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DETERMINATION AND COMPARATIVE ANALYSIS OF THE CALORIFIC VALUES OF RICE HUSK, MAIZE COB AND CHARCOAL USING A BOMB CALORIMETER

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ABSTRACT

The determination and comparative analysis of the calorific values of rice husk, maize cob andcharcoal was carried out using a standard bomb calorimeter; the samples were crushed grinded, sieved and binds using the laboratory scale tablet machine. The calorific values obtained are 3502.20 Kcal/Kg,3575.68 Kcal/Kg and 2440.16 Kcal/Kg for rice husk, maize cob and charcoal and respectively. The study revealed that maize cob has the highest calorific value followed by rice husk and charcoal with the least. The agricultural waste used in this work (rice husk and maize cob) met the minimum standard calorific value which range from 1500Kcal/kg-1670Kcal/kg.

Keywords: Agricultural waste, Bomb Calorimeter, Maize cob, Rice Husk, Charcoal, Calorific value.

INTRODUCTION

All elements considered to be fuels have a calorific value which is basically a measure of energy or heat released (kJ or kcal) per kilogram (solid or liquid) or per cubic metre (gas) when burnt with an excess of oxygen in a calorimeter [1]. However, [2] added that the calorific value of a fuel is the number of heat units evolved when unit mass (or unit volume in the case of a gas) of a fuel is completely burned and the combustion products are cooled to 298 K. This definition of calorific value includes the provision that the products of combustion are cooled to 298 K which means the sensible heat and the latent heat of condensation of the water produced during combustion are included in the heat liberated [2].

Rice husk, maize cob, and other agricultural residues used as fuel will give a high calorific value and has the tendency to conserve heat for a long time [3]. Large amount of rice husk, maize cob and other agricultural residues are laying waste in many farms, rice mills and household. It has been a common practice by most sawmills and rice mills to burn and/or dispose their maize cob and rice husk instead of using them effectively [3].

One of the more promising energy sources with an overwhelming potential and environmentally friendly is the "Biomass". Biomass is a non- conventional, renewable energy obtained from mainly organic matters storage of images (Solar) and materials in complex organic substances primarily by gross photosynthesis [4]. Biomass has been the principal source of food, energy and materials for man since early time. It still provides practically all food, except salt and a few minerals, and it is applied commercially in energy generation in fire places and wood stoves, wood and waste boilers, biogases and sugar cane plantations [5]. Biomass fuels, however, are available almost everywhere on earth; often relatively cheap, virtually inexhaustible and when properly managed, renewable and environmentally friendly; this situation is expected to continue into the foreseeable future. Moreover, the applications of biomass residue are summarized as follows; fuel, fodder, fiber, feedstock and further uses (such as conditioning of soil, straw for mush room growing and parking materials). Some even have simple purpose; for example, rice husk can be burnt as fuel and the ashes used by steel industry as insulator and source of carbon [6].

MATERIALS AND METHODS

The materials used in this work were maize cob, rice husk, charcoal, bomb calorimeter and siever.

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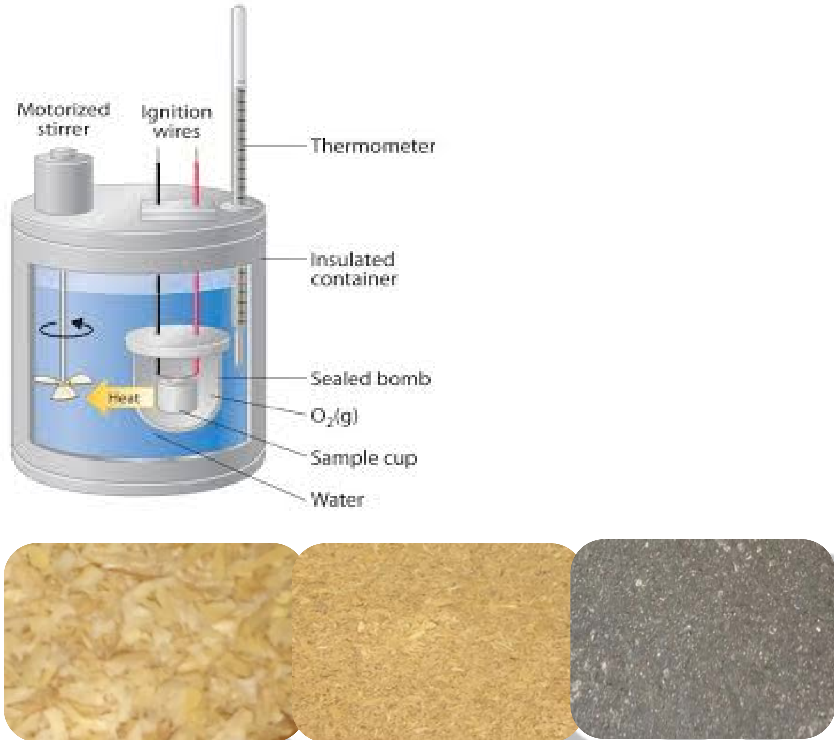

