Fast-growing exotic tree species as fuelwood alternative for refugees and host communities in Northern Uganda

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Research Article

Keywords: Fuelwood, Firewood, Calorific value, Fuel Value Index, Refugees, Host communities

Posted Date: June 15th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1733023/v1

Fast-growing exotic tree species as fuelwood alternative for refugees and host communities in Northern Uganda

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ABSTRACT

The high demand for firewood and charcoal has exerted high pressure on the indigenous trees in Uganda. Communities believe that the indigenous trees are better fuel sources despite limited evidence to support this claim. This study was carried out in 2021 to evaluate the fuelwood properties of selected indigenous tree species in comparison to three exotic tree species that have been promoted for use by refugees and host communities in Lamwo District of Northern Uganda. Wood samples were collected from three different locations from the study area in Lamwo District and transported to Gulu University for laboratory analysis of their physical and chemical properties. Data were analysed using one way analysis of variance (ANOVA) at 5% level of confidence and the means were separated using Tukey HSD test. Results showed that moisture content, fixed carbon, volatile matter, and Fuel Value Index (FVI) did not significantly vary among the indigenous and exotic tree species. Fuel value index was observed to be negatively correlated with moisture content of the wood, implying both species' categories retard in fuel quality when their moisture contents increases. Overall, the results show that there were no significant differences in the FVI of all the indegeneous and exotic tree species investigated in this study. It is recommended that fast-growing exotic species such as *Eucalyptus grandis*, *Caliandra calothyrsus*, and *Senna siamea* that are grown in the region be promoted to ensure regeneration and reduction of pressure on the use of natural forest.

Key words: Fuelwood; Firewood; Calorific value; Fuel Value Index; Refugees; Host communities

Article Highlights

- Exotic tree species *Eucalyptus Grandis* had the highest Fuel Value Index (FVI)
- Fuel Value Index was observed to decrease in with increase in moisture content
- There was no significant variation in the FVI between the indegenous and exotic tree species

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- Increasing CV of wood is positively associated with the Fuel Value Index

1. INTRODUCTION

About half of the world's population uses woody biomass as an energy source for cooking and heating [1]. Estimated by IEA [2] indidates that 2.7 billion of the world population rely on traditional use of solid biomass for cooking, and it is projected by 2030, 2.3 billion will still have no acces to clean cooking. Firewood constitutes over 10% of the global energy supply with a rural daily per capita consumption of 0.7-7kg [3]. It is estimated that, over 900 million people in Africa are dependent on solid fuels such as charcoal, dung, firewood, and other biomass for cooking purposes [4] and this number is projected to increase to 1 billion by 2030 [5].

Globally, deforestation and forest degradation continue to take place at alarming rates, which contributes significantly to the ongoing loss of biodiversity. Since 1990, it is estimated that some 420 million hectares of forest have been lost globally through conversion to other land uses. Although, between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year, down from 16 million hectares per year in the 1990s. The area of primary forest worldwide has decreased by over 80 million hectares since 1990 [6]. As of 2015, it was estimated that up to 65 million people were living in forced displacement, majority of whom rely on biomass for cooking [7]. People living in forced displacement contribute significantly to deforestation at an estimated annual rate of 64,000 acres (about 26,000 ha) per year [4].

In Uganda, over 93% of the population meet their primary energy needs using biomass [8] of which 80% is fuelwood, 10% is charcoal, and others plant residues. With a refugee population of over 1.4 million, Uganda has one of the highest refugee population in the world [9]. More than 800,000 of the refugees are from South Sudan, and are hosted in northern part of Uganda [10]. The refugee and host households are highly dependent on forests and other woodlands as primary sources of wood fuel for cooking and for income generation. Recent estimates indicate that daily per capita firewood consumption of refugees and host communities are 1.6 and 2.1 kg, respectively [11]. The three-stone open fire is the dominant technology used by the communities, representing a classic case of energy poverty, characterized by non-commercial consumption of firewood from forest adjacent to the refugee settlement. The three-stone open fire has been reported to cause indoor air pollution leading to acute respiratory tract infection, time loss by women and children collecting firewood, and very high combustion rates [12], [13].

