Energy Database of the Oil Palm

Vijaya Subramaniam*; Chow Mee Chin* and Ma Ah Ngan*

ABSTRACT

All the palm oil mills in Malaysia use fibre and shell as boiler fuel to produce steam to generate electricity, for the milling process and also for other uses within the mill complex. This combustion process has been more of a disposal rather than optimal utilization of the biomass for energy. This research attempts to create an energy database for the oil palm biomass/products, which can be used by interested parties to obtain information regarding its energy potential. The calorific value, volatile matter content, ash content, moisture content, hexane extractable, elemental content and CHNS content are determined for the various oil palm biomass/ products such as empty fruit bunch, fibre, shell, palm kernel cake, nut, crude palm oil, kernel oil, liquor from empty fruit bunch, palm oil mill effluent, oil palm trunk, frond and root.

INTRODUCTION

Malaysia has over 3.7 million hectares of oil palm plantation capable of producing over 28 million tonnes of biomass annually. The palm oil mills in Malaysia have been combusting these biomass mainly fibre and shell in their boiler to generate steam to produce electricity which is then used to power the milling process as well as for other uses within the facility. This combustion process has more been a disposal rather than optimal utilization of the biomass for energy.

In view of the potential of these biomass as a renewable energy source it is only appropriate that the various biomass/products from the oil palm be characterized systematically with respect to its energy potential so that a reliable database will be made available whenever required. The characteristics of the oil palm biomass in particular those of the fibres and shell have been characterized and published in various papers. However, these data are usually illustrated singularly where the method of analysis, sampling and other related information is not accompanied.

SAMPLES

Samples were collected form various palm oil mills and oil palm plantations over a period of time for analysis. The samples collected were oil palm biomass and some oil palm products. The samples are:

- empty fruit bunch;
- mesocarp fibre;
- shell;
- palm kernel cake;
- nut;
- crude palm oil;
- kernel oil;
- liquor from empty fruit bunch;
- palm oil mill effluent;
- oil palm trunk;
- oil palm frond; and
- oil palm root.

All samples were dried, chopped and ground to fine particles for the analysis.

*Malaysian Palm Oil Board,
P. O. Box 10620,
50720 Kuala Lumpur,
Malaysia.

ANALYSIS

The analyses carried out are as follows:

- determination of calorific value;
- determination of ash content;
- determination of volatile matter content;
- determination of moisture content;
- determination of hexane extraction content;
- determination of elemental content; and
- determination of carbon, hydrogen, nitrogen and sulphur content (CHNS).

The determination of elemental content and carbon, hydrogen, nitrogen and sulphur content were carried out at other research institutions, which had the facilities for these analyses. All other analysis was carried out at MPOB.

METHODOLOGY

All analyses were carried out based on the Standard Methods available. However, slight modifications were made wherever necessary to accommodate for the oil palm biomass sample.

Table 1 gives the standard methods used for each analysis

TABLE 1.

Analysis	Standard Method
Calorific value	ASTM 2015
Ash content	ISO 1171-97
Volatile matter content	ISO 562-98
Moisture content	BS 4289: Part 3: 1978
Hexane extraction content	ISO 734-79
Elemental content	ASTM D 5373-93 ASTM D 6349-98
CHNS content	ASTM D 5373-93

RESULTS AND DISCUSSION

Tables 2 to *6* show the results obtained for each analysis. For every analysis, there is an average value as well as the range. This range is a guide to show the minimum and maximum value for the particular sample for the particular analysis.

TABLE 2. CALORIFIC VALUE AND ASH CONTENT

Sample	Average calorific value (kJ kg^{-1})	Range (kJ kg^{-1})	Average ash content (%)	Range (%)
Empty fruit bunch	18 795	18 000 – 19 920	4.60	3.70 – 5.30
Fibre	18 795	18 800 – 19 580	6.10	5.00 – 7.40
Shell	20 093	19 500 – 20 750	3.00	1.40 – 4.80
Palm kernel cake	18 884	18 880 – 18 895	3.94	3.88 – 3.99
Nut	24 481	24 265 – 24 830	4.05	3.95 – 4.07
Crude palm oil	39 360	39 330 – 39 385	0.91	0.82 – 0.99
Kernel oil	38 025	37 947 – 38 086	0.79	0.78 – 0.80
Liquor from empty fruit bunch	20 748	20 567 – 20 099	11.63	11.58 – 11.67
Palm oil mill effluent	16 992	16 100 – 17 650	15.20	12.20 – 17.80
Trunk	17 471	17 000 – 17 800	3.38	2.90 – 3.70
Frond	15 719	15 400 – 15 950	3.37	3.15 – 3.80
Root	15 548	15 300 – 15 680	5.92	5.20 – 6.65

Note: *Samples were analysed at 0% moisture content.

