VALORIZATION OF AGRICULTURAL WASTE THROUGH HYDROTHERMAL TREATMENT

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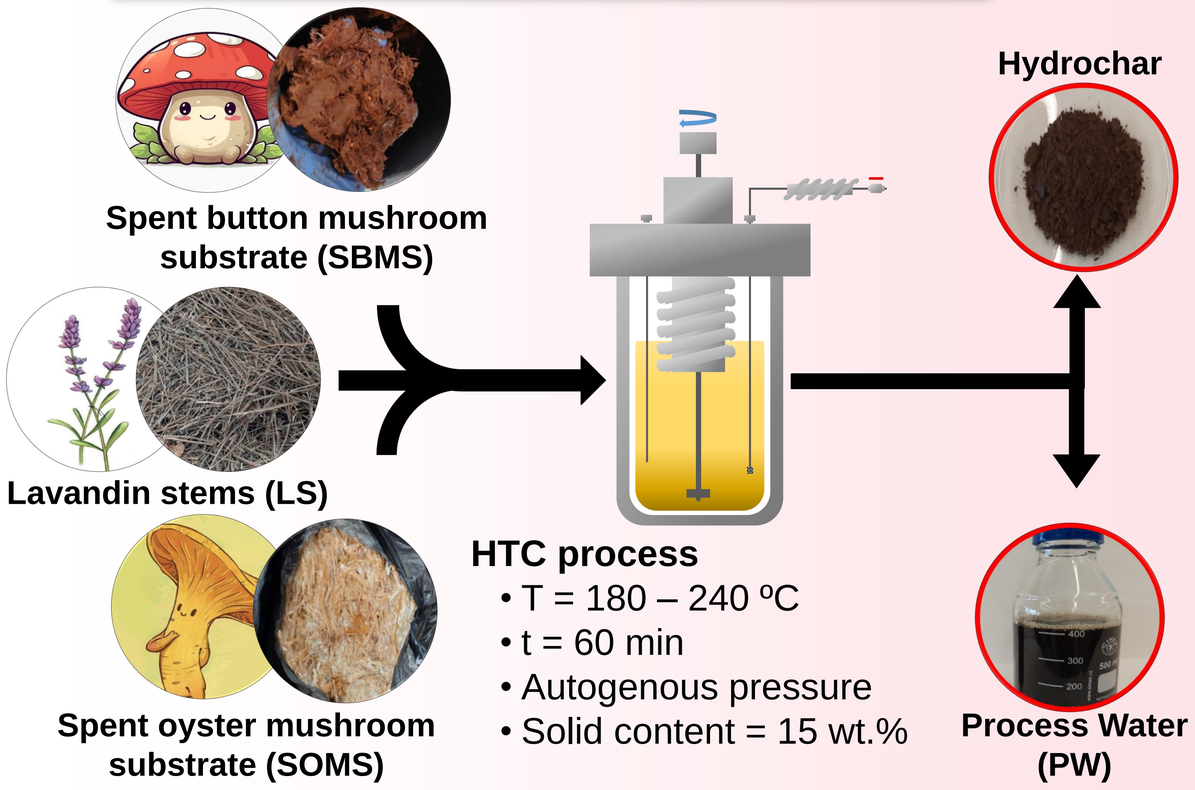
INTRODUCTION

Hydrothermal carbonization (**HTC**) is an efficient technology for the **treatment of organic wastes**, especially those with high moisture content, such as those derived from agriculture. Through this process, which is carried out at moderate temperatures in an aqueous environment, two main products are obtained: a solid fraction known as **hydrochar** (HC) and a liquid fraction or **process water** (PW). These products can be exploited within a circular economy framework for various applications. Hydrochar can be use as **solid biofuel**, **soil amendment** or **catalyst** support. Process water can be used for **nutrients** and **methane production** through anaerobic digestion.

Spain is one of the **main mushroom producers** in Europe, and interest in **lavandin** cultivation to **produce essential oils** has grown considerably. As a result, the generation of **agricultural waste** has increased significantly. These vegetable by-products, far from being simple waste, can be transformed into useful products through hydrothermal carbonization, promoting their efficient and sustainable use.

MATERIALS AND METHODS



RESULTS AND DISCUSSION

Analysis of hydrochar as solid biofuel: ISO normative and carbon combustion study

ISO 17225-8:2023
Graded thermally treated and densified biomass fuels for commercial and industrial use

Table 1. *ISO 17225-8:2023:* Limit values to use an hydrochar as biofuel.

