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Combustion behaviour of agro-industrial and livestock waste blends

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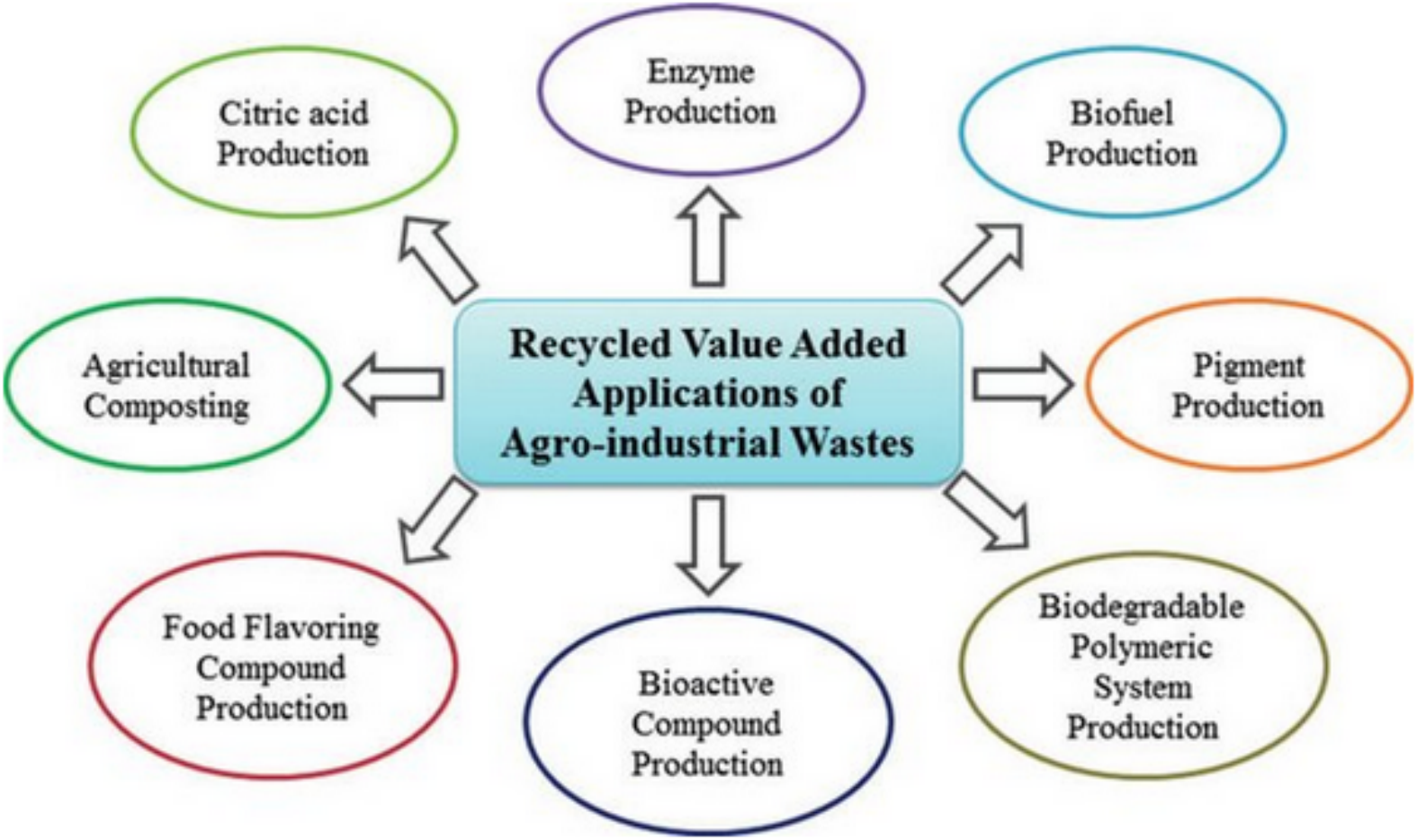
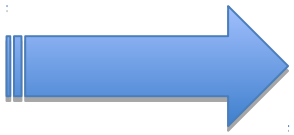
Agro-industrial Waste

Source: M.Yusuf, Handbook of Ecomaterials, 2017

Applications of agro-industral waste



The aim of the work is to study thermal decomposition of selected agro-industrial waste and animal livestock burned alone and their blends via termogravimetric analyses to determinate the conditions of the combustion process for their application as fuel.