Fig.1: processed rice husk, maize cob and charcoal samples, and a Bomb calorimeter

METHODOLOGY

The rice husk, maize cob and charcoal was obtained from available sources. They were separately dried crush-grinded and sieved through an 850 micrometer sieve to remove the granular impurities and the samples powders, which tend to influence the result. The rice husk, maize cob and charcoal are then pressed using the laboratory scale tablet machine which binds the powdered samples into convenient form for use in the bomb calorimeter that cannot be easily disintegrated.

1g each of the prepared sample of rice husk, maize cob, and charcoal were collected and transferred to the sample cup of the bomb calorimeter; making sure the interior of the bomb including the support and crucible are properly cleaned and dried. A 10cm long nickel wire was fixed to the two electrodes and the sample cup containing the sample was carefully fixed into the electrode seat inside the bomb. The bomb head or cover was carefully and tightly closed using a special vice and spanner and then connected to the oxygen cylinder at a pressure of 207 Kpa and the calorimeter bucket filled with 2 liters of distilled water. The bomb was carefully transferred into the bucket and ignition wires were pushed into the terminal socket on the bomb head; making sure no water is removed from the bucket with the fingers.

The calorimeter jacket was covered with thermometer facing down ward. The stirrer was turned by hand to make sure it runs freely without touching the calorimeter jacket or the bucket, the drive belt was then slipped into the pulleys and the motor was started. The stirrer was allowed to run for 5 minutes to reach equilibrium before any measured run. The temperature was read and recorded at one-minute interval for 5 minutes; at the end of the 6th minutes, the calorimeter bomb was fired by pressing the ignition button and holding it down until the indicator light goes out. The bucket temperature started rising rapidly during the first few minutes, then becomes slower as the temperature approaches a stable maximum. After the final temperature reading; the motor was stopped, the drive belt removed and the calorimeter cover lifted. The knurled knob on the bomb head was carefully and steadily opened to release the gas pressure before removing the cap. The interior of the bomb was then examined for evidence of incomplete combustion; the bomb was then cleaned and dried. The whole procedure was repeated three times and temperature readings were taken for each sample. The mean temperature reading is then plotted against time for each of the sample with the error bar of the graph used to obtain the correction factor of each sample further use to evaluate the corrected temperature value. The calorific values, H were computed using [7];

$$H = \frac{T \times W_c}{W_{gs}} \qquad \text{(i)}$$

Where;

T is the corrected temperature rise (Tmax – Tmin + correction factor) for each sample.

Wc is the Energy equivalent of the calorimeter which is 2416 cal

Wgs is the Weight of samples used.

RESULTS AND DISCUSSION

Table 1 shows the pre-firing period of combustion rate for rice husk, maize cob and charcoal.The pre-firing period is the period during which the water in the inner vessel was gradually stirred for homogeneous distribution of heat. The temperature decreases simultaneously as the time increases. It ranges from 0-6 minutes for each of the samples with mean temperatures rising from 26.57°C - 26.80°Cfor rice husk, 24.69°C - 2.78°C for maize cob and 25.93°C - 25.98°C for charcoal.

