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Research Article

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Performance Evaluation of Some Local Wood Species Found within the Vicinity of Adamawa State, Nigeria

Joseph Aidan

Department of Physics, Modibbo Adama University of Technology, P. M. B. 2076, Yola, Adamawa State, Nigeria

Abstract The rates of change in mass of four wood species have been fitted to an exponential function and their performances have been analyzed using the cooking test. It was found that 24 days of air drying was sufficient to reduce the moisture content of the wood species to relatively less than 10%. It was also found that 0.125 kg of African birch was sufficient to cook 1.925 kg of rice in 30 min. The African birch use though having the least fire power of 1298.61 W and burn rate of 0.0044 kg/min has been naturally economical in its use and in facts, the fastest in cooking the same quantity of food. It is therefore recommended as the best cooking wood specie for fuel wood users.

Keywords fuel wood, performance, cooking test, Adamawa state, African birch

1. Introduction

Poor income and low standard of living have brought majority of the African populace into depending on fuel wood for cooking. As a result more of fuel woods may be consumed in developing countries. On the other hand, the continuous falling down of trees for this purpose of cooking had partly contributed to the recurring desertification process presently witnessed; particularly, in parts of North and West African countries. However, in order to minimize desert encroachment on parts of the continent, several improved efficiency stoves have been designed and tested for use.

Unfortunately, while researchers are preoccupied with designs of stove only few others efforts are made toward limiting the indiscriminate falling down of trees irrespective of species for cooking. There should be simultaneous need in promoting only the consumption of some specific woods species that can provide good cooking with lesser fuel consumption. Though wood species vary from region to region and place to place, chances are that common wood species capable of offering just that exist in every community.

In this work, performances of four common wood species (African birch, Shear butter, Locust bean and Tammarindus) found in Adamawa state, Nigerian was evaluated using the cooking test. Based on the findings, recommendations were also made as to which specie should be relatively patronized for cooking.

2. Materials and Methods

2.1. Sample Collection

Fresh and sizable samples of four different species of wood: African birch, locust bean, Shear butter and Tamarindus found within the vicinity of Adamawa state were used. The woods were shaped into equal dimensions of 60 cm by 4 cm by 3 cm and weighed separately before putting them on a rigid skeletal support for air drying. At the end of every 48 hours (2 day), the four samples changes in weights were recorded till drying was achieved (i.e. weight repeatedly stagnates).

2.2. Cooking test experimental procedures

An Aluminium pot of mass 1.925 kg and an improved efficiency stove (Save 80) were used in this experiment. Equal amounts of per boiled rice + water weighted m_i each were separately cooked using the four different species of the dry woods. Initial mass of woods M_i, and final mass M_f after cooking were recorded alongside their corresponding temperature changes from initial T_i to final T_f. Also measured are the final masses of cooked food m_f (water + rice) and cooking time t for every of the species of wood used.

2.3. Data analysis

2.3.1 Wood drying process

As the drying proceeded, the rate of change in mass of wood R ($kgday^{-1}$) and the moisture content M of the woods were progressively calculates using equations (1) and (2) respectively:

$$M = \frac{M_o - M_d}{M_d} \times 100\% \qquad (1)$$

$$R = \frac{M_t}{t} \qquad (2)$$

where M_d is the final mass of air-dried wood, M_o is the initial mass of wood and M_t is the mass of wood at anytime t within the drying period in days.

2.3.2 Wood performance analysis

The performances of the species of wood during cooking were based on the values of their specific fuel consumption *SC*, burn rate F_b and fire power P_f given [1] by:

$$SC = \frac{M_c}{m_f} \qquad (3)$$

$$F_b = \frac{100 \times M_c}{t_c} \qquad (4)$$

$$P_f = \frac{M_c \times LHV}{60 \times t_c} \qquad (5)$$

where M_c is the mass of wood consumed during test, t_c is the cooking time in minutes and *LHV* is the lower heating value, in this work assumed to be about 18.7 MJ/kg.

3. Results and Discussion

The measurements of the changes in the masses of wood samples over time and the calculated moisture content for each of the wood specie using equation (1) and (2) are presented in Table 1.

It could be seen that the dried stage of the woods were reached after about 18 to 20 days. The dried samples weighs 0.73 for African birch, 0.63 kg for Locust bean, 0.50 kg for Shear butter and 0.55 kg for Tamarindus with respective moisture contents of 3.44, 4, 10 and 4.54%.