Materials

Turkey

Cotton stalk (CS)

Camel manure (CAM)

Poland

Rapeseed oil cake (ROC)

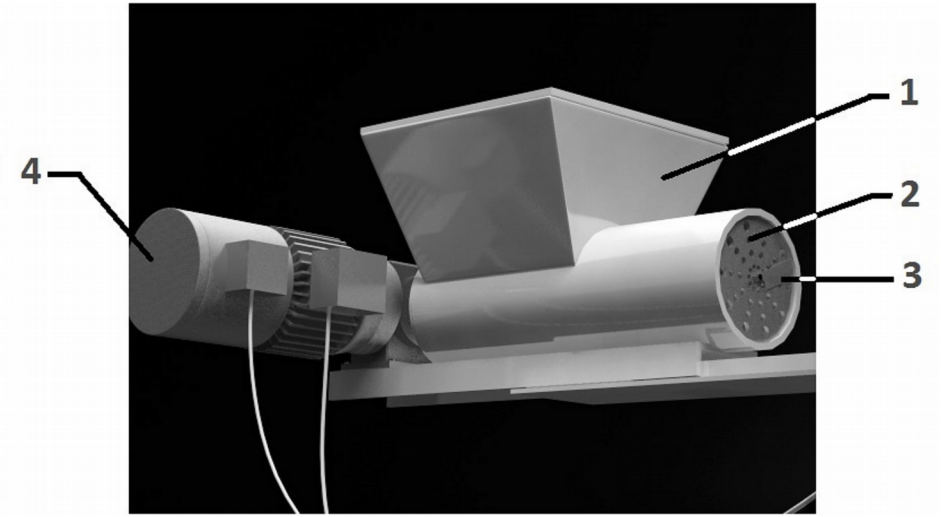
Cow manure (COM)

Materials

In order to identify the blends - pellets, individual symbols were attributed to them:

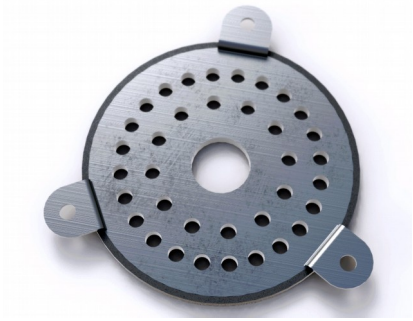
- **CAM90** – 90% camel manure and 10% cotton stalk
- **CAM80** – 80% camel manure and 20% cotton stalk
- **COM90** – 90% cow manure and 10% rapeseed oil cake
- **COM70** – 70% cow manure and 30% rapeseed oil cake

Pelletization



1 – dosing funnel equipped with a feeding screw, 2 – replaceable sieve, 3 – cutting element,
4 – feeding screw motor.

Sieve



ϕ- 8 mm

Pellets produced on the basis of animal waste and agro-industrial waste

90% camel manure and 10% cotton straw
CAM90

70% cow manure and 30% rapeseed oil cake
COM70

Methods

1. The energy parameters:

- **moisture -** PN-EN ISO 18134
- **ash -** PN-EN ISO 18122 and PN-ISO 117
- **volatile matter -** PN-EN ISO 18123
- **elementary analysis** using Vario Macro Cube analyser 2.
- **higher heating value (HHV)** with the use of the IKA Calorimeters C 5000 according to PN-EN 14918:2010 and PN-ISO 1928 standard