Table 1: Pre-firing period of combustion rate for rice husk, maize cob and charcoal

	Average Temperature (^{o}C)		
Time (min)	Rice husk	Maize cob	Charcoal
0	26.57	24.69	25.93
1	26.59	24.7	25.93
2	26.6	24.7	25.94
3	26.63	24.72	25.96
4	26.68	24.74	25.96
5	26.72	24.76	25.98
6	26.80	24.78	25.98

Table 2 shows the firing period, which is the period the bomb was fixed and the temperature rose gradually until it reaches a constant value. The range of firing period for rice husk is 7–16min; for maize cob is 7 – 16 min;for charcoal is 7–17min; and the temperature rises from 26.84°C - 27.80°C,25.47°C - 25.91°C, 26.34°C - 26.77°C, and for rice husk, maize con and charcoal respectively.

Table 2: Firing period of combustion rate for rice husk, maize cob and charcoal

	Average Temperature (^oC)		
Time (min)	Rice husk	Maize cob	Charcoal
7	26.84	25.47	26.34
8	26.92	25.54	26.45
9	26.99	25.62	26.48
10	27.21	25.64	26.59
11	27.34	25.78	26.63
12	27.48	25.82	26.67
13	27.66	25.85	26.69
14	27.73	25.87	26.71
15	27.80	25.91	26.74
16	27.80	25.91	26.77
17	-	-	26.77

The temperature-time graph of rice husk, maize cob and charcoal from the pre-firing to firing period are plotted in figures (2) – (4). The error bar from the graph of each sample are; 0.22 for rice husk. 0.26 for maize bob and 0.17 for charcoal. These values are termed the correction factors for the temperature rise. The correction factor is then added to the differencebetween the final and initial temperature for each of the sample to correct for the temperature rise.

