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Comparative analysis of the effectiveness of different charcoal as fuel for domestic purposes

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Abstract

The objectives are to study the differences between Charcoal as fuel on Temperature, during the burning time, and Temperature at boiling time. The 500 g of Teak, *Pterocarpus macrocarpus*, and Cratoxylum Formosum Charcoal were used according to Completely Randomized Design (CRD). The three treatments included T1 = teak charcoal, T2 = *Pterocarpus macrocarpus* charcoal, and T3 = Cratoxylum Formosum charcoal. The trial period spanned the sampling time of 3 hr for the burning temperature and the boiling temperature was corrected at 15 mn, 20 mn, 30 mn, 40 mn, and 50 mn. The results showed the temperature at burning and completed burning time analysis, significant differences in No of RDF (Pieces) showed a considerable difference $P < 0.05$ among the experiments higher in teak charcoal T1 and followed by T2 and T3. However, the temperature at the burning time showed a very high significant difference $P < 0.05$ at 15 mn where T2 and T3 were higher than T1. Moreover, at 30 mn and 1 hr a highly significant difference $P < 0.05$ at T1 was higher than at T2 and T3. After 2 hr was showed a highly significant difference $P < 0.05$ at T3, T1 than T2. At the end of heating, energy showed a highly significant difference $P < 0.05$ at T1 than at T3 and T2. Therefore, Temperature at boiling time from 15 mn, 20 mn, 30 mn, and 40 mn showed a highly significant difference $P < 0.05$ at T1 than T2 and T3. Therefore, the biomass, and weight of charcoal were affected by the temperature on burning and the temperature at boiling, based on this study charcoal from teak was a highly significant difference and was used for further use on potential bio-residues being utilized as fuel as sustainable energy solutions.

Keywords: Charcoal; Energy; Fuel; Temperature; Burning; Boiling

1. Introduction

Laos has many resource potentials of biomass any plant- or animal-based material that can be used to burn as fuel. Waste from forestry, agriculture, and wood products are all included in this. A safe energy source that anyone can use as fuel directly is biomass. It is essential to give it further processing to improve its usefulness and effectiveness, for example, by creating biomass briquettes or pellets. Moreover, woody bio-residues have continued to gain significant interest and attention because of their renewability, greenness, and global availability [1]. These woody bio-residues have been proposed as sustainable sources for utilization as domestic fuel [2]. This proposition is due to their potential replacement for conventional energy sources such as firewood [3]. Woody bio-residues could also be a viable substitute for fossil fuels such as coal. Charcoal is a solid fuel used for heating and cooking that is created through the process of carbonization, which is a process where complex carbon substances such as wood or other biomass are broken down through a slow heating process into carbon and other chemical compounds. Generally, the discussion about charcoal is more about the solid fuel used in developing economies rather than the material used in a barbeque in a developed country. However, these woody bio-residues have been utilized as fuel for sustainable energy solutions.

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The charcoal in Laos is an important renewable energy source that benefits the environment, provides jobs to local and national economies, and is easily manageable in small-scale domestic systems. The heat market related to domestic households can be best addressed by using pellets as this fuel is as convenient to use as a fossil fuel [4]. In the north of Laos, many washes from wood industries particularly, Teak, *Pterocarpus macrocarpus*, etc. the farmers use for energy for cooking and making charcoal but limited information about the quality of charcoal and which type of wash wood or timber should be promoted to economic scale. Therefore, this experiment was to study the differences in Charcoal from teak, *Pterocarpus macrocarpus*, and Cratoxylum Formosum in heat energy, Temperature during the burning time, and Temperature at boiling time.

2. Material and Methods

2.1. Materials

The 500 g of Teak, *Pterocarpus macrocarpus*, and Cratoxylum Formosum Charcoal were collected from the local area of Luangprabang and used as raw material. The experiment was conducted at the Faculty of Agriculture and Forest Resource, Souphanouvong University, Laos.

Strove, Butane Gas ASAHI-JAPAN (TS2019RN) for Starting a burning fire, Aluminum foil for Ash residue, and clay stove for the temperature for boiling water.

2.2. Experimental design and process for data corrections

The experiment trial followed a completely randomized design with three replications, utilizing a Completely Randomized Design (CRD).

The three treatments included

- T1 = teak charcoal,
- T2 = *Pterocarpus macrocarpus* charcoal,
- and T3 = Cratoxylum Formosum charcoal.

The samples were used 500g of each charcoal sample in was weighing machine. Each sample at the time of burning was put in a domestic stove. The combustion was initiated by the addition of a little kerosene and igniting with matches. The temperature of the burning samples was taken by the measure of a thermocouple at every 15 mn and 30-minute intervals using a stopwatch until it was completely burnt. The trial period spanned 3 hr for the temperature at burning.

This was carried out to compare the cooking efficiency of each pellet sample to the charcoal. It measures the time taken for each pellet and charcoal sample to boil an equal volume of water under similar conditions. 500g of each pellet and charcoal sample was used to boil 1000ml of water using a small stainless-steel pot the temperatures at boiling were corrected at 15 mn, 20 mn, 30 mn, 40 mn, and 50 mn were corrected and the domestic stove

The data correction used professional instruments, an Infrared thermometer (WT323E) -50°C - 1050°C.