Table 1: Wood masses M_w, drying rate R and corresponding moisture contents M

Time	African birch			Locust bean			Shear butter			Tamarindus		
(day)	M_t (kg)	R kg/day	M (%)	M_t (kg)	R kg/day	M (%)	M_t (kg)	R kg/day	M (%)	M_t (kg)	R kg/day	M (%)
0	1.30	-	79.31	1.40	-	124	1.05	-	110	0.95		72.72
2	1.28	0.638	75.86	1.33	0.663	112	0.93	0.463	85	0.93	0.465	69.09
4	1.18	0.294	62.06	1.05	0.263	68	0.90	0.225	80	0.93	0.231	68.18
6	1.13	0.188	55.17	0.98	0.163	56	0.85	0.143	70	0.80	0.133	45.45
8	1.00	0.125	37.93	0.93	0.116	48	0.75	0.094	50	0.75	0.094	36.36
10	0.95	0.095	31.00	0.78	0.078	24	0.65	0.065	30	0.73	0.073	31.81
12	0.95	0.079	31.00	0.68	0.056	8	0.65	0.054	30	0.73	0.060	31.81
14	0.85	0.061	17.24	0.68	0.048	8	0.58	0.041	15	0.60	0.043	9.09
16	0.85	0.053	17.24	0.68	0.042	8	0.58	0.036	15	0.60	0.038	9.09
18	0.75	0.042	3.44	0.65	0.036	4	0.55	0.031	10	0.58	0.032	4.54
20	0.73	0.036	0.00	0.65	0.033	4	0.53	0.028	10	0.58	0.029	4.54

22	0.73	0.033	0.00	0.63	0.028	0	0.50	0.023	0	0.55	0.025	0.00
24	0.73	0.030	0.00	0.63	0.026	0	0.50	0.021	0	0.55	0.023	0.00

When the rate of change in the mass of drying wood R is plotted against moisture present (M_t – M_d), an exponential relations resulted (Figure 1).
This relationship can be represented as follows:

$$\frac{dM_t}{dt} \propto M_t - M_d$$

$$\ln(M_t - M_d) = kt + const$$

At t = 0, $M_t = M_o \quad \Rightarrow const = \ln(M_o - M_d)$
Therefore,

$$M_t = (M_o - M_d)e^{kt} + M_d$$

where k is the proportionality constant and $(M_o - M_d)$ is the max moisture present in the wood and is equivalent to $M_d M$; M is the corresponding moisture content at a drying time t.

