

Table S1. Analysis of variance response variables (solid yield (%), microwave energy consumption (KJ), higher heating value (MJ/kg)) to experimental variables (biochar (%), residence time (min), microwave power (W)) for torrefied camelina straw with and without biochar.

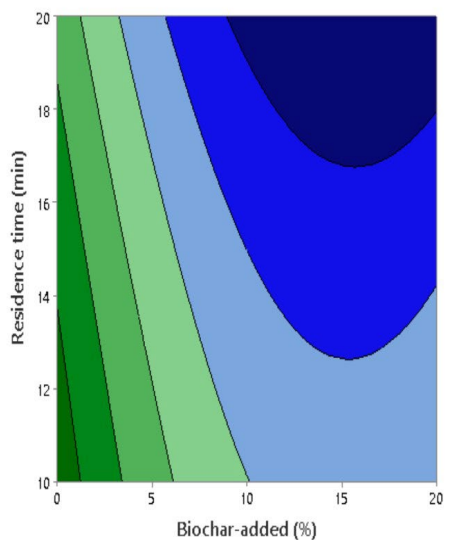
Source	DF	Solid yied (%)			MW-EC (KJ)			HHV (MJ/kg)		
		Adj SS	F-Value	P-Value	Adj SS	F-Value	P-Value	Adj SS	F-Value	P-Value
Model	8	2464.84	101.31	0.000	24289.20	134.91	0.000	19.87	2048.12	0.000
Linear	3	2089.82	229.06	0.000	22452.90	332.56	0.000	19.09	5248.23	0.000
Biochar (%)	1	1614.72	530.95	0.000	20698.60	919.74	0.000	14.30	11794.5	0.000
RT (min)	1	238.79	78.52	0.000	194.60	8.65	0.016	3.09	2549.01	0.000
MW power (W)	1	236.31	77.70	0.000	1559.80	69.31	0.000	1.70	1401.19	0.000
Square	2	317.62	52.22	0.000	1169.90	25.99	0.000	0.12	50.05	0.000
Biochar (%)*Biochar (%)	1	316.48	104.07	0.000	1152.40	51.21	0.000	0.00	0.04	0.852
RT (min)*RT (min)	1	1.13	0.37	0.557	17.50	0.78	0.400	0.12	100.07	0.000
2-Way Interaction	3	57.4	6.29	0.014	666.40	9.87	0.003	0.66	180.06	0.000
Biochar (%)*RT (min)	1	4.76	1.56	0.243	653.20	29.03	0.000	0.03	20.88	0.001
Biochar (%)*MW power (W)	1	34.95	11.49	0.008	6.10	0.27	0.615	0.02	14.54	0.004
RT (min)*MW power (W)	1	17.69	5.82	0.039	7.10	0.31	0.589	0.61	504.75	0.000
Error	9	27.37			202.50			0.01		
Total	17	2492.21			24491.80			19.88		
R²			0.989			0.991			0.999	
R² Adjusted			0.979			0.944			0.998	
R² predicted			0.949			0.966			0.996	

RT: Residence time; R²: Correlation coefficient; DF: degrees of freedom; Adj SS: Adjusted sum of squares; MW-EC: Microwave energy consumption, HHV: High heating value

Table S2. Analysis of variance response variables (solid yield (%), microwave energy consumption (KJ), higher heating value (MJ/kg)) to experimental variables (biochar (%), residence time (min), microwave power (W)) for torrefied camelina straw with and without biochar.