This high community dependence on biomass energy in the district has resulted in huge pressures on the natural forests which have consequently affected indigenous trees that have been the primary source of wood energy in the district [14]. Management of landscapes to produce wood fuel or maintain existing stocks requires that wood fuel species with qualities acceptable to rural communities are identified [15]. A report by MWE [14] and a study by Ojelel *et. al*., [14], [15] suggests that there is preference for indigenous species such as *Combretum collinum* or *Combretum molle*, *Albizia grandibracteata*, and *Grewia mollis* for wood fuel. Ojelel *et. al*., [15] suggested that the preference for indigenous species is because of the high energy values of the species.

With a refugee *population of over* 61,600 [16], Lamwo District in Northern Uganda has experienced a rapid decline in forest cover from approximatetly 28% in 2010 to 13% in 2018, mainly attributed to influx of refugees in the area [17]. Tree species in the area that are listed as threatened or endangered by IUCN include; *Mimusops bagshawei, Polyscias fulva, Pterygota mildbraedii* [18]. Other specicies in the area with special conservation interest include *Vitellaria paradoxa* [19] and *Afzelia Africana* which is classified as vulnerable [18],[20]. There is need to protect indigenous trees since they contribute enormousely to the livelihood of local people considering their ecosystem, biological, aesthetic and cultural values [20]. In addressing vegetation loss, Non-Governmental Organisations (NGOs) such as Tree Talk Uganda and Lutheran World Federation are promoting the growing of trees for fuelwood in Lamwo District. The United Nations High Commission for Refugees (UNHCR) in partnership with National Forest Authority and Lamwo District Local Government have also promoted the growing of fast-growing exotic tree species. Some of the exotic species planted include *Grevillea robusta*, *Senna siamea, Leucaena leucocephala*, and *Calliandra calothyrsus* [11],[21].

Selection of tree species for fuelwood is determined by factors such as climatic conditions, tree growth rate, and management practices. However, the selected exotic tree species being introduced in the area have a high growth rate to meet energy demand but with variable fuelwood qualities [22]. As noted by Backes [22], protection of indigenous tree species supports biodiversity richness in a given ecosystem. The study by [22], [23] suggest that the exotic tree species such as those in being introduced in Lamwo District have suitable fuelwood properties for cooking. However, our search of literature indicates that there is limited comparative studies to support choice of an exotic tree species as alternative to the indigenous ones. Studies have been carried out in other countries but cannot be generalised since environmental factors can lead to variations in the fuelwood properties [15]. This study therefore evaluated the energy potential of some selected promoted exotic species in Lamwo District by determining the Fuel Value Index (FVI) to be able to create an avenue for the selection of high energy performing wood fuel species for possible inclusion into the tree planting programme. It will support identified fast-growing exotic tree species for community tree planting programmes and biodiversity conservation.

2. MATERIAL AND METHODS

2.1 Study Design

Wood samples from the selected species were collected from Lamwo district. Parameters analysed were fuel properties through proximate analysis and Higher Heating Values, from which the FVI for each of the selected species was determined. Completely randomised experimental design was adopted for the study with at least three replications for every parameter analysed.

2.3 Selection of tree species for the study

A total of six tree species given in Table 1 were selected for the study, three of which were indenenous to the study area while the others were introduced to the study area through tree planting programmes. Three indigenous species were selected based on fuelwood use and preference studies in the Northern Uganda region by [15], [24]. Exotic species were selected based on a tree planting program in Lamwo [21] in Lamwo District.

Table 1. Tree species selected for the study

No.	Scientific name	Common name	Local name (Acholi*)	Origin
1.	*Combretum collinum/ Combretum molle*	Weeping Bushwillow or Bicoloured Bushwillow or Zulu Bushwillow	*Odugu*	Indegenous to the study area
2.	*Albizia grandibracteata*	Large-leaved albizia	*Owak*	Indegenous to the study area
3.	*Grewia mollis*	Grewia mollis	*Opobo*	Indegenous to the study area
4.	*Senna siamea*	Black-wood cassia	*Gacia*	South and Southeast Asia
5.	*Eucalyptus grandis*	Flooded gum or rose gum	*Karatuc*	Australia
6.	*Calliandria calothyrsus*	Calliandra	None	Central America

* Acholi is the predominant local language spoken in the study area

2.4 Sampling methods

A purposive sampling approach was applied during the sample collection of the fuelwood on the basis of availability in the locality. A sub-county with abundance of the indegenous tree species was selected and narrowed to a sample plot where the samples were taken. The exotic tree species were taken from the individual beneficiaries from the area that benefited from *Teko-Wa* project implemented by Lutheran World Federation, Tree Talk, and National Forest Authority, and local government tree planting energy access programme using the record of the distribution lists and applying a simple random sampling approach. The GPS coordinates for location of sample plots were taken and recorded.