N (%)	S (%)	VM (%)	Ash (%)	HHV (MJ/kg)
< 2.5	< 0.3	< 75	< 12	> 17

Table 2. Analyzed parameters of different wastes and hydrochars.

Hydrochar	Yield (wt.%)		C (wt.%)		N (wt.%)		S (wt.%)		Ash (wt. %)		VM (wt.%)		HHV (MJ/kg)	
SBMS	**-**		**29.6**		**2.5**		**1.3**		**31.6**		**60.0**		**10.3**	
SBMS_180	83.4	↑	32.3	↓	2.3	✓	2.4	✗	42.4	✗	52.6	✓	12.6	✗
SBMS_210	78.2	↑	32.6	↓	2.3	✓	2.5	✗	41.2	✗	53.6	✓	12.4	✗
SBMS_240	72.2	↑	33.8	↓	2.5	−	2.6	✗	40.8	✗	48.2	✓	12.7	✗
SOMS	**-**		**39.1**		**1.5**		**0.1**		**14.3**		**75.8**		**14.6**	
SOMS_180	70.6	↑	42.6	↓	1.4	✓	0.1	✓	16.8	−	75.0	−	16.2	−
SOMS_210	64.6	↑	43.8	↓	1.4	✓	0.1	✓	18.2	✗	68.7	✓	18.8	✓
SOMS_240	50.8	↑	47.4	↓	1.9	✓	0.2	✓	26.7	✗	67.4	✓	18.1	✓
LS	**-**		**47.8**		**1.1**		**0.1**		**3.8**		**78.3**		**18.5**	
LS_180	62.7	↑	54.0	↓	1.2	✓	0.1	✓	4.7	✓	78.9	−	21.5	✓
LS_210	59.2	↑	56.5	↓	1.1	✓	0.1	✓	1.8	✓	70.5	✓	22.0	✓
LS_240	51.0	↑	63.4	↓	1.4	✓	0.1	✓	4.4	✓	62.1	✓	25.5	✓

- The combustion of hydrochars is highly reactive due to ignition temperatures (T_i) around 265 ºC.
- For some materials, several weight loss drops (T_m), and two maximum combustion temperatures (T_b) are observed.
- Activation energy increases as increasing HTC temperature between 67 – 314 kJ/mol.

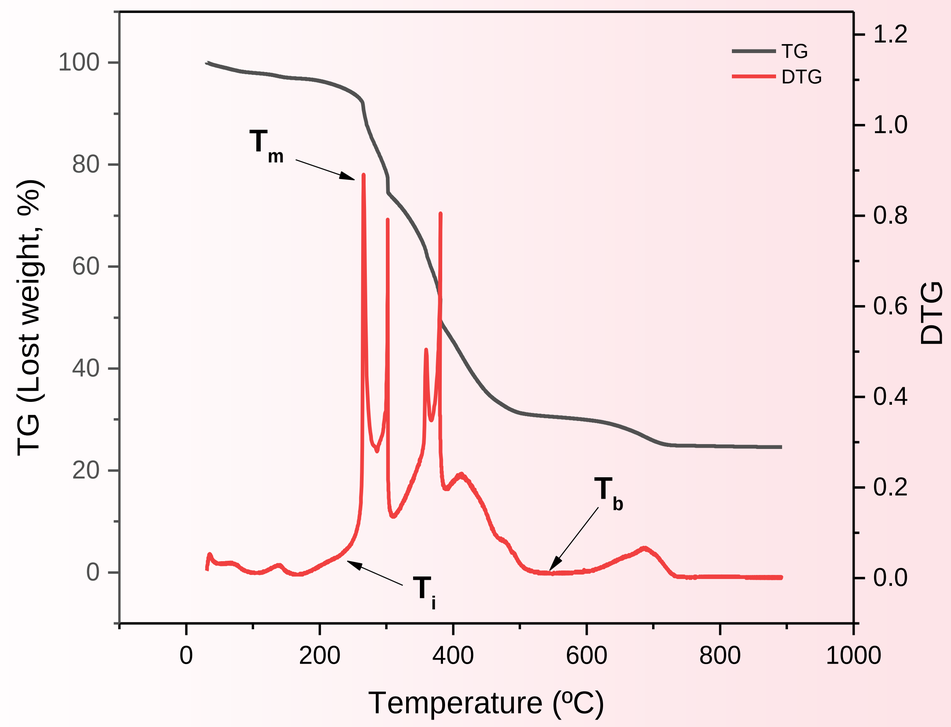


Fig. 1: DT and DTG plots of LS_240 hydrochar for combustion analysis.