Analysis of Variance		Solid yield (%)			MW-EC (KJ)			HHV (MJ/kg)		
Source	DF	Adj SS	F-Value	P-Value	Adj SS	F-Value	P-Value	Adj SS	F-Value	P-Value
Model	8	1454.74	68.73	0.000	18026.00	64.01	0.000	16.53	54.48	0.000
Linear	3	1303.63	164.25	0.000	16482.00	156.08	0.000	16.17	142.15	0.000
Biochar (%)	1	784.89	296.68	0.000	15298.90	434.64	0.000	9.45	249.21	0.000
RT (min)	1	360.91	136.42	0.000	135.40	3.85	0.081	4.68	123.26	0.000
MW power (W)	1	157.83	59.66	0.000	1047.80	29.77	0.000	2.05	53.97	0.000
Square	2	132.21	24.99	0.000	788.80	11.20	0.004	0.01	0.12	0.889
Biochar (%)*Biochar (%)	1	132.21	49.97	0.000	779.10	22.13	0.001	0.00	0.00	0.980
RT (min)*RT (min)	1	0.00	0.00	0.977	9.70	0.28	0.611	0.01	0.24	0.637
2-Way Interaction	3	18.89	2.38	0.137	755.20	7.15	0.009	0.35	3.06	0.084
Biochar (%)*RT (min)	1	8.74	3.30	0.103	660.50	18.76	0.002	0.05	1.31	0.282
Biochar (%)*MW power (W)	1	9.00	3.40	0.098	92.00	2.61	0.140	0.03	0.66	0.436
RT (min)*MW power (W)	1	1.16	0.44	0.525	2.70	0.08	0.789	0.27	7.20	0.025
Error	9	23.81			316.80			0.34		
Total	17	1478.55			18342.80			16.87		
R²			0.983			0.982			0.979	
R² Adjusted			0.969			0.967			0.961	
R² predicted			0.917			0.926			0.923	
Correlation coefficient (%)			1.63			5.93			0.20	

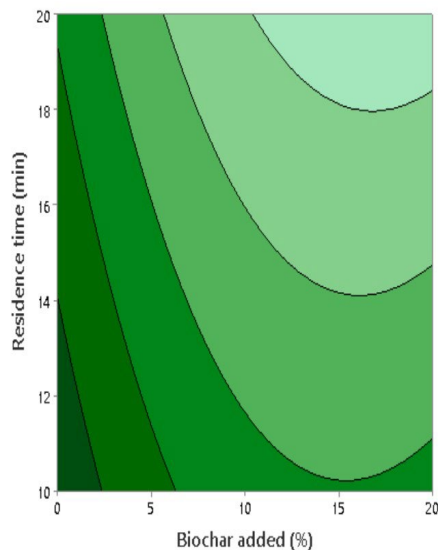
RT: Residence time; R²: Correlation coefficient; DF: degrees of freedom; Adj SS: Adjusted sum of squares; MW-EC: Microwave energy consumption, HHV: High heating value



Solid yield (%)

- < 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- > 80

Hold Values
MW power (W) 520

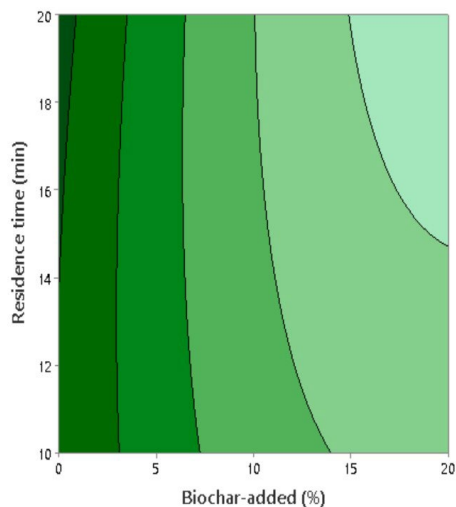


Solid yield (%)

- < 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- > 70

Hold Values
MW power (W) 520

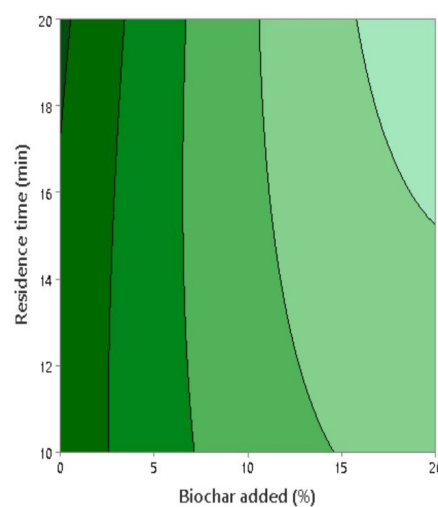
a. Solid yield (%)



