CHARACTERIZATION OF THE FUEL PROPERTIES OF *ANANAS COMOSUS* LEAF FOR THERMAL APPLICATION

A. Alir, A. Johari, T.A. Tuan Abdullah, M.J. Kamaruddin

Institute of Hydrogen Economy (IHE), Faculty of Chemical Engineering, UniversitiTeknologi Malaysia, 81310 Skudai, Johor Bharu, Malaysia

Corresponding author email: afizahalir@gmail.com

Keywords*: proximate analysis, ultimate analysis, pineapple leaf, thermogravimetric analysis (TGA), thermal properties*

ABSTRACT

In recent years, the demand of energy in Malaysia increases significantly. It is generally accepted that the source of fossil fuel will be depleted in future since it is classify as non-renewable energy. Consequently, Malaysia is a country rich in biomass energy resource that easily can be converted into biomass fuel for thermal applications such as AnanasComosus leaf for clean energy production. This study is aimed to characterizing AnanasComosus leaf of N36 hybrid, selected from between 'Gandul' (Spanish) and the 'Smooth Cayenne'.The physical and chemical properties of the AnanasComosus leaf were analyzed using ultimate analysis, proximate analysis and heating value. The thermal decomposition behavior of the fuel was determined through thermogravimetric analysis (TGA). From the result obtained, the parameter of ignition temperature (T_{ign}) 322°C and maximum temperature (T_{max}) 367°C, and final temperature (T_f) 810°C were gathered. The total weight of the fuel remaining at $T_f$was 14.01% signifying that the conversion of the fuel will result in 85.99% conversion.

INTRODUCTION

In recent years, the demand of energy in Malaysia increases significantly. It is generally accepted that the source of fossil fuel will be depleted in future since it is classify as non-renewable energy. Utilization of fossil fuel also contribute major environmental problems with the emission of carbon dioxide, nitrogen oxide, sulfur oxide and other greenhouse gases lead to global warming. A lot of alternative energy sources been explored to lessen reliance on fossil fuel and reducing environmental issues. In 2010, Malaysia established the National Renewable Energy Policy 2010.

This policy aims to further increase the exploitation of local renewable energy resources and contribute to national energy security and sustainable socio-economic development [1].Among the various sources of renewable energy, biomass seems to be the one of the most promising option for Malaysia. Malaysia is a country rich in biomass energy resource that easily can be converted into biomass fuel for thermal applications.

Pineapple can be classified as perennial plant with average height between 75-150 cm, spread between 90-120 cm and have a leaf long between 50-180 cm with fibrous, narrow and spiny leaf shape [2-3].

Ananas comosus (pineapple) cultivation is one of the most agriculture activities in Johor state. Malaysian Pineapple Industry Board (MPIB) reported that for year 2008, Johor produced the highest yield of pineapple with 143,963.00 metric tons [4].There are a few different types but N36 covers most of the pineapple cultivation land because of its commercial value especially in food canning industries. The N36 pineapple is a hybrid selected from between ‘Gandul' (Spanish) and the ‘Smooth Cayenne'. This variety is developed by Malaysian Agricultural Research and Development Institute (MARDI) has some special characteristic where it is suitable for export and has high commercial value in food canning industry [5] (Nadya*et al.,* 2012). In pineapple food industry, it is estimated that the volume production of waste are high which are 60 % from the total harvest, which consists of 21% of pineapple leaves, 33% of pineapple peel and 46% from other parts of the plant [6].In the year of 2010, the total panted area of pineapple was 17 601 hectares and the total pineapple leaf produced was about 28 469 MT [7].

Therefore, the aim of this study is to characterize the properties of *Ananas comosus* leaf. The study will investigate the physiochemical properties of *Ananas comosu s*leaf through ultimate and proximate analysis. Thermal analysis techniques such as thermogravimetric analysis (TGA) and bomb calorimeter will also be used to determine the thermal and kinetics of the thermochemical conversion of *Ananas comosus* leaf.

MATERIAL AND METHODS

Ananas comosus leaf was collected from Pekan Nanas farming area, Johor as in Figure .