Analysis of hydrochar as catalyst precursor

CO_2 Adsorption Isotherms
✓ Mean pore size: 1.72 – 1.87 nm
✓ SDA: 140 – 250 m^2/g → **SOMS_240**

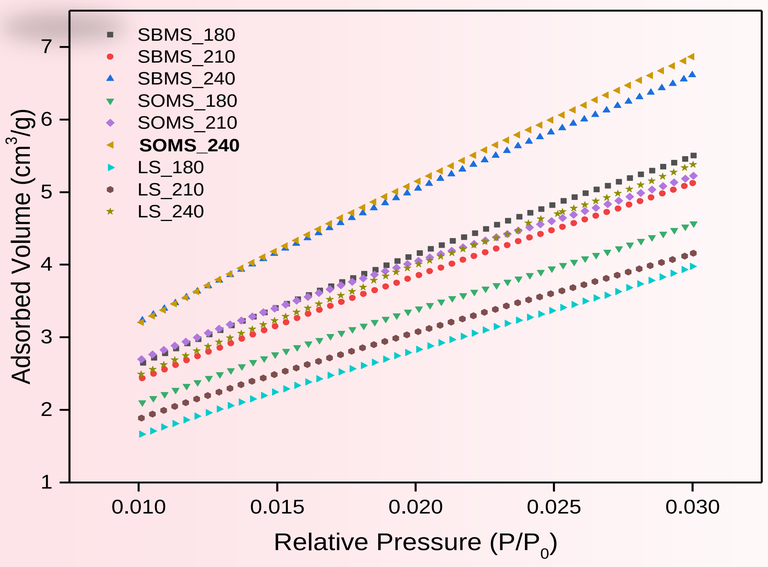


Fig. 2: CO_2 adsorption isotherms of different hydrochars.

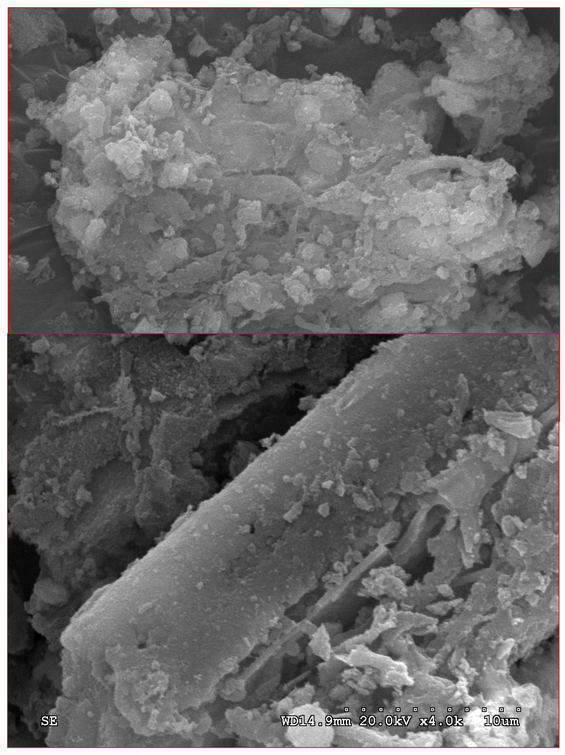


Fig. 3: SEM images of SOMS_240.

Analysis of hydrochar as soil amendment

Table 3. *RD 2051/2022, RD 824/2024*: Standards for sustainable nutrition in agricultural soils. Limit values (mg/kg dry basis).

Cd	Cu	Ni	Pb	Zn	Hg	Cr	As
10	1000	300	750	2500	10	1000	40

CONCLUSIONS

✓ Hydrochars from spent oyster mushroom and lavandin stems showed good combustible properties and comply with ISO standards.
✓ Hydrochars obtained at high temperatures appear to be good candidates for catalytic precursors.
✓ All hydrochars complied all the regulations for use as soil amendment in agricultural soils.

ACKNOWLEDGEMENTS: MCIN/AEI/10.13039/501100011033/FEDER,UE PID2022-138632OB-I00, PREP2022-000792 MCIN/AEI/10.13039/501100011033 TED2021-130287B-I00, RYC2021-032796-I

Financiado por la Unión Europea NextGenerationEU