TABLE 3. VOLATILE MATTER AND HEXANE EXTRACTABLE CONTENT

Sample	Average volatile matter content (%)	Range (%)	Average hexane extractable content (%)	Range (%)
Empty fruit bunch	87.04	86.50 – 87.70	11.25	10.20 – 15.00
Fibre	84.91	84.00 – 85.60	7.60	6.60 – 8.50
Shell	83.45	82.70 – 84.40	3.26	2.80 – 3.60
Palm kernel cake	88.54	87.00 – 89.00	3.85	3.70 – 3.92
Nut	84.03	83.50 – 84.50	4.43	4.30 – 4.90
Crude palm oil	75.45	75.00 – 75.95	95.84	95.00 – 96.00
Kernel oil	74.27	74.10 – 74.50	95.06	94.50 – 95.80
Liquor from empty fruit bunch	78.50	78.00 – 79.00	3.85	3.83 – 3.86
Palm oil mill effluent	77.09	75.00 – 79.20	12.55	10.10 – 14.40
Trunk	86.73	86.30 – 88.30	0.80	0.60 – 0.99
Frond	85.10	83.60 – 86.30	0.62	0.50 – 0.80
Root	86.30	85.70 – 86.90	0.20	0.15 – 0.30

Note: *Samples were analysed at 0% moisture content.

TABLE 4. MOISTURE CONTENT

Sample	Average moisture content (%)	Range (%)
Empty fruit bunch	67.00	66.00 – 69.00
Fibre	37.00	35.00 – 48.00
Shell	12.00	11.00 – 13.00
Palm kernel cake	0.28	0.26 – 0.29
Nut	12.67	12.58 – 12.75
Crude palm oil	0.07	0.05 – 0.09
Kernel oil	0.02	0.02 – 0.02
Liquor from empty fruit bunch	88.75	88.50 – 88.90
Palm oil mill effluent	93.00	90.00 – 95.00
Trunk	76.00	67.00 – 81.00
Frond	71.00	62.00 – 77.00
Root	36.00	28.00 – 45.00

TABLE 5. CARBON, HYDROGEN AND NITROGEN CONTENT

Sample	Carbon (%)	Hydrogen (%)	Nitrogen (%)
Empty fruit bunch	45.90	5.70	0.80
Fibre	45.20	5.50	1.10
Shell	49.70	5.70	0.40
Liquor from empty fruit bunch	50.00	6.80	1.60
Palm oil mill effluent	40.17	5.81	5.26
Trunk	41.88	5.98	3.76
Frond	42.38	5.83	3.60
Root	48.85	5.52	3.35

Note: *Samples were analysed at 0% moisture content.

TABLE 6. ELEMENTAL CONTENT

Elements	Empty fruit bunch (%)	Fibre (%)	Shell (%)	Liquor from empty fruit bunch (%)
Al	1.01	1.49	1.65	1.14
B	3.75	3.63	5.84	3.50
Ca	0.59	1.08	0.47	1.04
Cd	0.00	0.00	0.00	0.00
Cr	0.02	0.08	0.04	0.04
Fe	0.20	1.34	0.35	0.44
K	5.91	1.48	2.20	10.60
Mg	0.23	0.49	0.24	1.42
Na	1.83	1.56	2.79	2.52
P	0.08	0.12	0.07	0.36
Pb	0.01	0.01	0.01	0.01
S	0.15	0.23	0.19	0.36
Si	86.17	88.29	86.07	78.54
Ti	0.05	0.21	0.08	0.03

Note: *Samples were analysed at 0% moisture content.

CONCLUSION

The palm oil industry is bestowed with plentiful supply of co-products such as empty fruit bunch, mesocarp fibre and shell that can be readily used as energy resources. These biomass should be commercially exploited to make the palm oil industry more sustainable.

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