MW energy consumption (KJ)

- < 320
- 320 - 340
- 340 - 360
- 360 - 380
- 380 - 400
- > 400

Hold Values
MW power (W) 520

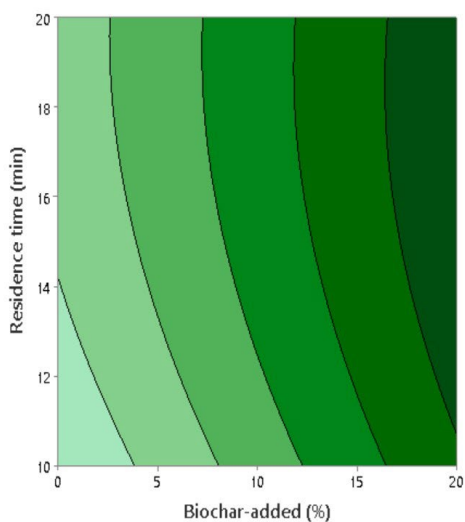


MW energy Consumption (KJ)

- < 300
- 300 - 320
- 320 - 340
- 340 - 360
- 360 - 380
- > 380

Hold Values
MW power (W) 520

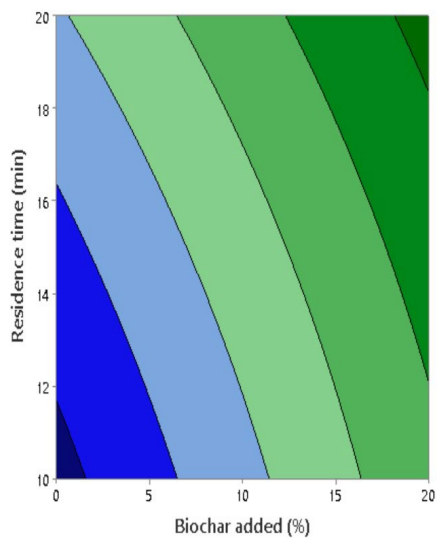
b. Microwave energy consumption (KJ)



HHV (MJ/kg)

- < 20.0
- 20.0 - 20.5
- 20.5 - 21.0
- 21.0 - 21.5
- 21.5 - 22.0
- > 22.0

Hold Values
MW power (W) 520



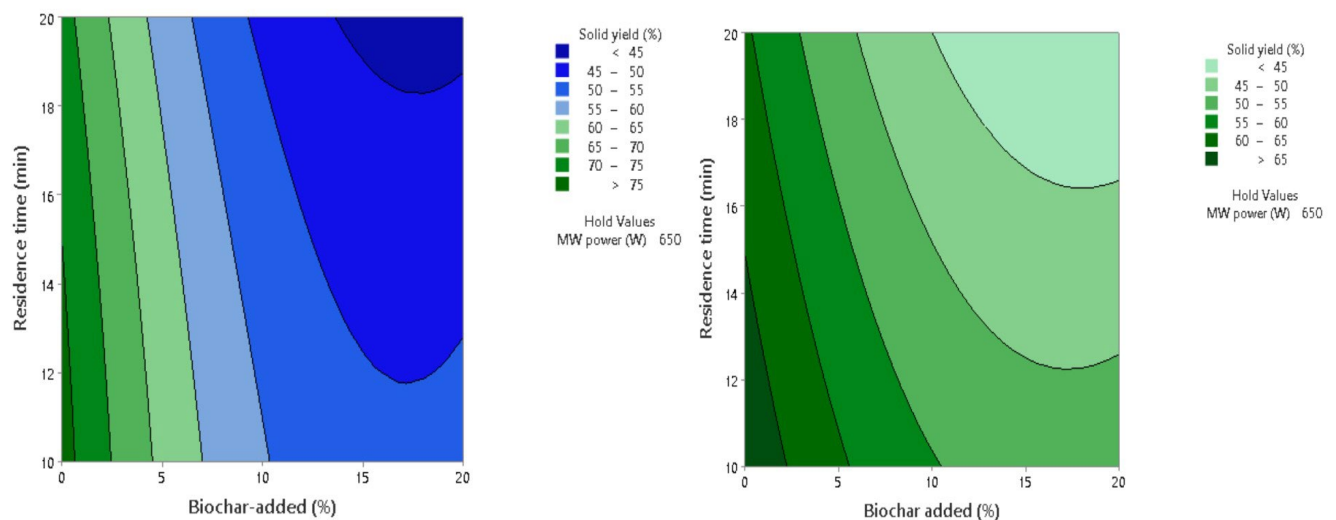
HHV (MJ/kg)

