

Table 2
Summary of few salient data used for derivation and validation of correlation

Sr. no.	Raw material	Proximate analysis			Ultimate analysis					Measured HHV Dry basis MJ/kg	Calculated HHV MJ/kg	Reference
		[% by wt. dry basis]			[% by wt. dry basis]							
		FC	VM	ASH	C	H	O	N	S			
<i>1 Coals/coke</i>												
1	Northumber land no. 8-Anth. coal	84.59	7.09	8.32	83.67	3.56	2.84	0.55	1.05	32.856	30.951	[14]
2	German-Anna	79.60	12.00	8.40	82.62	3.02	3.66	0.92	0.73	33.000	29.952	[15]
3	Coal sample	30.00	30.00	40.00	–	–	–	–	–	14.772	14.973	[16]
4	German Braunkohole lignite	46.03	49.47	4.50	63.89	4.97	24.54	0.57	0.48	25.100	23.953	[15]
5	L01	27.72	38.32	33.96	–	–	–	–	–	15.630	15.511	[4]
6	L14	39.37	52.05	8.58	–	–	–	–	–	24.080	21.969	[4]
7	Charcoal	89.10	9.88	1.02	92.04	2.45	2.96	0.53	1	34.388	33.038	[17]
8	Coke	91.47	0.92	7.61	89.13	0.43	0.98	0.85	1	31.124	32.428	[18]
<i>2 Manufactured fuel/wood</i>												
9	Cotton shells briquettes	17.10	77.80	5.10	–	–	–	–	–	19.055	18.136	[16]
10	Lantana briquettes	11.90	20.80	67.30	–	–	–	–	–	7.687	6.926	[16]
11	Press mud briquettes	8.60	54.70	36.70	–	–	–	–	–	11.972	11.282	[16]
12	Block wood	14.59	83.32	2.09	46.9	6.07	43.99	0.95	0	18.261	18.132	[PS]
13	Ply wood	21.80	74.20	4.00	–	–	–	–	–	19.720	19.245	[16]
<i>3 Biomass—pit/shells/seeds/cobs</i>												
14	Peach Pit	19.80	79.10	1.10	49.14	6.34	43.52	0.48	0.02	19.423	19.324	[19]
15	Macadamia shell	23.68	75.92	0.40	54.41	4.99	39.69	0.36	0.01	21.010	20.206	[20]
16	Pistachio shell	16.84	82.03	1.13	48.79	5.91	43.41	0.56	0.01	19.260	18.734	[20]
17	Hazelnut shell	28.30	69.30	1.40	52.9	5.6	42.7	1.4	–	19.300	20.800	[5]
18	Coconut shell powder	20.58	79.07	0.35	–	–	–	–	–	19.675	19.601	[16]
19	Cotton shells	16.90	68.50	14.60	–	–	–	–	–	16.376	16.541	[16]
20	Spire-mint	11.80	70.10	18.10	37.23	5.34	33.38	5.95	–	15.530	14.960	[16]
21	Corn cob	18.54	80.10	1.36	46.58	5.87	45.46	0.47	0.01	18.770	19.033	[20]
22	Corn cob	12.50	86.50	1.00	49	5.4	44.6	0.4	–	17.000	17.898	[5]
23	Cornstover	17.60	78.70	3.70	–	–	–	–	–	17.800	18.464	[5]
24	Corn cob	16.80	82.10	1.10	–	–	–	–	–	18.795	18.731	[16]
<i>4 Biomass—wood/energy crops</i>												
25	Wood Chips	23.50	76.40	0.10	48.1	5.99	45.74	0.08	0	19.916	20.220	[21]
26	Canyon live Oak	11.30	88.20	0.50	47.84	5.8	45.76	0.07	0.01	18.981	17.742	[19]
27	Red wood	19.92	79.72	0.36	50.64	5.98	42.88	0.05	0.03	20.720	19.469	[20]
28	Softwood	28.10	70.00	1.70	52.1	6.1	41	0.2	–	20.000	20.836	[5]
29	Spruce wood	28.30	70.20	1.50	51.9	6.1	40.9	0.3	–	20.100	20.939	[5]
30	Es	17.90	82.00	0.10	47.3	6	46.5	0.1	–	20.080	19.112	[3]
31	Pine wood	15.70	73.60	11.30	–	–	–	–	–	16.644	16.938	[16]
32	Subabul wood	18.52	81.02	1.20	48.15	5.87	44.75	0.03	0	19.777	19.170	[PS]
33	Eucalyptus	21.30	75.35	3.35	46.04	5.82	44.49	0.3	0	18.640	19.253	[PS]
34	Eucalyptus-Grandis	16.93	82.55	0.52	48.33	5.89	45.13	0.15	0.01	19.350	18.852	[20]
35	Sudan Grass	18.60	72.75	8.65	44.58	5.35	39.18	1.21	0.01	17.390	17.851	[20]
36	Subabul	13.80	85.20	1.00	–	–	–	–	–	16.660	18.155	[16]
<i>5 Other biomass—barks/prunings</i>												
37	Douglas Fir	25.80	73.00	1.20	56.2	5.9	36.7	0	0	22.098	20.494	[22]
38	Loblolly Pine	33.90	65.70	0.40	56.3	5.6	37.7	0	0	21.772	22.227	[23]
39	Eucalyptus bark	15.30	65.70	19.00	–	–	–	–	–	15.195	15.505	[16]
40	Almond	21.54	76.83	1.63	51.3	5.29	40.9	0.66	0.01	20.010	19.582	[20]
41	Cabernet Sauvignon	19.20	78.63	2.17	46.59	5.85	43.9	0.83	0.04	19.030	19.031	[20]
42	Walnut	20.80	78.50	0.70	48.2	6.25	43.24	1.61	–	19.967	19.588	[16]
43	Olive twigs	10.73	88.25	1.02	–	–	–	–	–	18.699	17.544	[6]
44	Wood chips	15.40	83.40	1.20	–	–	–	–	–	20.031	18.438	[16]
45	Coffee chaff	19.60	75.80	4.60	–	–	–	–	–	17.686	18.712	[16]
46	Tapero root skin scale scrapping	11.40	35.10	39.20	–	–	–	–	–	9.228	9.197	[16]
<i>5 Other biomass—straws</i>												
47	Wheat straw	23.50	63.00	13.50	45.5	5.1	34.1	1.8	–	17.000	18.026	[5]
48	Paddy straw	11.80	72.70	15.50	35.97	5.28	43.08	0.17	–	14.522	15.386	[16]
49	Rice straw (ground)	16.20	68.30	15.50	–	–	–	–	–	15.614	16.255	[16]
50	Wheat straw	24.00	69.60	6.40	–	–	–	–	–	18.905	19.287	[16]