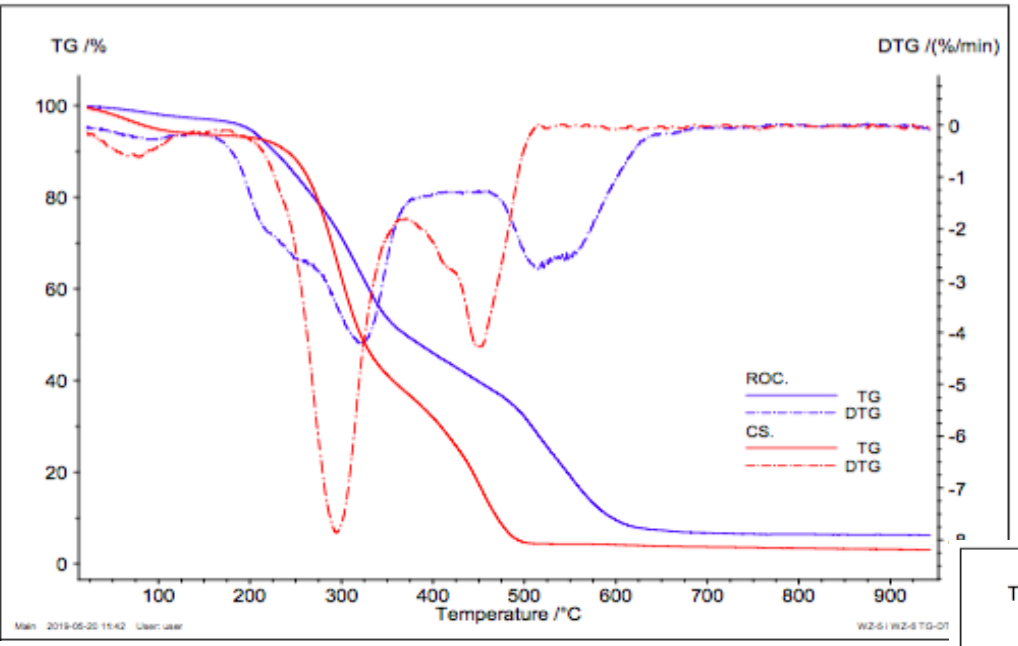
2. The simultaneous thermal analysis (TG-DTG) and (DSC) was carried out in NETZSCH STA 449 F3 Jupiter device.

- in a dry air atmosphere with the gas flow of 70 mL/min
- temperature up to 1,000^{o}C
- heating rate: 10 K/min

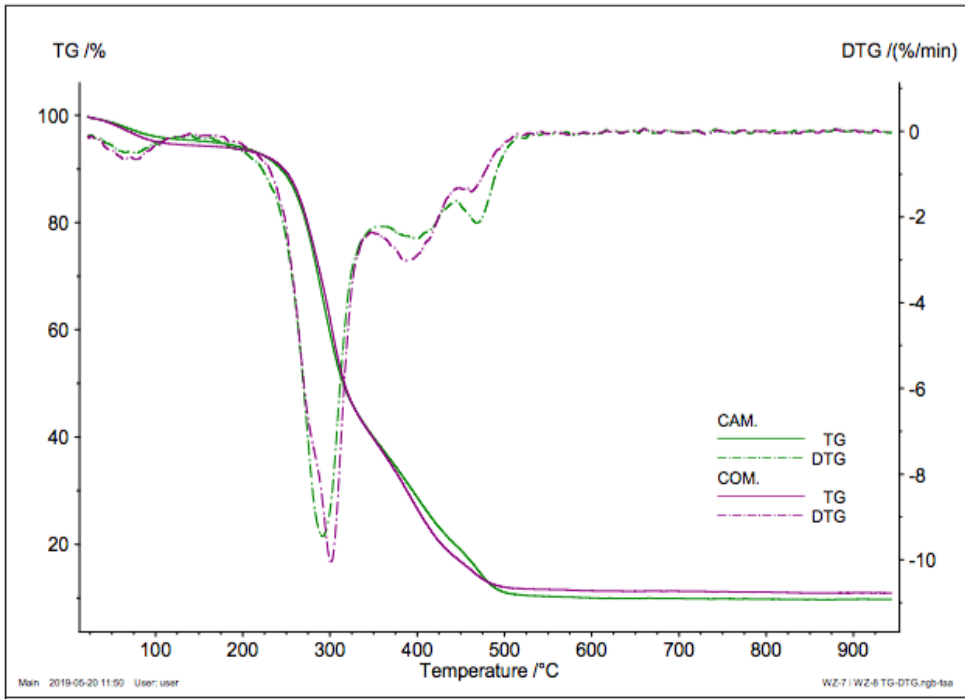
The proximate and ultimate analysis of tested biomass and blends