2.3. Statistical analysis

The effect of differences of charcoal in heat energy content was analyzed for significance ($p<0.05$) by using a one-way analysis of variance (ANOVA). The statistical analysis was displayed using the statistical software Sirichai Statistical 6.07.

3. Results

Based on the results of the temperature at burning and completed burning time analysis, significant differences in No of RDF (Pieces) showed a significant difference ($P < 0.05$) among the experiments higher in teak charcoal (T1) and followed by T2 and T3.

The Average Temperature at burning (°C) and Completed Burning time (hr) was not a significant difference ($P > 0.05$) among the treatments.

Table 1 The temperature at burning and completed burning time

Indicators for heat energy	Treatments			SEM	P-value
	T1	T2	T3		
Mass (g)	500	500	500		-
No of RDF (Pieces)	18.0[a]	12.7[b]	12.3[b]	0.43	0.0004
Average Temperature at burning (℃)	508.5	471.5	486.1	9	0.07
Completed Burning time (hr)	3.23	3.03	3.13	5.7	0.12

Table 2 Temperature at burning and boiling time

Temperature at burning time	Treatments			SEM	P-value
	T1	T2	T3		
Staring burning	1.03	1.23	1.17	7.4	0.23
15 mn	74.1[b]	585.8[a]	576.1[a]	61.4	0.002
30 mn	442.7[a]	143.3[b]	123.0[b]	4.6	0.000
1 hr	717.9[a]	654.0[b]	539.6[c]	2.8	0.000
1:15 hr	559.8[b]	664.0[a]	672.4[a]	1.7	0.000
1:30 hr	612.5[a]	620.1[a]	574.3[b]	1.8	0.0001
2 hr	529.0[b]	406.8[c]	569.3[a]	1.5	0.001
3 hr	623.3[a]	226.5[c]	347.8[b]	1.2	0.001
Temperature at boiling time					
Staring boiling	15.0	12.3	13.3	0.6	0.06
15 mn	93.4[a]	91.9[a]	77.2[b]	1.2	0.0004
20 mn	95.1[a]	91.4[b]	92.1[b]	0.46	0.003
30 mn	92.9[a]	87.8[b]	89.1[ab]	0.72	0.007
40 mn	93.1[a]	85.1[b]	82.3[c]	0.44	0.0001
50 mn	0.0[b]	82.7[a]	81.8[a]	0.28	0.0000

Based on the results of Staring burning and Staring boiling was not a significant difference ($P > 0.05$) among the treatments. However, the temperature at the burned time showed high significant difference ($P < 0.05$) at 15 mn where T2 and T3 were higher than T1. Therefore, at 30 mn and 1 hr high considerable difference ($P < 0.05$) at T1 was higher than at T2 and T3.

However, after 1:15 hr showed a high significant difference ($P < 0.05$) at T2, and T3 was higher than at T1. However, after 1:30 hr showed a highly significant difference ($P < 0.05$) at T1 and T2 than T3.

After 2 hr, a highly significant difference ($P < 0.05$) at T3, T1 than T2. At the end of heating, energy showed a highly significant difference ($P < 0.05$) at T1 than T3 and T2.

Therefore, Temperature at boiling time from 15 mn, 20 mn, 30 mn, and 40 mn showed a highly significant difference ($P < 0.05$) at T1 than T2 and T3.

4. Discussion

In the result was a significant difference ($P < 0.05$) in Pieces of charcoal with different types of wood. It is seen that according to the weight or compact of charcoal. Temperature at boiling time from 15 mn, 20 mn, 30 mn, and 40 mn showed a highly significant difference ($P < 0.05$) at T1 than T2 and T3. It would be an important indicator when we used the Infrared thermometer (WT323E) to analyze the temperature because when the water was boiled 1 L the teak charcoal boiling pot was finished according to the time burning at 30 mn and 1 hr was a highly significant difference ($P < 0.05$) at T1 was higher than at T2 and T3. This experiment was lower than [5] with the water boiling test, 100g of pellet sample P1 (Rice Husk Pellets), achieved 100^0C in 6 minutes to boiling 500 ml of water while 100g of pellet sample P6 and each achieved 100^0C in 8 minutes to boil 500 ml. Comparative studies of the rice husk pellets and charcoal were conducted, and the results showed that 100g of pellet burns uniformly under free convection with a pale yellow flame and very little smoke, while 100g of charcoal burns irregularly and would require forced convection. With the water boiling test, 100g of the charcoal sample achieved 100^0C in 14 and 20 minutes to boil 500ml of water for C1 and C2 respectively. However, the resulting experiment was considered on different methodology.

5. Conclusion

Based on this study, it could be concluded that the temperature at burning and completed burning time analysis, significant differences in Pieces showed a considerable difference $P < 0.05$ among the experiments higher in teak charcoal T1, the temperature at boiling time from 15 mn, 20 mn, 30 mn, and 40 mn showed a highly significant difference $P < 0.05$ at T1 than T2 and T3. However, other factors such as biomass and weight of charcoal were affected by the temperature at burning and the temperature at boiling, based on this study charcoal from teak was a highly significant difference and should be recommended.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest statement at all.

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