- < 21.5
- 21.5 - 22.0
- 22.0 - 22.5
- 22.5 - 23.0
- 23.0 - 23.5
- 23.5 - 24.0
- > 24.0

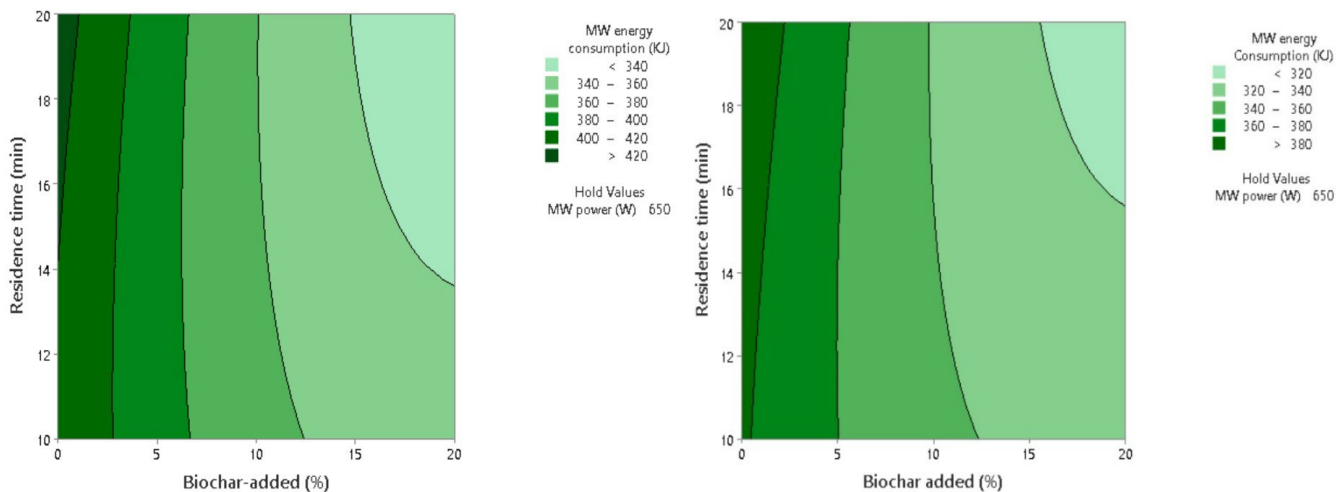
Hold Values
MW power (W) 520

c. Higher heating value (MJ/kg)