Samples	Proximate analysis wt%			Ultimate analysis wt%					HHV MJ/kg
	Moisture	Ash d.m.	Voltaire matter d.m.	C	H	N	S	O	
				d.m.					
CS	7.98	4.83	64.90	48.79	5.98	1.47	0.14	58.80	17.09
ROC	11.66	6.47	66.31	50.66	6.83	5.89	0.68	62.74	20.23
CAM	57.43	9.09	64.28	47.75	5.86	1.97	0.33	60.41	17.43
COM	84.21	12.12	61.49	48.09	6.13	1.72	0.25	60.01	17.10
CAM90	50.20	8.4	51.82	47.65	6.10	1.94	0.25	60.64	17.70
CAM80	46.54	8.24	62.36	47.88	6.01	1.73	0.24	60.10	17.51
COM90	74.60	11.43	59.97	48.72	6.39	2.26	0.29	60.22	17.48
COM70	62.00	9.89	66.97	49.20	6.48	3.03	0.39	60.70	18.08

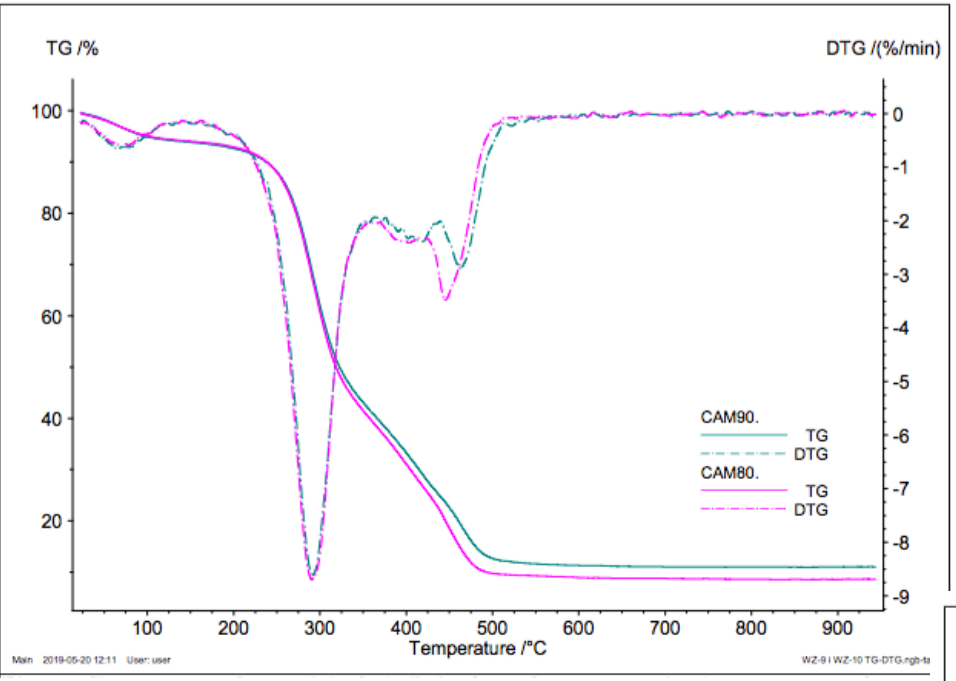
TG/DTG curves:
cotton stalk (CS) and rapeseed oil cake (ROC)