2.5 Sample preparation and laboratory analysis

The wood samples of about 2.5cm in diameter at breast height were chopped into pieces of 10cm in length as recommended by [15], [25] and taken for laboratory analysis. A pair of vaneer calipers was used for measuring the dimensions of the samples and a GPS set was used for picking coordinates of the sample trees and area. Photographs of the study area and the selected tree species were taken using a camera. The samples were contained in the sample holder registered using pencil on a notebook, and a thermometer was used for recording the temperature of the study area. On arrival in the laboratory, the stem discs were then cut into smaller sizes and kept for oven-drying to calculate moisture content. An oven-dried sample was ground into sawdust with the help of Wiley Mill and used for further analysis.

2.5.1 Determination of moisture content

The samples were dried in an electric oven at 100ºC $\pm$ 5ºC for 24 hours until they attained a constant weight. The moisture was then determined on a dry weight basis according to the Equation 1 [25].

$$MC = \frac{W_w - W_0}{W_0} X\ 100 \quad \text{...Eqn 1}$$

Where W_w and W_o, are the weights of the wet and dry samples, respectively.

2.5.2 Density

Basic density was calculated from the oven-dry mass of a wood sample divided by its green volume. It was determined using bark-free wood samples following the procedure by [26]. The wood cubes were inserted in a measuring cylinder containing a known quantity of water 24 hours after harvesting. The change in the water level in the measuring cylinder was recorded before and after inserting the wood cube and the difference used as a parameter in calculating the basic density of the wood sample. The green wood cubes were then placed in an oven at 103±2 °C for 72 hours and the initial and final weights determined. The basic density (g cm^{-3}) was calculated using Equation 2.

$$Basic\ Density = \frac{E_2}{F+G} \text{……………………………………………………… Eqn 2.}$$

Where E_2 and F are the green weight of the and the oven dry weight of the wood samples, respectively, while G is the deflection of the needle in cm due to water displacement.

2.5.3 Ash content

The method for determining the ash content was adopted from [26] and [27]. Oven dried wood samples of 1.0g were weighed and placed in silicon crucibles and subjected to a treatment in a muffle furnace at 550°C for four hours and weighed after cooling. The ash content (%) was then calculated from the weight difference using formula in Equation 4 [26], [27]

$$Ash\ Content = \frac{W2 - W1}{O.D.Weight\ of\ the\ sample} \times 100 \text{ ……………………………………….. Eqn. 3}$$

Where, W_1 is the weight of dry crucible and W_2 is the weight of ash content with crucible.

2.5.4 Determination of calorific value (CV)

Test samples (1g) were placed in a crucible inside the bomb calorimeter and subjected to rapid combustion at 25 atmospheres. For this, a 1g sawdust pellet was burned in the sample holder of the bomb by connecting a nichrome fuse between the terminals to the pellet through a small cotton thread [28]. Before ignition, the bomb was filled with oxygen and placed in the calorimeter vessel, to which 1.5 L of distilled water was added. The initial temperature of water (*Ti*) in the vessel and the maximum temperature attained after burning pellets was recorded (*Tf*). The *CV* was then calculated by Indian Standard (IS 1350-1966) using Equation 4 with a water equivalent value of 2250.

$$CV = (Ti - Tf \times Water\ equivalent\ Value) \text{………………………………………….. Eqn 4}$$

2.5.7 Fuel value index

This was calculated by considering density and gross calorific value as a positive character and moisture content as a negative character using an Equation 5 [15].

$$FVI = \frac{Gross\ Calorific\ Value (KJ/g) \times Density\ (g/cm)}{Moisture\ Content\ (\%)} \text{ .... Eqn 5}$$

2.6 Data management and analysis

All data collected were entered into an Excel design, screened and cleaned. A computerised data check was developed in the data entry screen to validate the quality of data entered. The data were then exported to SPSS for further management, processing, and analysis. Appropriate value labels were assigned to all the categorical response variables to make the datasets user-friendly. Also, labels were assigned to all variables in the datasets for ease of identification. The Analysis of Variance (ANOVA) procedure was carried out to compare means of the values of the parameters measured, while correlation analysis was carried out to determine the nature of the relationships between the parameters.