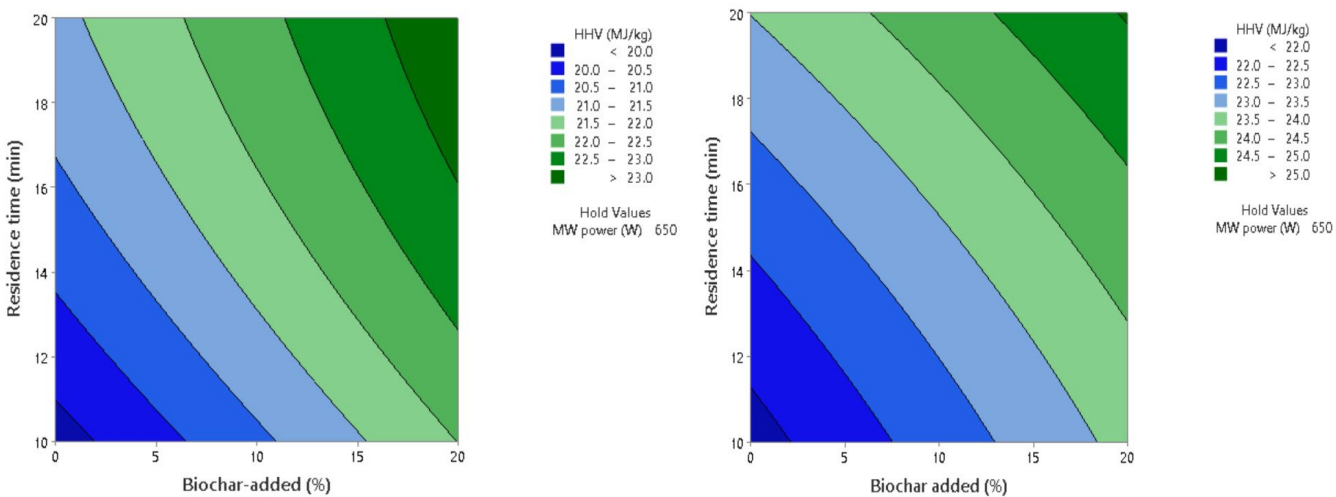
Figure S1. Contour plots (a) Solid yield (%), (b) MW energy consumption and (c) HHV as a function of residence time (min) and biochar at 520 W: torrefied camelina straw (left-hand side) and torrefied switchgrass (right-hand side).



a. Solid yield (%)



b. Microwave energy consumption (KJ)



(c). Higher heating value (MJ/kg)

Figure S2. Contour plots (a) Solid yield (%), (b) MW energy consumption and (c) HHV as a function of residence time (min) and biochar at 650 W: torrefied camelina straw (left-hand side) and torrefied switchgrass (right-hand side).