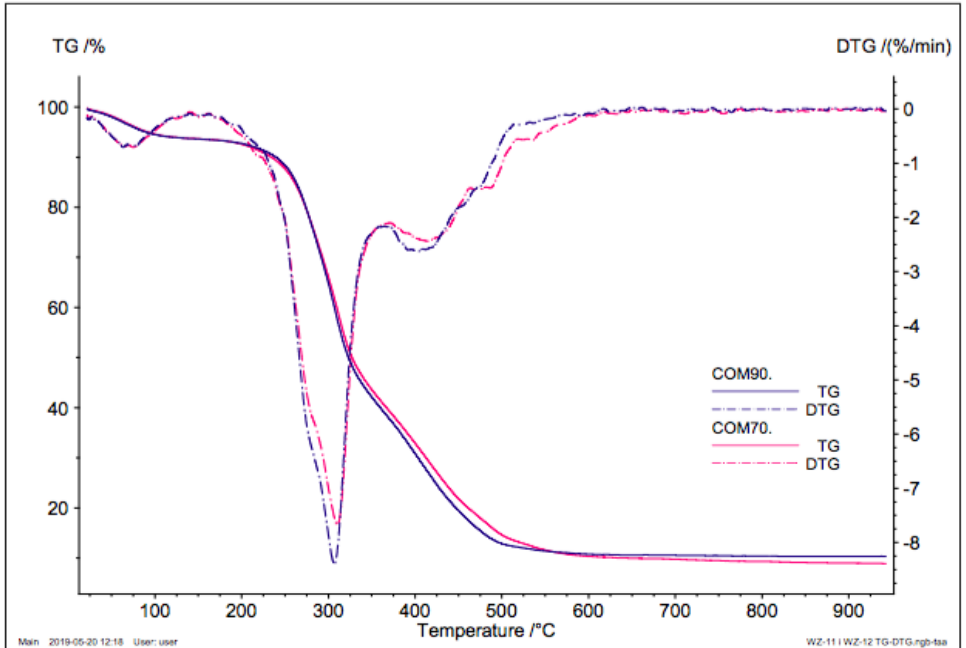
camel manure (CAM) and cow manure (COM)



TG/DTG curves of blends: camel manure and cotton stalk (CAM)



