevent torrefied pellets become wet. Torrefied pellets made with the inclusion of 5% starch binder had more tendency to expand in humid environment or disintegrate in water than torrefied pellets made from feedstock with no binder.
- The higher is the value for HGI (Hargove Grindability Index) the easier the material is to grind. The measured HGI varied from a low of 22 for willow to a high of 62 for switchgrass. This variation in particle durability represent the variability and thus un predictability of torrefied biomass.

Production of “high quality torrefied wood pellets” with minimum energy consumption

Is it better to do torrefaction before or after pelletisation?

Low quality wood residue

Regular pellets

Torrefied pellets