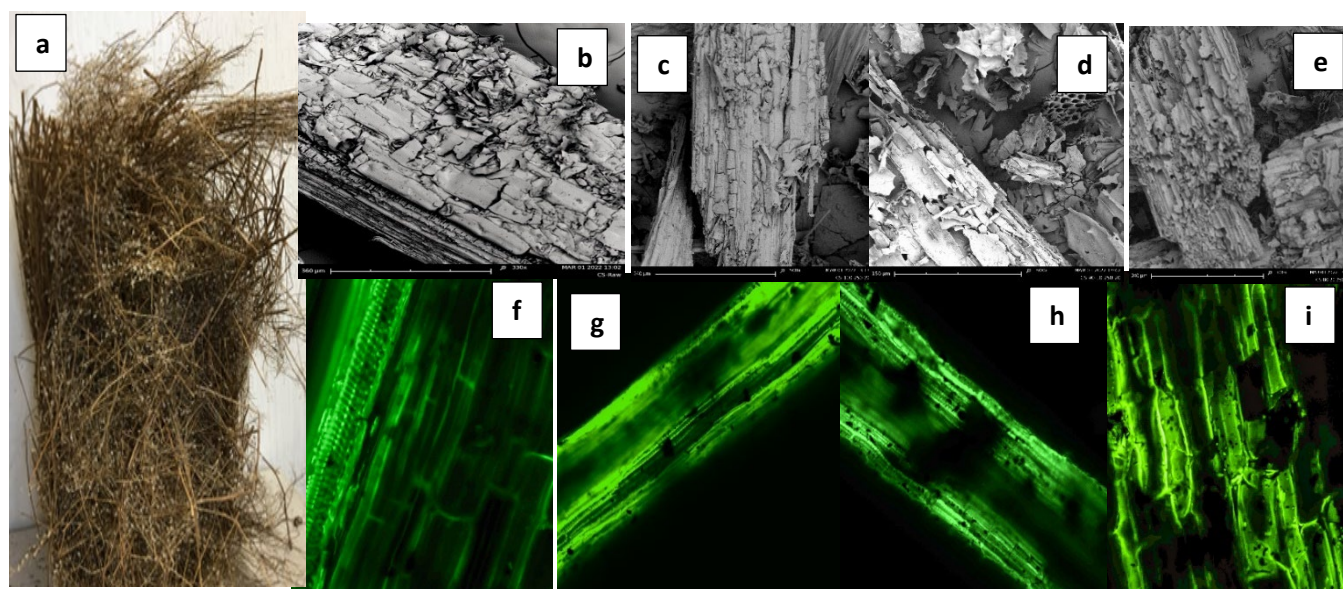


Figure S3. SEM and confocal laser scanning 2.5D imagery plots for raw and torrefied camelina straw. (a) Raw camelina straw, SEM images (b) ground camelina straw, (c) torrefied camelina straw without biochar, (d) microwave torrefied camelina straw with biochar at 520 W, (e) microwave torrefied camelina straw with biochar at 650 W; confocal laser microscopy 2D imagery (f) ground camelina straw, (g) torrefied camelina straw without biochar, (h) microwave torrefied camelina straw with biochar at 520 W, (i) microwave torrefied camelina straw with biochar at 650 W

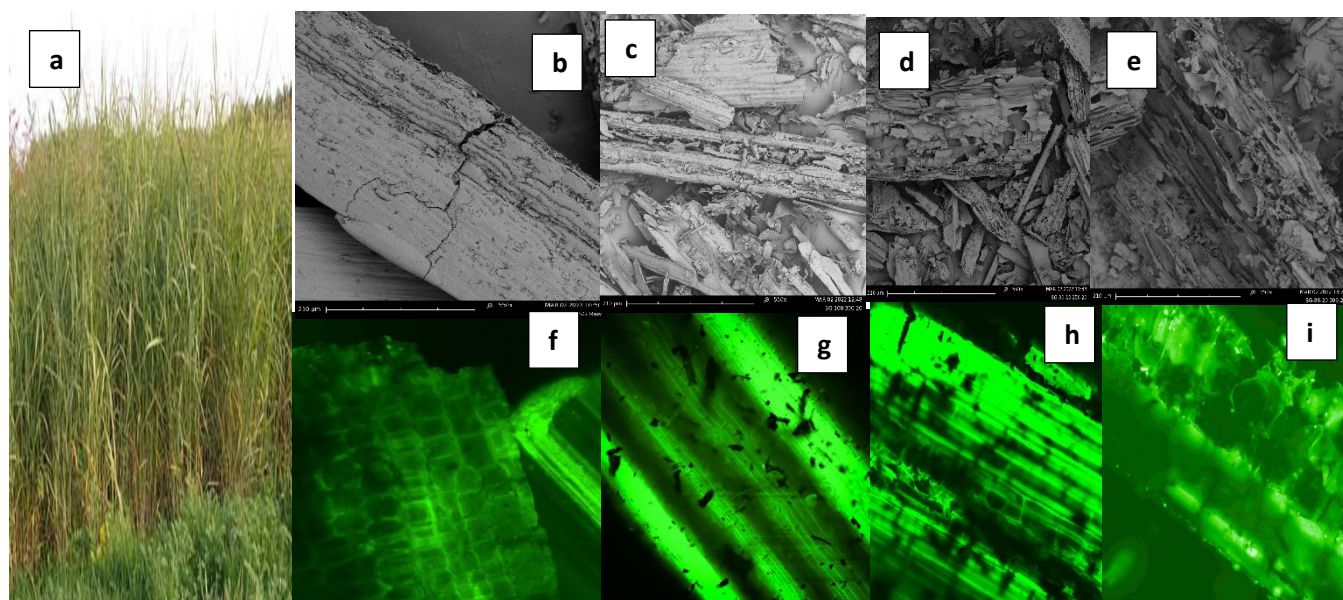


Figure S4. SEM and confocal laser scanning 2.5D imagery plots for raw and torrefied switchgrass. (a) Raw switchgrass, SEM images (b) ground switchgrass, (c) torrefied switchgrass without biochar, (d) microwave torrefied switchgrass with biochar at 520 W, (e) microwave torrefied switchgrass with biochar at 650 W; confocal laser microscopy 2D imagery (f) ground switchgrass, (g) torrefied switchgrass without biochar, (h) microwave torrefied switchgrass with biochar at 520 W, (i) microwave torrefied switchgrass with biochar at 650 W