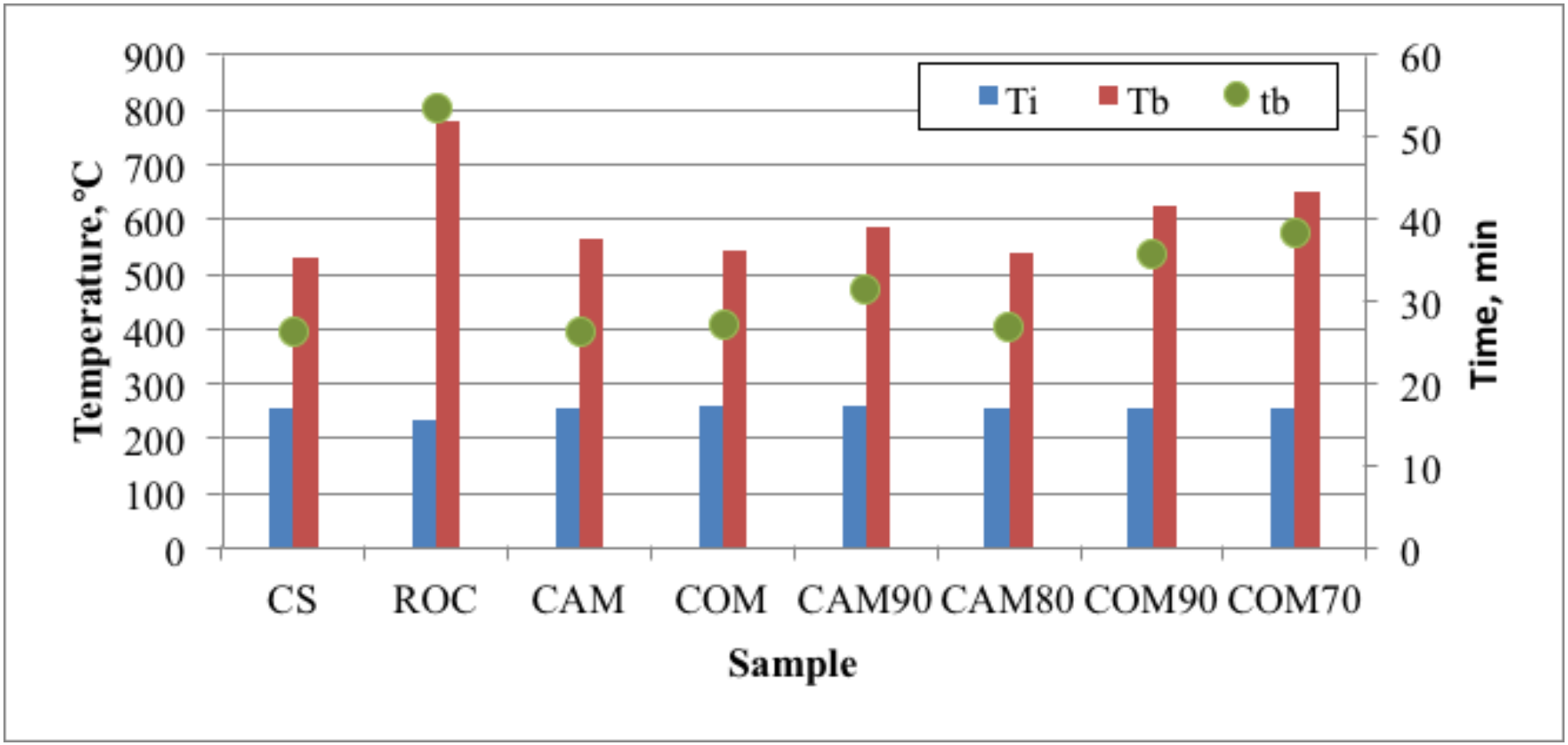
caw manure and rapeseed oil ca



Temperature ranges of combustion stages

Sample	Stage II	Stage III	Stage IV
	°C	°C	°C
CS	176-372	372-530	-
ROC	150-420	420-781	-
CAM	157-360	360-445	445-565
COM	158-347	347-448	448-545
CAM90	163-365	365-440	440-585
CAM80	156-362	362-421	421-540
COM90	152-368	368-625	-
COM70	160-371	371-468	468-652

Ignition temperature T_i, temperature of end combustion T_b and total combustion time t_b

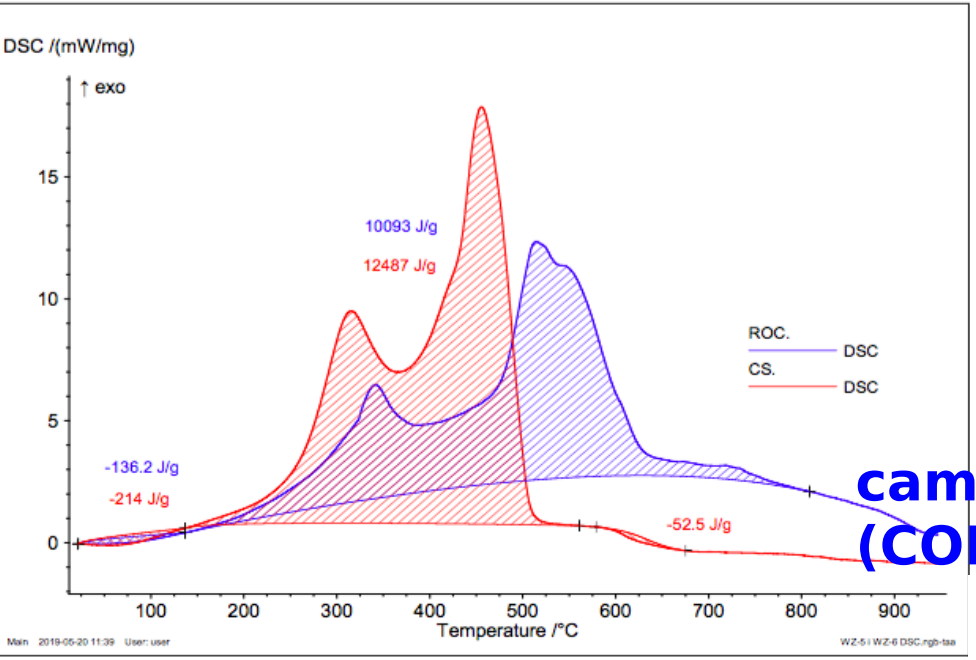


The maximum values of peaks on the DTG (Differential Thermogravimetry) and DSC (Differential Scanning Calorimetry) curves and their temperatures at

