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Fuel Briquette Potential of Lantana camara L. Weed Species and its Implications for Weed Management and Recovery of Renewable Energy Sources in Ethiopia

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Abstract: *This study aimed to produce fuel briquettes from Lantana camara and weed management in eco friendly manner, which is most serious invasive weed, spreading throughout the world particularly at alarming rate in Ethiopia. Utilization of biomass like invasive weed such as lantana camara L. species in Ethiopia have greater advantage for discovery of clean renewable energy sources and for reduction of deforestation of indigenous trees. Producing and evaluation of the fuel briquetting potential of root, stem, branch and leaves and the charcoal potential of root, stem, and branch of weed species were carried out by using ASTM procedure. The mean average value for fixed carbon content(FCC) and calorific value of the root, stem ,branch and leaves were:53.89±1.84(%)and6525.54±250.03(cal/gm); 52.77±0.39% and 6479.59± 1004.51(cal/gm);50.22 ± 3.21(%) and 5135.36± 150.29 (cal/gm); 37.56 ± 0.69 (%) and 3690.67 ± 182.32 (Cal/gm); respectively. The result for fixed carbon content(FCC) and calorific value of the root, stem and branch of charcoal produced were:65.6(%)and 7483.99(Cal/gm);6.44(%) and 7483.99(Cal/gm);64.89(%) and 7222.66(Cal/gm);respectively The finding shows that by eco friendly utilization of lantana camara weed as a clean energy fuel briquette. it's possible to manage the spread of such type alien invasive weed as well as to increase farmers crop production, access for livestock grazing land; reduce deforestation of indigenous trees .*

***Keywords*:** *Biomass, Briquette, Fuel quality, Lantana camara.L. Charcoal.*

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I. Introduction

Higher standard of living as well as population growth has resulted in an increasing demand of food and new form of clean energy throughout the world. Among the clean energy source, biomass is one. The use of biomass energy sources in most part of developing country is mostly traditional one but now days due to many health and environmental problems, the world tend to shift to modern renewable biomass energy utilization. Lantana camara L.weed or commonly known as Sleeper weed (Yewof_Kolo or YeragnaKolo in Amharic Ethiopian official language). It is a typical weed plant which is most persistent and that are alien or non-native to the ecological unit and its introduction threaten agriculture productivity of most arable area mainly in Africa and Asia. This impact even extended to food security of the community, on the health of domestic animal and has impact on the biodiversity of the native valuable tree Its impact extended to many parts of Ethiopia such as east Shewa Oromia region like most part in Ada district up to Shashemene and some parts of Wondogent in southern part of Ethiopia;Alien invasive species are one of the major factors threatening biodiversity resources in north Shewa especially Kewet district.

The aim of this research is to evaluate and characterized the fuel briquette potential from *Lantana camara L.* as an option for bio-fuel(briquette) and weed management in Ethiopia. Therefore, converting this alien invasive weed species to value added material like generating clean energy is one of the objective of this study, since most weed controlling methods are not effective and if it continues erratically then very soon it would be beyond rectification. Thus, management of weed by utilization, therefore, becomes very important in order to minimize the adverse effect of such weed in many aspect of agricultural food security of one country many related research shows that most invasive weeds like *Lantana camara* .L cannot be removed effectively with the common method. So changing it into valuable material like briquette production, give as many other multi socio economic benefit like saving agricultural land, increasing agricultural production, and in production of clean energy and utilize it asbiomass to produce fuel briquette or bio fuel is one form of renewable energy that can be utilised to reduce the impact of energy production and use on the global environment. The key issue concerning the bio fuel production is to make the process economically viable. [1] A low cost of feedstock(Biomass) is a very important factor in establishing a cost-effective technology.[2]

Fuel briquette produced from alien weed species like *Lantana camara .L*. are economical and environmentally friendly, healthy (no smoke at all) by reducing GHG emission, reduce impact of deforestation especially indigenous tree and also enable to solve food security problem with dual nature. The application of *lantana camara.L* weed for briquette production as clean energy source at a household level means adding a new biomass source that reduce the deforestation of indigenous tree. In addition to this it will save time for women and children, who were mostly engaged in many house hold activity like cooking food by burning traditional biomass, time that were spent for collection of fire wood. The remaining after briquette production the ash even can be used as a soil fertilizer to adjust soil pH, soil conditioner or land filled.

II. Materials And Methods

2.1* Geographic location of the study area*: The study site, Adele Mecho Kebele. It is one of 18 rural Kebeles of Liben Chukala district, which is one of the 10 districts in East Showa administrative zone, Oromia regional state.

The study site is found south of Adulala town and is located at latitudes 8°45'36" – 8°54'07" N and longitudes 38°87'49"– 38°95'47" E (Figure.3). It is found in altitude ranges from 1656m to 1932m(Figure.3).This value was extracted from Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM) 30 m spatial resolution (http://edcsns17.cr.usgs. gov/Earth Explorer/)viewed on date February 1st, 2015.