3. RESULTS

3.1 Physical properties of indigenous and exotic fuel species

3.1.1 Moisture content

When moisture content and density were compared among the indigenous and exotic tree species considered in this study, the values varied significantly ($p<0.05$) (Figure 1). Generally, the moisture content of the six selected species ranged from 17.49% to 44.56% in descending order from *E. grandis*, *A. grandibracteata*, *G. mollis*, *C. molle*, *C. calothyrsus* and least in *S. siamea*. The Moisture content of *E. grandis* was significantly higher than that of *C. calothyrsus* and *S. siamea* ($p<0.05$). However, the moisture content of *G. mollis*, *C. molle* and *A. grandibracteata* were not significantly different from those for Eucalyptus and *C. calothyrsus* and *S. siamea*.

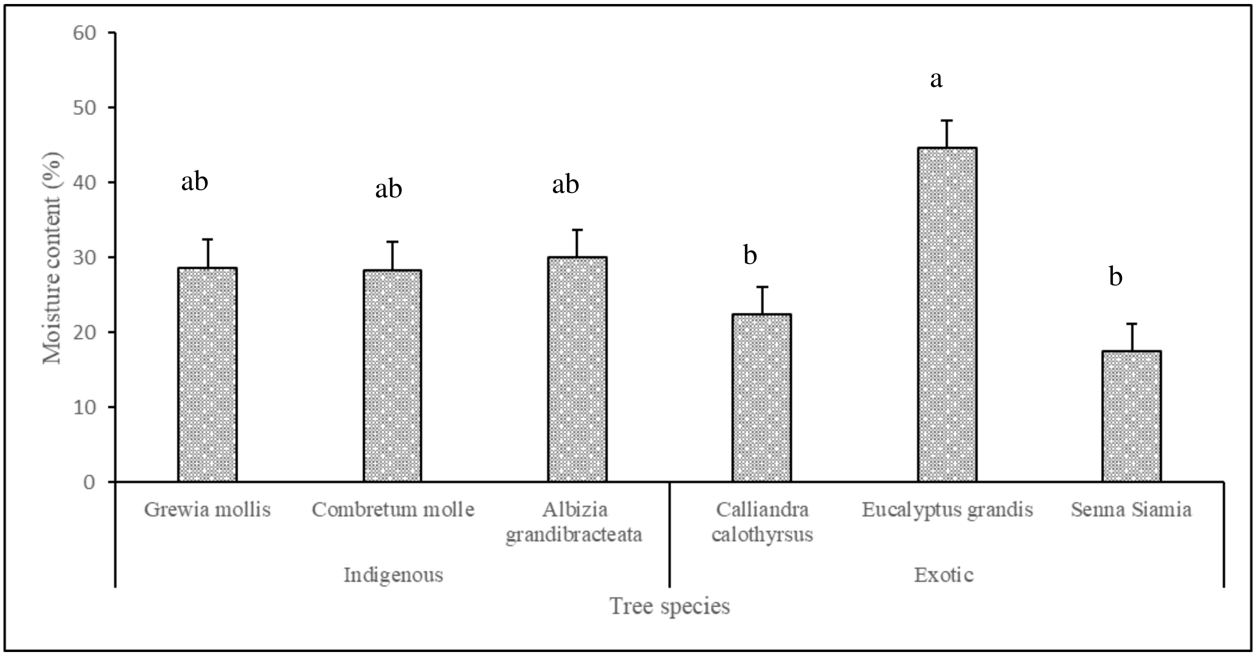

Figure 1: Moisture content of indigenous and exotic fuel species (Bars with different superscripts are significantly different)

3.1.2 Density of the tree species samples

The density of the six indigenous and exotic fuel wood species were is shown in Figure 2. The values ranged from 974 kg m^{-3} to 940kg m^{-3} with the highest being that for *A. grandibracteata* and lowest for *G. mollis.* The density of the *A. grandibracteata* and *E. grandis* had no significant difference but the values were higher than for the rest of the tree species studied. The density of the *E. grandis* had no significant difference with that of *S. siamea, C. molle*, *C. calothyrsus* but the values were higher than that of *G. mollis.* The density of *S. siamea, C. molle*, and *C. calothyrsus* had no significant difference but their values were lower than those of *A. grandibracteata* and *E. grandis*.