Figure 1 *Ananascomosus* leaf

Sample of *Ananas comosus* was oven dried at 105°C. Sample was shredded and pulverized to give particle size ranging 0.25-1.0mm in a high speed mixer grinder PANASONIC model MX-AC400. The ultimate analysis was determined using LECO 932 CHNS/O elemental analyzer. The proximate analysis of fuel was carried out using ASTM standard techniques for determining the moisture content (MC), volatile matter (VM), ash content and fixed carbon (FC) content of biomass.

The higher heating value (HHV) of the *Ananas comosus* was analysed using a bomb calorimeter according to ASTM standard D-2015 technique. The lower heating value (LHV) was calculated by using an equation given

$$LHV = HHV - hg\,(9H/100 + M/100) \qquad (1)$$

Where LHV, HHV H and M are lower heating value, higher heating value, hydrogen percentage and moisture percentage respectively. The latent heat of steam denoted as *hg* in the same unit as HHV (970BTU/lb, 2260 kJ/kg or 540kCal/kg).

The thermal decomposition behavior of *Ananas comosus* leaf was determined using a thermogravimetric analyzer (TGA) Model Perkin Elmer TGA 7. The thermal stability of the fuel was determined by heating approximately the fuel sample was 30°C to 810°C at heating rate 10 °C min^{-1} using nitrogen (N_2). This was used to obtain information about the thermal and physical properties of the sample.

RESULT AND DISCUSSION

The ultimate analysis of *Ananas comosus* leaf was listed in Table 1 while the proximate analysis and heating value of the feedstock (HHV and LHV) are presented in Table 2.

Table 1:Ultimate analysis of *Ananascomosus* leaf

Ultimate analysis (wt %) Dr Ash Free Basis	
Carbon	44.2
Hydrogen	6.28
Nitrogen	1.23
Sulfur	0.22
Oxygen	48.3

Table 2: Proximate analysis of *Ananas comosus* leaf

Proximate analysis (wt %) Dry Ash Free Basis	
Moisture content (MC)	7.90%
Volatile Matter (VM)	76.22%
Ash content (ASH)	8.15%
Fixed Carbon	7.73%
HHV, MJ/kg	16.73
LHV, MJ/kg	15.27

Table 1 shows the ultimate analysis of *Ananas comosus* leaf including carbon, hydrogen, oxygen, nitrogen and sulfur elements. Typically, the composition of oxygen elements in biomass range between 30 to 40 wt% of the dry basis and the result of *Ananas comosus* leaf was 48.3%. In line with the principal constituent of biomass is carbon, making up from 30 to 60 wt% of dry basis depending on ash content, the *Ananas comosus* leaf shows that the percentage of it was 44.2%. Hydrogen is the third major components in biomass, comprising typically 5 to 6% dry basis and fuel sample showed that the composition was slightly higher which was 6.28%. Nitrogen and sulfur can also be found in low quantity, usually less than 1% dry basis but occasionally well above this. The result of nitrogen and sulfur were 1.23% and 0.22% respectively. Thesecan lead in the formation of pollutant emissions and sulfur in certain ash reactions leading to fouling and slagging. Nitrogen is a macronutrient for plants, and critical to their growth [8].

Table 2 shows the proximate analysis results of the *Ananas comosus* leaf. In general, biomass typically has high volatile matter content in nature up to 80% during heating process. *Ananas comosus* leaf presented a high volatile matter content of 76.2% and this is ideal to use as a fuel for gasification. Less heat is required in a gasifier system for the reaction to taken up when the content of volatile matter is high, which makes it is possible to gasify fuel at lower temperature.

Ash content in fuels cause variety problems in gasification process. These problems may vary from clogged-ash removal caused by slagging ash to severe operating problems such as air channeling that lead to a risk of explosion. The slagging problems can occur depends on the ash content of the fuel together both the melting characteristics of the fuel and the operation temperature in gasifier system. In general, fuels with ash content in range between 5-6% observed with no slagging problems whereas fuels with ash content of 12% and above expected to have severe slagging problems. Ash content in pineapple leaf is 8.15% that it is expected to have moderate problems in gasifier. Continuous ash removal during gasification is therefore essential.

Fixed carbon content is factors to relate with the heating value. Fixed carbon content of pineapple leaf is 7.73%.The fixed carbon is used to relate the heating value of the product and co-products.