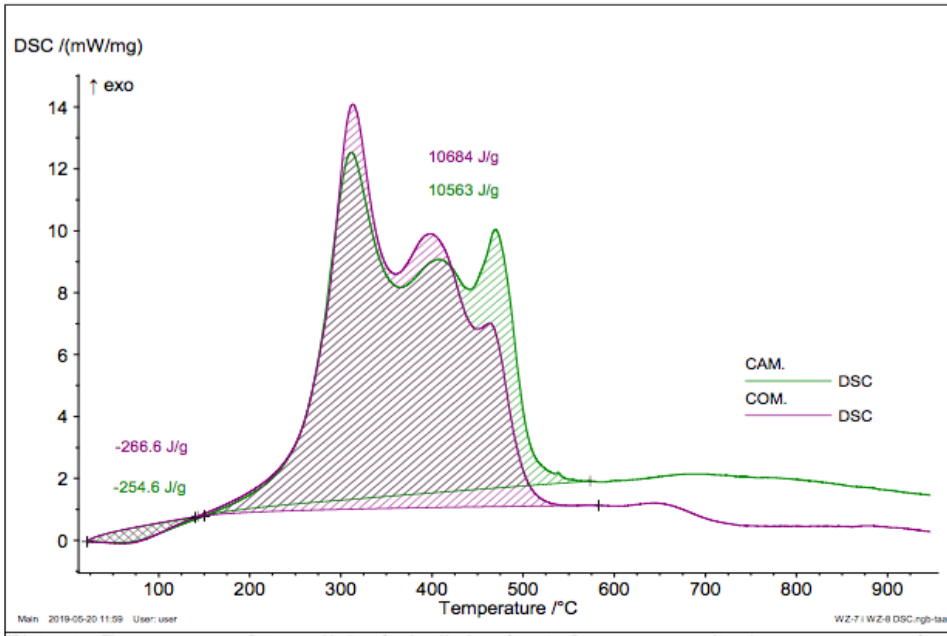
Sample	Stage II				Stage III				Stage IV			
	DTG		DSC		DTG		DSC		DTG		DSC	
	Mass loss rate	T_{II}	Max. heat release	$T_{Max\ II}$	Mass loss rate	T_{III}	Max. heat release	$T_{Max\ III}$	Mass loss rate	T_{IV}	Max. heat release	$T_{Max\ IV}$
	%/min	°C	MW/mg	°C	%/min	°C	MW/mg	°C	%/min	°C	MW/mg	°C
CS	-7.86	294.6	9.50	315.7	-4.27	449.1	17.87	455.6	-	-	-	-
ROC	-4.23	323.8	6.47	341.6	-2.79	515.6	12.35	514.5	-	-	-	-
CAM	-9.45	291.7	12.53	311.5	-2.50	400.0	9.08	406.2	-2.14	468.4	10.04	469.6
COM	-10.06	301.2	14.08	313.1	-3.02	385.9	9.90	399.6	-1.41	462.2	7.02	463.3
CAM90	-8.62	291.5	9.75	315.9	-2.39	418.8	8.93	423.7	-2.89	463.0	12.06	465.9
CAM80	-8.69	290.8	10.08	313.5	-2.41	403.4	13.05	451.0	-3.48	445.3	-	-
COM90	-8.39	306.9	12.08	319.4	-2.63	403.5	9.67	423.5	-	-	-	-
COM70	-7.67	310.3	11.56	323.2	-2.44	415.1	9.27	433.0	-1.46	486.6	7.71	487.7

DSC curves of tested biomass

cotton stalk (CS) and rapeseed oil cake (ROC)