The study site covers an area of 3802 ha; while the sample data was collected from nearly one hectare. Rainfall varies between 450-1600 mm. However, the general pattern shows the highest precipitation during the rainy seasons from July to August and there is low precipitation from February to March. Forty percent of the total area of the districts lowland while 52% is classified as mid altitude and the remaining 8% is classified under highland. [3]

***2.2* Collection of Lantana camara. L.:** The biomasses *Lantana camara* L. was collected as a sources for briquette production during January 25 to 25, February, 2015 from Adele Mecho Kebele, Liben Chukala district, in East Showa administrative zone, Oromia regional state, Ethiopia.

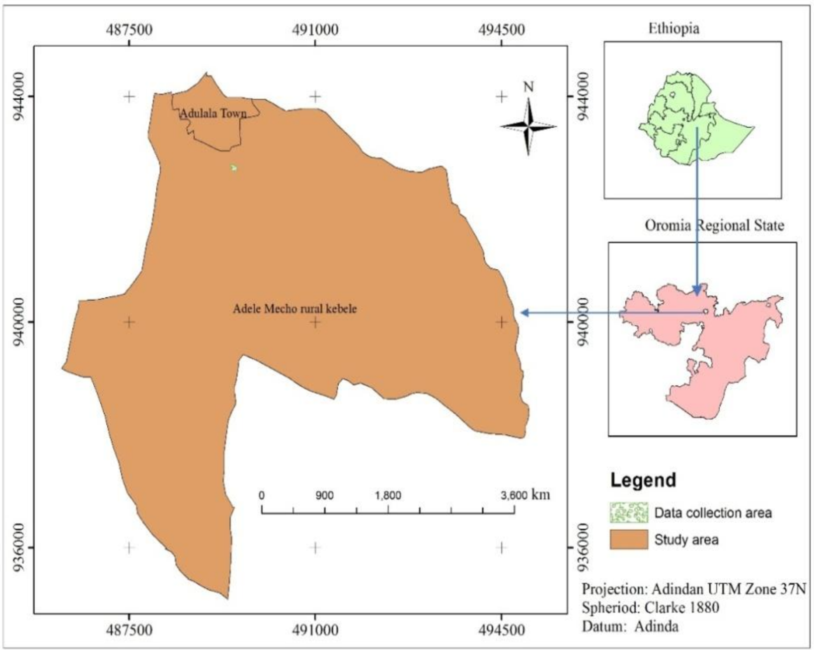

Figure 1: Map of the study area, by Sintayehu Abebe.

2.3 Sampling and quality control: Samples (plants) were collected from site, with appropriate safety using like glove then sorted with its type such as root, stem, branch, leave and flower then chopped with proper size to fit the kiln for carbonization processes and dried for a month. The carbonization process proceed with proper way feeding to the kiln and cleaning of the kiln followed by proper controlling of the air for proper dehydration and carbonization and following the chimney smoke type and closing the whole opening that show completion of carbonization and cooling to proceeded.[4]

2.4 Sample Analysis*:* The study conducted at the Addis Ababa University College of Natural Science in the Centre for Environmental Science laboratory. Fuel Briquette and charcoal part of the study were conducted in

Alternative energy development and promotion laboratory at MOWIE Energy laboratory and workshop center, Addis Ababa Ethiopia.The samples of Lantana camara L. was taken from its root, steam, branch and leave with trunk and flower part. The collected plants were chopped to dimension that fit the carbonization metal kiln. Then it was taken to the Ministry of water, irrigation and energy at Alternative energy development and promotion laboratory and workshop center around Gurd Sholla; Addis Ababa for carbonization, to determine proximate analysis, bulk density and calorific value of the fuel charcoal and briquette.

The process of carbonization was carried out in oxygen limited condition in barrel kiln which have long chimney; which used to control the proper air for carbonization process. Then closed with screw when dehydration completed just when cloudy smoke become closely to blue or black so as limited oxygen environment is created and the chimney also covered by clay mud for charcoal production and cooling in controlled manner. The resulted charcoal were ground to fine particles by using charcoal mill to produce charcoal powder. Finally, this mixture was fed into the beehive briquette machine press mold that press out 2000 briquettes per hour with the right amount of output each fuel briquette closely weigh 400-600g required dimensions with axial holes up on proper amount of feed to the behave machine.

***2*.5 Characterization of the produced fuel briquette:** To determine calorific value, Bomb Calorimeter at Alternative Energy Development and Promotion Directorate Laboratory, MOWIE, the briquette specimens analyzed by an adiabatic oxygen bomb Calorimeter Parr 6200 calorimeter of Parr M39889 and Parr M39805 oxygen bomb, which were used following the Parr instruction manual according to ASTM D-5865-95.[5] The briquette specimens milled with 0.7-1 gram and then placed in a capsule and combusted in and analyzed by an adiabatic oxygen bomb Calorimeter Parr 6200-calorie meter and the resulting calorific value measured. The bulk density was determined by placing the charcoal powdered in metal cub with size x =y=z and then the weight of powdered measured and the result computed as the weight of charcoal divided by the volume of the container.