(continued on next page)

Table 2 (continued)

Sr. no.	Raw material	Proximate analysis			Ultimate analysis					Measur-	Calcula-	Refer-
		[% by wt. dry basis]			[% by wt. dry basis]					Dry basis		
		FC	VM	ASH	C	H	O	N	S	MJ/kg	MJ/kg	
51	Wheat straw	11.70	80.60	7.70	–	–	–	–	–	17.355	16.643	[16]
52	Coconut stem	23.10	74.40	2.50	–	–	–	–	–	19.436	19.748	[16]
<i>5 Other biomass—stalks</i>												
53	Cotton stalk	17.30	65.40	17.30	39.47	5.07	39.14	1.2	0.02	15.830	16.178	[20]
54	Musturd stalk (A)	21.90	60.90	17.20	–	–	–	–	–	17.489	17.104	[16]
55	Eucalyptus stalk	12.20	87.30	0.50	–	–	–	–	–	19.097	17.920	[16]
56	Mulberry stick	22.80	75.10	2.10	44.23	6.61	46.25	0.51	–	18.356	19.754	[16]
<i>5 Other biomass—fibrous material/leaves/grass</i>												
57	Coconut coir	29.70	66.58	3.72	50.29	5.05	39.63	0.45	0.16	20.050	20.853	[20]
58	Bagasse	7.00	70.90	22.10	–	–	–	–	–	14.258	13.356	[16]
59	Bagasse	11.90	86.30	1.80	–	–	–	–	–	18.167	17.648	[16]
60	Bagasse pith	10.60	86.60	2.80	–	–	–	–	–	17.192	17.227	[16]
61	Sweet sorghum bagasse	5.00	75.00	20.00	–	–	–	–	–	13.730	13.305	[16]
62	Moringa-oleifera (leaves)	10.70	67.80	21.50	–	–	–	–	–	14.232	14.186	[16]
63	Sena leaves	25.50	57.20	17.30	36.2	4.72	37.49	4.29	–	18.125	17.799	[16]
64	Sugar cane leaves	14.90	77.40	7.70	39.75	5.55	46.82	0.17	–	17.410	17.275	[16]
65	Olive marc	25.83	69.45	4.72	–	–	–	–	–	21.055	19.924	[6]
66	Miscalthus (elephant grass)	12.40	87.20	0.40	–	–	–	–	–	19.297	17.976	[16]
67	Dal lake weed	3.60	47.70	48.70	19.12	2	25.96	4.22	–	8.887	8.330	[16]
68	Tea bush	21.80	76.50	1.70	47.67	6.13	43.16	1.33	–	19.842	19.622	[16]
<i>5 Other biomass—hull/husk/dust</i>												
69	Sal seed husk	28.06	62.54	9.40	48.12	6.55	35.93	0	0	20.600	19.599	[24]
70	Bamboo dust	9.30	74.20	16.50	–	–	–	–	–	15.890	14.728	[16]
71	Eucalyptus saw dust	16.20	83.60	0.20	49.37	6.4	42.01	2.02	–	18.502	18.760	[16]
72	Saw dust	25.00	72.40	2.60	–	–	–	–	–	20.930	20.107	[16]
73	Saw dust + musturd	11.90	55.40	32.70	–	–	–	–	–	13.727	12.590	[16]
<i>5 Other biomass—others/misc.</i>												
74	Mentha Piperita	7.50	79.00	13.50	–	–	–	–	–	15.153	14.863	[16]