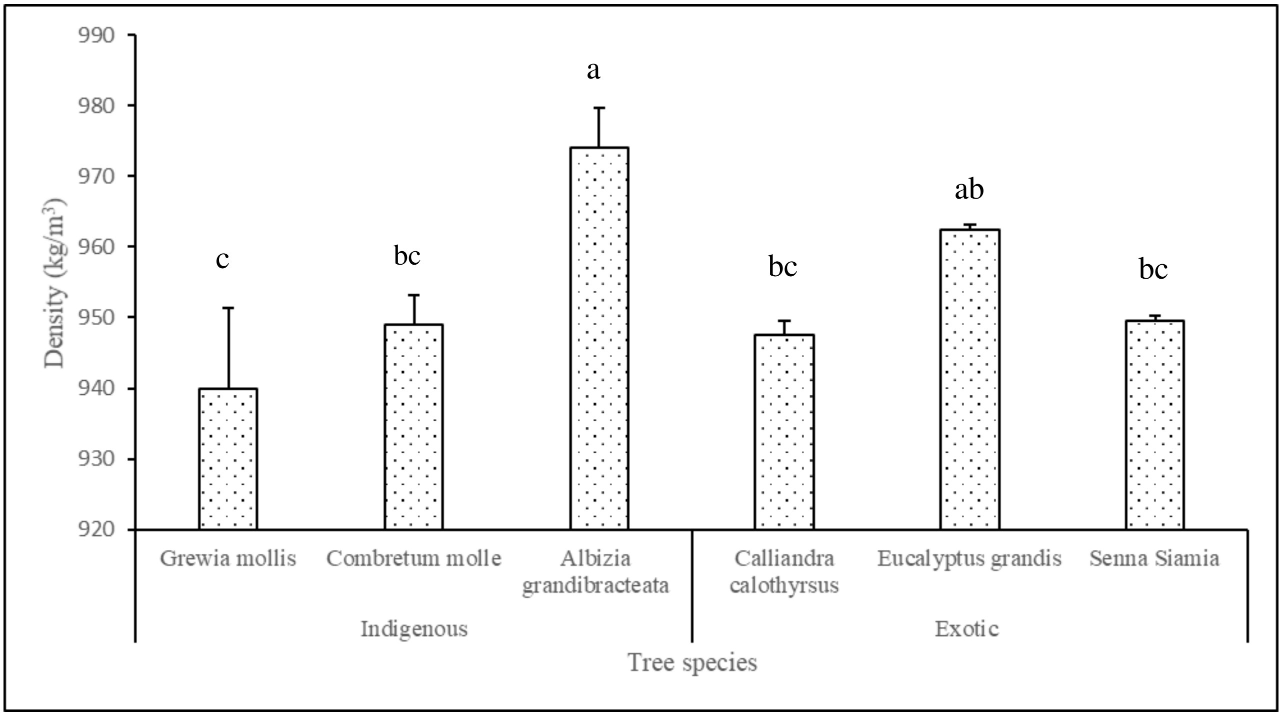

Figure 2: Density of indigenous and exotic tree species

3.2 Chemical properties of indigenous and exotic tree species

Results of the chemical properties of the indigenous and exotic tree species are shown in Table 2. Only ash and CV were values significantly different among the six-fuel species ($p<0.05$). The Ash content values of the six fuel species range from 2.97 and 1.02% with the highest in *C. molle* and the lowest in *G. mollis*.

Table 2: Chemical properties of indigenous and exotic fuel species

Species Classificaiton	Species name	Ash (%)	VM* (%)	FC** (%)	CV (MJ kg^{-1})
Indigenous	*Grewia mollis*	1.02±0.03^{d}	72.85±20.94^{a}	14.46±2.15^{a}	18.34±0.04^{c}
	Combretum molle	2.97±0.06^{a}	79.74±4.68^{a}	17.29±4.74^{a}	17.75±0.04^{d}
	Albizia grandibracteata	1.09±0.00^{cd}	84.52±2.18^{a}	18.76±2.39^{a}	17.63±0.29^{d}
Exotic	*Calliandria calothyrsus*	1.39±0.18^{cd}	85.94±1.76^{a}	25.77±20.76^{a}	18.92±0.21^{b}
	Eucalyptus grandis	1.96±0.12^{b}	80.15±2.40^{a}	12.41±0.58^{a}	18.80±0.04^{b}
	Senna siamea	1.53±0.19^{bc}	85.64±0.69^{a}	12.54±1.95^{a}	19.80±0.08^{a}