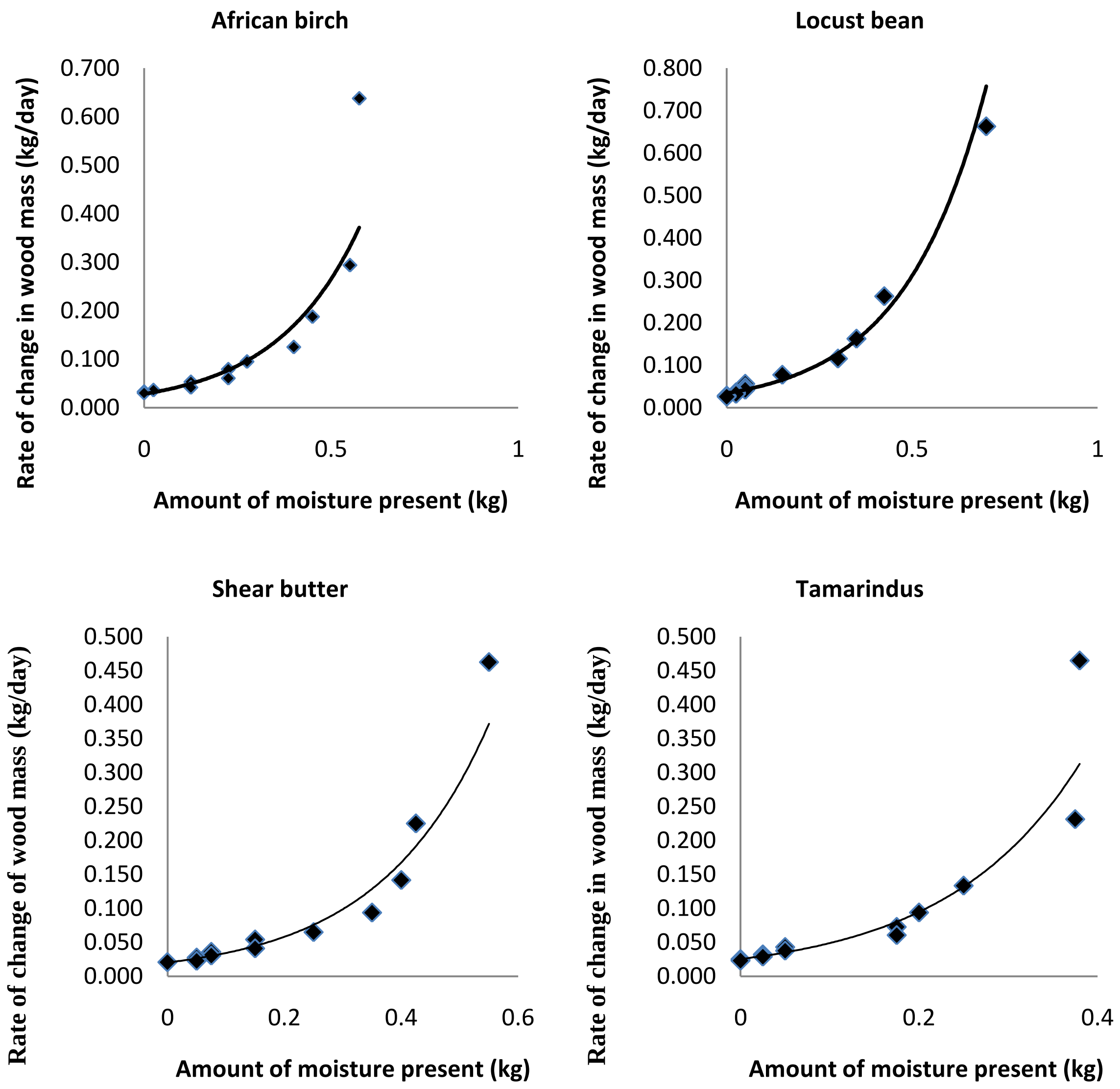

Figure 1: Rate of change of wood masses against amount of moisture present at anytime t

Hence,

$$M_t = M_d(Me^{kt} + 1)$$

This equation implies that any of the species mass of wood picked on the street, its dry mass M_d can be estimated with negligible errors (Sum of Square Errors) since all of the woods were air-dry after about 18-24 day and using the values of k given in Table 2.

Table 2: Estimates of the values of k for different species of wood

Wood specie	African birch	Locust bean	Shear butter	Tamarindus
k	-0.06128	-0.15019	-0.07961	-0.07833
SSE (%)	13.58	3.27	6.06	3.75

Table 3 presents masses of fuel wood consumed during cooking test and their corresponding temperature changes over the cooking duration time using each the wood species.

Table 3: Fuel wood utilized, temperature changes and time duration

Wood specie	M_i (kg)	M_f (kg)	M_c (kg)	m_i (kg)	m_f (kg)	T_i (^oC)	T_f (^oC)	t_c (s)
African birch	0.725	0.600	0.125	3.325	3.600	29	95	1800
Locust bean	0.625	0.375	0.250	3.325	3.640	28	93	3300
Shear butter	0.500	0.275	0.225	3.325	3.675	29	94	2400
Tamarindus	0.550	0.185	0.365	3.325	3.650	29	95	2820

It is clear from Table 3 that the least quantity of wood used is from African birch specie followed by Shear butter. Also it is the African birch that had least cooking time. Therefore, the African birch despite its least fuel consumption, it still had cooked the fastest.

Table 4: Calculated values of F_b, P_f and *SC* for the wood species

Wood specie	African birch	Locust bean	Shear butter	Tamarindus
F_b (kg/min)	0.0040	0.0044	0.0055	0.0081
P_f (W)	1298.61	1417.67	1753.13	2652.48
SC (%)	0.00347	0.0687	0.0612	0.1000

Table 4 shows that woods having higher fire powers do not guarantee faster cooking; rather it's the gentleness of the fire streams that offered the speed. Perhaps, this discrepancy may be related to the natural properties of the food. In facts, local people recommend gentle heating for a better and softer cooking. What is quite interesting about the African birch specie is having the least of all the values of the performance indicators and wonderfully outperforming the others. It is remarkable that out of the dry mass of 0.725 kg of the African birch wood sample, only 0.125 kg was actually used by the Save 80 to accomplish the same task of cooking the food sample. This means that using the African birch specie would result in lesser consumption of woods while species like Tamrindus that is twice as faster at burning (0.0081 kg/min against 0.0044 kg/min) would require more trees to be cut down and consequently opening up spaces for desertification.

The African birch woods coupled with high efficiency stoves would make a good cooking companion for women of the rural areas. It will reduce the stress of fetching large quantities wood for their all-year round cooking experience. On the other hand, lesser stress, shorter cooking time and fewer woods consumed would no doubt make healthy living for the rural women. It is therefore recommended that more of the African birch be planted in large quantities and harvested for the purpose of cooking in Adamawa state. The wood workers should be enlightened about choosing the African birch specie in order to avoid indiscriminate falling down of trees for cooking.

4. Conclusion

The wood samples would require between 18 to 24 days of drying to achieve relatively low moisture contents. The drying process can be fitted to an exponential growth relation for dry mass estimation of any of the sample found and weighed. The African birch has shown the fastest and economical cooking potential against the other samples. Very few quantity of it can easily cook a meal. It is therefore recommended that it should be planted in large quantities to reduce the consumption of other species that burn easily.

References

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