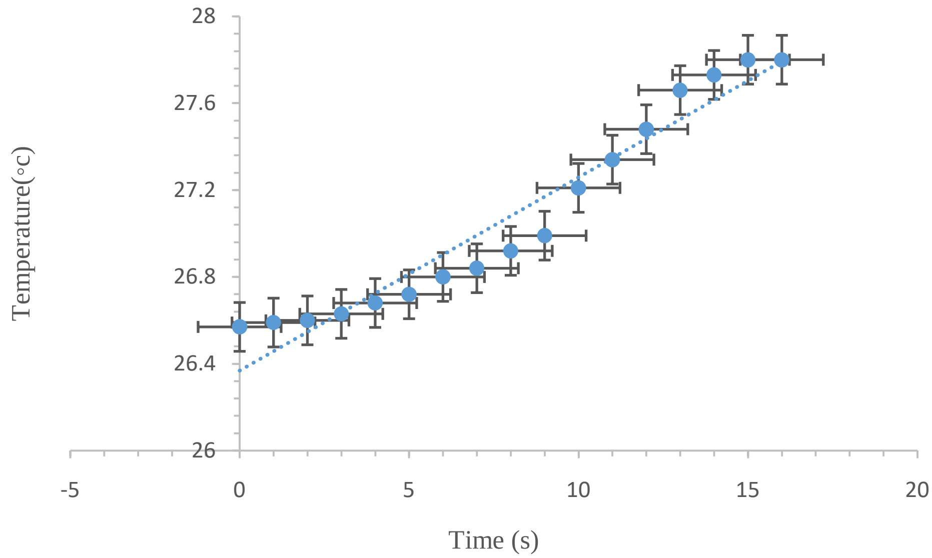

Fig.2: Temperature-time graph for rice husk

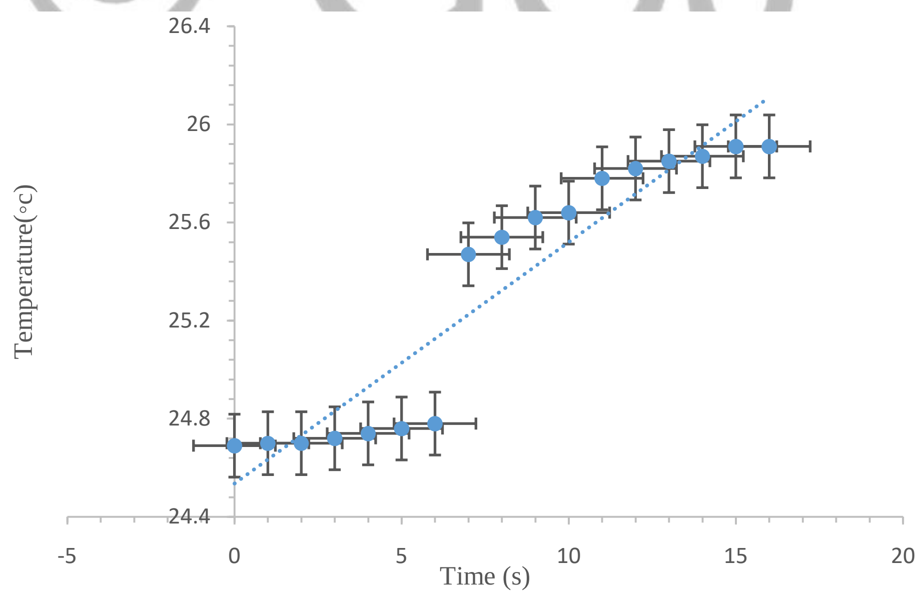

Fig.3: Temperature-time graph for maize cob

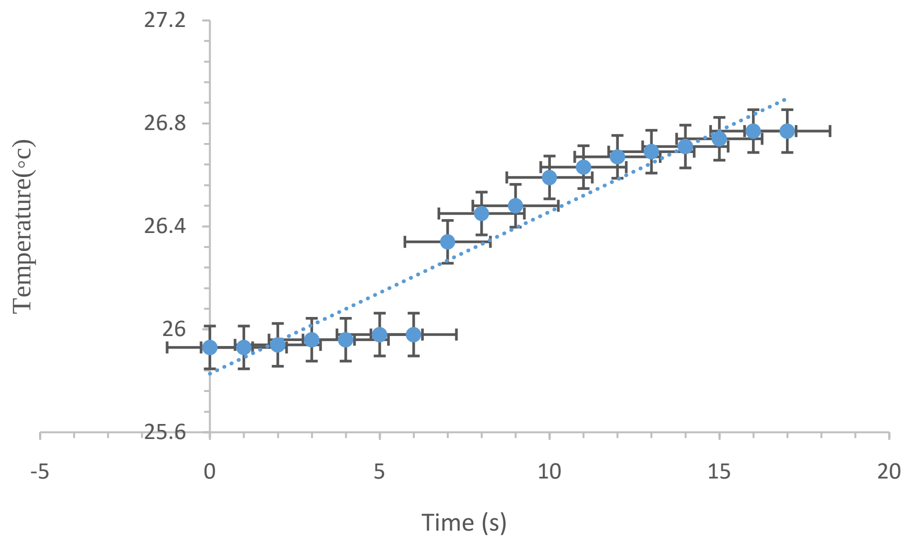

Fig.4: Temperature-time graph for rice husk

Correction factor values obtain from the errorbar of the temperature – time graph for all the sample is presented in table 3 alongside their corrected temperature values. These values are substituted in equation (i) to obtained the calorific values for each of the sample and the result presented in table 4.

Table 3: Values of corrected temperature for the utilization of rice husk, maize cob and charcoal

Sample	Initial Temp. (^oC)	Final Temp. (^oC)	Difference in Temp. (^oC)	Correction Factor	Corrected Temp. (^oC)
Rice husk	26.57	27.80	1.23	0.22	1.45
Maize cob	24.69	25.91	1.22	0.26	1.48
Charcoal	25.93	26.77	0.84	0.17	1.01

Table 4: The calorific values of rice husk, charcoal and maize cob

Sample	Calorific value (Kcal/Kg)
Rice husk	3,502.20
Maize cob	3,575.68
Charcoal	2,440.16

Conclusion

It can be concluded from the results of experimental analysis that the agricultural waste used in this work (maize cob and rice husk) produced more heating value than the popular charcoal being used for cooking. The range of calorific values are in the order of Maize cob> Rice husk > Charcoal with the following values 3,575.68 Kcal/Kg, 3,502.20 Kcal/Kg and 2,440.16 Kcal/Kg respectively. These values met the minimum standard calorific value of 1500Kcal/kg - 1670Kcal/kg by[8].

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