VM* = Volatile Matter, FC** = Fixed Carbon, CV*** = Calorific value; ♦implies that the values are predicted on basis of the mean recults of proximate analysis

The ash content of *C. Molle* was significantly higher than for all the fuelwood species. However, the Ash contents of *E. grandis* was not significantly different from that of Senna but was significantly higher than that of *C. calothyrsus*, *A. grandibracteata* and *G. mollis*. The as content value of *A. grandibracteata* was not significantly different from that of *S. siamea* and *G. mollis*

Results of Calorific Values (CV) of the species are given in Table 2, and they range from 19.80 MJ kg^{-1} and 17.63 MJ kg^{-1}, with the highest in *S. siamea* and lowest in *A. grandibracteata* and *C. Molle*. The CV of *S. siamea* was significantly higher ($P<0.05$) than those of the other tree species studied. Further it was found that CV of *C. calothyrsus* and *E. grandis* are not significantly different from those of *G. mollis, A. grandibracteata* and *C. Molle*. Meanwhile, the CV of the *C. Molle* and *A. grandibracteata* were found to be significantly lower than that *G. mollis.* The Volatile Matter (VM) of the wood species ranges from 72.85 to 85.94%, with the highest value in *C. calothyrsus* and the lowest in *G. mollis*. Table 2 also gives the Fixed Carbon (FC) content of the six tree species ranging from 12.41 to 25.77% with the highest values in *C. calothyrsus* and lowest in *E. grandis*.

3.3 Fuel value index of indigenous and exotic fuel wood types

The difference in the Fuel Value Index of the indigenous and exotic fuel types is presented in Figure 4.

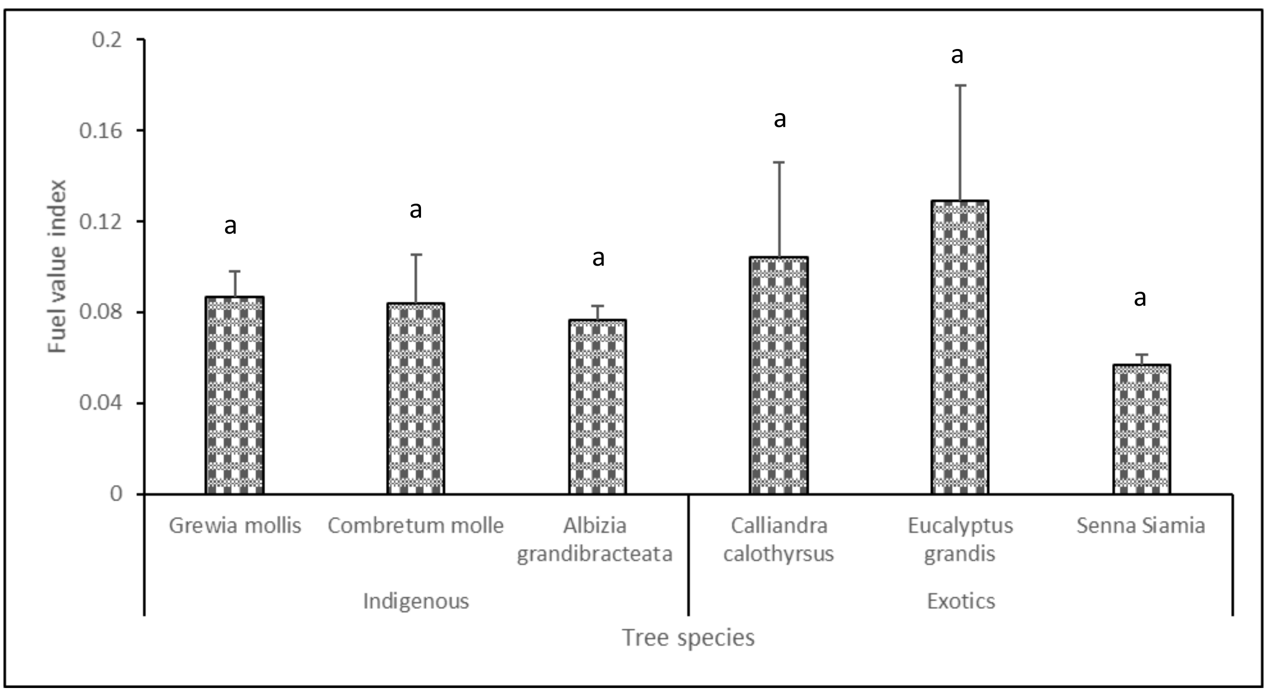

Figure 4: Fuel Value Index of the indigenous and exotic fuelwood species

Results of the Fuel Values Index (FVI) of the indigenous and exotic wood species are given in Figure 4, and were found not be be significantly different at 5% level of confidence. The value ranges from 0.13 and 0.06 with the value being that of *E. grandis* and lowest in *S. siamea*.