75	Grewia optiva (Bhimal)	14.20	85.50	0.30	–	–	–	–	–	18.000	18.348	[16]
76	Water hyacinth	1.90	87.30	10.80	–	–	–	–	–	14.806	14.198	[16]
77	Ceder cones	28.10	70.40	1.50	–	–	–	–	–	21.097	20.900	[16]
<i>6 Biomass waste material</i>												
78	Tea waste	13.60	85.00	1.40	48.6	5.5	39.5	0.5	–	17.100	18.050	[5]
79	Bamboo stick waste	47.70	12.70	39.60	–	–	–	–	–	17.657	18.538	[16]
80	Tannary waste	1.00	45.00	54.00	–	–	–	–	–	7.685	6.948	[16]
81	Fly ash (Bagasse fuel)	19.80	8.10	72.10	–	–	–	–	–	8.385	7.702	[16]
82	Pine needle (40% clay)	13.20	9.09	77.70	–	–	–	–	–	5.700	5.479	[16]
83	Castor seed cake	25.20	67.90	6.90	–	–	–	–	–	21.010	19.443	[16]
<i>6 Biomass waste material—millgin industry waste</i>												
84	Cotton gin waste	14.97	83.41	1.61	42.66	6.05	49.5	0.18	0	17.483	18.284	[PS]
85	Cottongin Trash	15.10	67.30	17.60	39.59	5.26	36.38	2.09	0	16.420	15.694	[20]
86	Alabama Oak wood waste	21.90	74.70	3.30	49.5	5.7	41.3	0.2	0	19.228	19.364	[25]
87	White Fir	16.58	83.17	0.25	49	5.98	44.75	0.05	0.01	19.950	18.827	[20]
88	Tan Oak	9.20	90.60	0.20	48.67	6.03	44.99	0.06	0.04	18.934	17.376	[19]
<i>6 Biomass waste material—refuse/MSW</i>												
89	Industrial waste (stalla)	20.10	75.10	4.80	–	–	–	–	–	18.928	18.778	[16]
90	Poultry pure waste	25.90	14.30	59.80	–	–	–	–	–	11.712	10.921	[16]
91	Municipal Solid Waste-Bareilly	5.00	25.00	70.00	–	–	–	–	–	5.630	5.120	[16]
92	Municipal Solid Waste-Morada-bad	4.00	35.70	60.30	–	–	–	–	–	7.183	6.510	[16]
<i>7 Biomass chars</i>												
93	Redwood char-790-1020 °F	67.70	30.00	2.30	75.6	3.3	18.4	0.2	0.2	28.844	28.598	[25]
94	Oak char-820-1185 °F	59.30	25.80	14.90	67.7	2.4	14.4	0.4	0.2	24.796	24.874	[25]
95	Coconut shell char-750 °C	87.17	9.93	2.90	88.95	0.73	6.04	1.38	0	31.124	32.349	[PS]
96	QrC550	82.20	14.70	3.10	87.1	2.4	6.9	0.5	–	32.720	31.333	[3]
97	PhC 300	31.30	68.10	0.60	57.8	5	36.5	0.2	–	22.840	21.680	[3]
98	EsC700	91.50	6.60	1.90	92.7	1.6	3.3	0.4	–	32.204	33.369	[3]
99	Rice husk char	41.20	5.90	52.90	–	–	–	–	–	14.944	15.076	[16]
100	Rose apple char	12.20	22.20	65.60	–	–	–	–	–	7.577	7.263	[16]

PS, present study.