The fuel ratio of *Ananas comosu* sleaf (ratio of fixed carbon to volatiles) is 0.10 which is in agreement with the general value of 0.20 for biomass species. However, the ratio of volatile matter to fixed carbon is higher (9.86), greater than 4.0 observed for biomass species [9].

The higher heating value (HHV) of the fuel is 16.73 MJ/kg is lower than the reported values for coal, due to the low fixed carbon content, high oxygen content and low density of the fuel [9-10].

From the DTG curve above, four peaks were observed during thermal decomposition. The peak between 30°C and 120°C denotes the drying stage of thermal conversion of the fuel. The peak between 120°C to 200°C shows the stage of preheating of the fuel. The large peak between 200°C to 400 °C represents the devolatilzation process. The peak between 400°C to 800°C shows the char aggregation.

Parameters of ignition temperature (T_{ign}) 322°C and maximum temperature (T_{max}) 367°C were deduced. The total fuel weight loss at T_{ign} and T_{max} was 16.81% and 36.25% respectively. The total weight of the fuel at 800°C was 14.01 % signifying that a total of 85.99% conversion of the fuel was converted via thermal conversion process.

CONCLUSION

This study was aimed at characterizing the fuel potential of *Ananascomosus*leaf for thermochemical conversion. The study were investigated the physical, chemical and thermochemical properties of the fuel using numerous techniques such as proximate, ultimate and thermogravimetric analysis. The results of ultimate analysis listed the elemental composition of Ananas*comosus*leaf including carbon (44.2%), hydrogen (6.28%), nitrogen (1.23%), oxygen (48.3%) and sulfur (0.22%) while the proximate analysis showed that moisture content (7.9%), volatile matter (76.22%), ash content (8.15%) and fixed carbon (7.73%). The thermal behavior of the *Ananas comosu s*leaf was also deduced and the result showed that the decomposition of the fuel occurs in for stages including drying, biomass preheating, devolatization and char aggregation. The total weight of the fuel at the end of thermal conversion in temperature of 800°C was __%.

ACKNOWLEDGEMENT

The financial support of the Research University Grant, VOT No 07H11 from the ministry of Higher education (MOHA) through the Energy Research Alliance of Universiti Teknologi Malaysia (UTM) and assistance of the Research Management Centre (RMC) is greatly appreciated.

REFERENCES

[1] Wendy, P.Q.N., Hon, L.L., Foo, Y.N., Mustafa, K. and Joseph, H.E.L. (2012). Waste-to-wealth: green potential from palm. *Journal of Cleaner Production*. 34, 57-65

[2]Tran, A.V. (2006). Chemical analysis of pulping study of pineapple crown leaves. *International Journal of Industrial Crops and Products*. 24, 66-74.

[3] Morton, J.F. (1987). Fruits of warm climates. Creative Resource Systems, Winterville, NC, pp. 18–28.

[4] Nadzirah, K.Z., Zainal, S., Noriham, A., Normah, I., SitiRoha, A.M. and Nadya H. (2013). Physico-chemical properties of pineapple variety N36 harvested and stored at different matuaritystages. International Food Research Journal. 20(1), 225-231

[5]

[6] Moya, M., Sibaja, M. and Vega, J. (2009). Exploitment of agriculture waste in costa rica to obtain high value-added products. *1st World Conference on Biomass for Energy and Industry*.1205-1206.

[7] Wan, M.Z and Zainuddin, Z. (2013). *Handbook of Jurutera*.Mechanization and automation Research Centre MARDI.18-20.

[8] Jenkins, B.M., Baxter, L.L., Miles Jr, T.r. and Miles, T.R. (1198) Combustion properties of biomass. *Fuel processing Technology*. 54(1-3), 17-46.

[9] Fadhzir, M.A.K., Oladukun, O.A., Aishah, N.S.A., Nyakuma, B.B. and Tuan Abduallah, T.A. (2013). Characterization of the fuel properties of Imperata cylindrical grass for thermal applications.

[10] Demirbas, A. Biofuels securing the planet’s future energy needs. *Energy conversion and management*. 50(9), 2239-2249