3.4 Correlation between the different parameters

Results of Pearson's correlation among the parameters investigated in this study is given in Table 2. Among all the parameters investigated, only moisture content was significantly ($p<0.05$) correlated with Fuel Value Index, however, the correlation was observed to be negative.

Table 3: Results for correlation among the parameters investigated

Parameters	Density	Moisture contents	Ash	Calorific Value	Volatile Matter	Fixed carbon	FVI
Density	1						
Moisture contents	0.392	1					
Ash	-0.087	0.179	1				
Cal Value	-0.330	-0.304	-0.190	1			
Volatile Matter	0.420	-0.329	-0.025	0.181	1		
Fixed carbon	0.011	0.060	-0.018	-0.067	0.012	1	
FVI	-0.300	-0.880*	-0.126	0.559	0.353	-0.226	1

***Shows significant values ($p<0.05$)**

4. DISCUSSION

4.1 Physical properties of indigenous and exotic fuel species

High moisture content in the wood results in a decrease in the amount of heat, as more energy is used to vaporise to water, which lowers the combustion efficiency [29]. Among the species assessed, there were significant differences in moisture content (Figure 6). The variations of moisture content among species is probably explained by the differences in the age of tree species. Further the number and size of wood capillaries amongst species was reported in previous studies [15], [30], which could also lead to variation in water holding capacities and moisture content.

In this study, the density of the 6 indigenous and exotic fuel wood species showed significant difference (Figure 7). The density of the fuelwoods plays an important role in the determination of its fuel value because denser wood contains more heat per unit volume and burn for longer periods of time [30]. Generally, the density of fuelwood of exotic tree species showed no significant differences amongst the spcicies evaluated in this study. The findings are in line with findings by Chevan *et. al*., [26] who attributed the variation to the age and structural anatomy of the tree species.

4.2 Chemical properties of indigenous and exotic fuel species

Ash content is the remaining inorganic part of wood matter that cannot be combusted and it's considered a negative parameter [26] therefore, a wood with high ash content is not desirable for fuelwood. As reported by Etitgni and Campbell, [31], the major component of ash is Ca, Mg, K, Ci and P. In the present study, ash content values of the six-fuel species range from 2.97 and 1.02%. *C. molle* is found to have high content compared to all the species. The finding corresponds to the study of [29] that evaluated the energy yield and characteristics of some wood species. High value of ash above 5% affects the heating value of a wood [32]. This finding values of ash within a range of less than 5% indicating all species are good for fuelwood despite *C. molle* showing high ash value compared to others. It should be noted that ash content of a wood also can change based on heating condition and other environmental factor which cause reaction to form other elements

The volatile matter of a fuelwood is the condensable and non-condensable vapour released when the fuel is heated and in wood, the amount depends on the rate of heating and the temperature to which it is heated [33]. According to Ogunsola *et. al*., [34], volatile matters are those components of fuel which are readily burnt in the presence of oxygen. This is usually a mixture of aromatic hydrocarbons, short and long chain hydrocarbons, and sulphur. During the pyrolysis process, fuel is heated in the absence of oxygen and volatile matter and inherently bound water in the fuel is driven off to form a vapour which consists of mainly tar, oil, and gases. High volatile matter in fuelwood is bad as it causes much tar [34],. In this study, the volatile matter of the fuel wood species was comparably the same though the value was high in *C. calothyrsus* and lowest in *G. mollis*. This finding is in agreement with a study by [29] which found volatile matters of the wood species with the same value range. Therefore, it's an indication that both the wood categories have similar volatile matter contents.