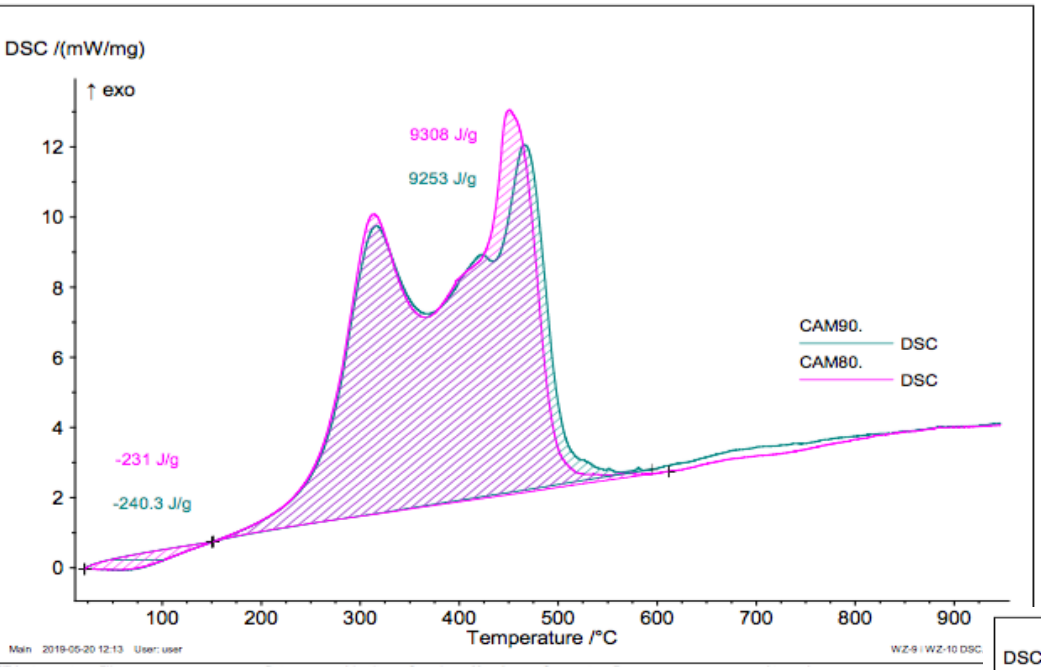


camel manure (CAM) and caw manu (COM)

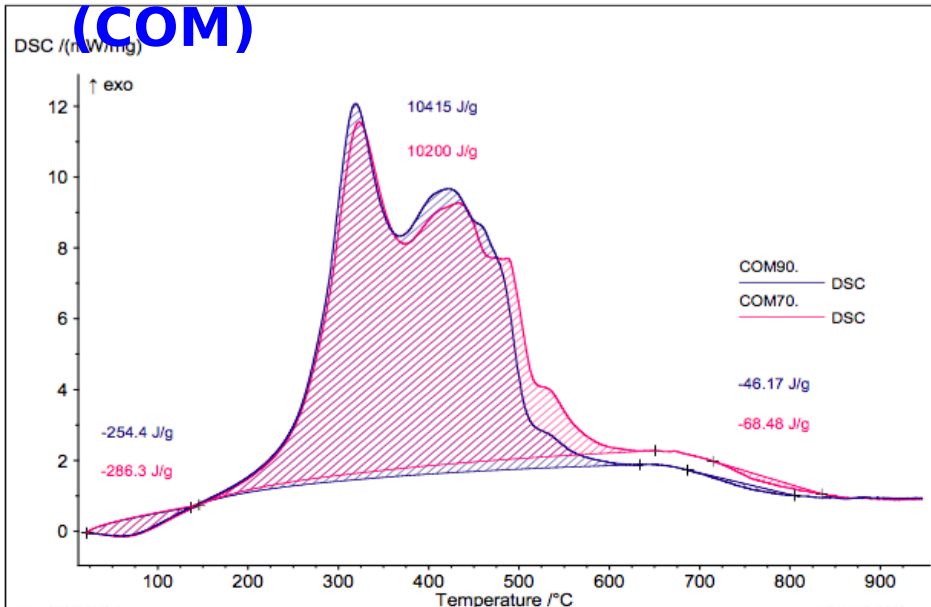


DSC curves of blends

camel manure and cotton stalk (CAM)



caw manure and rapeseed oi cake (COM)



Conclusions

- Thermal degradation of studied biomass and their blends shows three main stages: moisture evaporation, volatilization of the light molecules, and char combustion.
- For combusting blends, what has a decisive impact on the burning profile is the component occurring in the highest amount. The effect grows stronger as there is more of this component.
- Blend COM70 – (70% cow manure and 30% rapeseed oil cake) is recommended to application as a fuel because of proper energy parameters and combustion behaviour as well as mechanical strength of pellets.

Thank you for your attention