In this study, there was no significant difference in the values of the fixed carbon content in the species studied (Table 1). All the species exhibited average fixed carbon though *C. calothyrsus* had higher values compared to the other species. The high fixed carbon content indicates that the biomass has a long combustion time which gives a rough estimate of the heating value of a fuel that acts as the main heat generator during the burning of a biomass. Hence, the higher the content of carbon of the biomass fuel the more likely that the species would have higher heating value [35]. In the study to evaluate mechanical and thermal properties of firewood properties from some selected similar species such as *C. mole* and *A. grandibracteata* [36], similar results were reported. Therefore, all the exotic species would be good for fuelwood as the indigenous.

The CV of the species studied were significantly different despite all species exhibiting high energy values (Table 2). The result was contrary to the study by [37] which found no significance between indigenous and exotic species studied. In this study, exotic wood species had higher CV compared to indigenous species. The CV of *S. siamea* was higher compared to all the species studied. The insignificant variation of CV across species according to [15] shows that it is not an important factor in determining desirable wood fuel species. The heat of combustion of wood according to previous studies [22], [38], [39] depends upon the genetic character of the species and chemical composition of the wood including volatile matter, lignin, and extractives. Species with high volatile matter in this study such as *S. siamea, C. calothyrsus* and *E. grandis* had high CV which is an indicator that they perform well compared to indigenous species.

Fuelwood with high CV, high density, low ash and low moisture content are considered good wood fuel species making fuel value index the best indicator for quantifying the best or worst wood fuel species [15], [37]. In this study, both the indigenous and exotic species had no significant difference in the FVI (Figure 4). The FVI was low in all species with the highest value being at 0.13 in *E. grandis*. The finding of this study is in line with finding of [37] in his study to determine the CV and gravimetric yield of some selected species with highest value at 0.74 but the finding is not different with another study by [15] in which the fuel value indices of some preferred wood species was determined. The study by [15] indicated FVI of the species studied to be 13.09 which is perhaps attributed to variation in geographical location.

Lastly, fuel value index was negatively correlated with moisture content (Table 2). This finding suggests that wood fuel species of low moisture content are better sources of fuel. This result is supported by the fact that moisture content negatively affects combustion and hence the energy value [15].

5. CONCLUSIONS

The high dependence of community on biomass energy has resulted in huge pressures on the natural forests which have consequently affected indigenous trees that have been the primary source of wood energy. Indeed, the management of landscapes to produce wood fuel or maintain existing stocks requires that wood fuel species with qualities that are preferred and acceptable to rural communities are identified. This study evaluated the energy potential of some selected promoted exotic species to identify exotic trees with high energy potential compared to preferred indigenous species that can be promoted for addressing high energy demand and conserving indigenous tree species. Among the species assessed, the moisture content was high in *E. grandis* and lower in *S. siamea.* Making *S. siamea* is the best species for choice in terms of moisture content. Among the species evaluated in terms of Density, *A. grandibracteata* had high density value compared to all the other trees but was insignificantly variation with *E. grandis* so making *E. grandis* a species that can be promoted in terms of density. In terms of Ash content, the value was high in *C. mole* compared to the rest of the species. The 3 species of exotic species are therefore good for promotion as Ash content is lower compared to most of the indigenous species. In terms of Volatile matter and Fixed carbon, there was no significant difference in the values of indigenous and exotic species which means the exotic species can serve the same purpose as that of indigenous species. When the CVs are compared among the indigenous and exotic species, all the exotic trees had higher CV compared to the indigenous species. This study therefore, recommends promotion of exotic species such as *E. grandis, C. calothyrsus and S. siamea* has shown comparable quality to the indigenous species mostly preferred by the community. This will help to ensure regeneration and reduction of pressure for the use of natural forest. Community and agencies promoting tree planting in Lamwo Districts should use this evidenced based finding to ensure a decision in their effort to promote tree planting.

Statements and Declarations

Funding: The authors did not receive funds, grants, or other support from any organisation for the submitted work.

Conflict of Interest: The authors declare that they do not have conflict of interest with regard to this article

Authors Contributions

Conceptualization: Collins Okello, Decimon Anywar, Robert Loki Okongo; *Methodology*: Collins Okello, Decimon Anywar, Robert Loki Okongo; *Formal analysis and investigation*: Decimon Anywar, *Writing - original draft preparation*: Decimon Anywar, Richard Louis Labeja; *Writing - review and editing*: Kato Stonewall Shaban, Richard Louis Labeja, Collins Okello; Geoffrey Beyihayo; *Supervision*: Collins Okello, Robert Loki Okongo.

Acknowledgement

Technical support during laboratory analysis by Geoffrey Beyihayo is highly appreciated.

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