The proximate analysis (the chemical property) of the briquettes was determined according to ASTM D-1762-84 [6] protocol and on the other side the fixed carbon content was computed by using procedure given by Anon.[7]

***2*.6 Proximate analysis**: The proximate analysis briquette charcoal produced from root, stem, branch and leaves of *Lantana camara* L. was carried out. All proximate analysis of the produced fuel briquette includes moisture content, Volatile matter content, ash content and Fixed carbon content were carried out in the Alternative Energy Development and Promotion Directorate Laboratory, MOWIE, Ethiopia Addis Ababa and all proximate analysis were carried out accordance with ASTM D-1762-84 [6] protocol and theses proximate term can be defined as follow:

***2*.7 Moisture content:** The moisture content determined by heating a sample of powdered *Lantana camara* L. briquette and determined as a loss in weight in a drying oven at 105^0C to constant mass, then the moisture content computed and reported on weight basis. The same specimen used for volatile matter content and ash content determination and percentage of moisture content calculated as the difference between the weights before moisture removal i.e. in this study three gram were taken plus the mass of crucible and the weight after moisture removal and dividing the result by the sample weight taken i.e. Three gram for measuring moisture and multiplying the whole with hundred.[8]

The moisture content of sun dry leaves. Were determined with same procedure for better carbonization but six gram were taken and the same equation 3.1 were used.

$$\frac{\mathrm{MC} = \mathrm{Weight}_{\text{sample before moisture removal}} - \mathrm{weight}_{\text{sample after moisture removal}})\times 100}{3\mathrm{gram}} \ldots Eq.\,3.1$$

***2.8* Volatile matter content:** The volatile matter content of powdered briquette charcoal was determined by heating oven dried sample for moisture content at 950^0C by preheating the specimen in the muffle furnace for two minute at 300 ^{0}C then heating for three minute at 500 ^{0}C, Finally for six minute at 950 ^{0}C in covered crucible of specimen by lid prepared for this purpose. Then the percentage of volatile content of the sample is computed as the difference between initial (Oven dry weight of charcoal specimen for moisture determination or weight after moisture removal) and final weight of the sample after removal of volatile matter and dividing the result by the total sample weight taken and multiplying the whole with hundred.

$$\frac{\mathrm{Vm} = \mathrm{Weight}(_{\text{sample after moisture removal}} - \mathrm{Weight}(_{\text{sample after VM removal}})\times 100}{3\mathrm{gram}} \ldots Eq.\,3.2$$

2.9 **Ash content:**The ash content of a sample of powdered *Lantana camara L.* charcoal and briquette charcoal were determined from volatile matter content of the same sample and weighing it and the result obtained as the residue after burning of specimen obtained to a constant weight at 750°C for six hours in uncovered crucible of specimen. Ash content was computed as a proportion of the residue to the oven-dry weight of charcoal.

$$\%AC = \frac{\text{Weight}_{\text{sample before moisture removal}} - \text{Weight}_{\text{sample after ashing}})\times 100}{3\text{gram}} .. Eq. 3.3$$

2.10 **Fixed (pure) carbon content:** The fixed carbon content in sample of powdered Lantana *camara L.* charcoal and briquette charcoal were calculated as the difference between 100% and the sum of the percentage of moisture content, volatile matter content and ash content or subtracting these value from the total sample weight taken for analysis and converting the result in to percentage according to Anon.[7]

$$\%\text{FCC} = 100\% - (\text{Mc}\% + \text{Vm}\% + \text{Ac}). \dots \dots . Eq. 3.4a$$

OR

$$\text{Fcc} = \text{Total sample (3 gram)} - (\text{Mc} + \text{Vm} + \text{Ac}) \dots Eq. 3.4b$$

Where:

%Mc = Percentage Moisture content
% Vm = Percentage Volatile matter content
%Ac = Percentage Ash content
%FCC= Percentage of Fixed carbon content

2.11 **The physical property of briquette charcoal produced from root, stem, branch and leaves:** Standardization of calorie meter for calorific value determination. The term standardization of calorie meter denoted for the operation of calorimeter using graded one-gram benzoic acid as a test sample up running a number of test. In this study adiabatic bomb calorie meter used with model Parr 6200 and with Bomb ID 39905 and M3980, which were ISO 9001 certified.The procedure for the calorie meter standardization used in this study for determination of calorific value of the produced briquette were standardized for ten times with pellet of calorie graded benzoic acid with weight not less than 0.9gram and not more than 1.25 gram or mostly graded one gram benzoic acid were used.

Gross heat value of a sample and all result were calculated by the Central Power Unit of the calorie meter and the final result were obtained. The physical property of the produced. fuel briquette like bulk density, calorific value and weight(g)immediate after removal from briquette machine and up to 15 days were done in the same laboratory, Alternative Energy Development and Promotion Directorate; MOWIE. Beside this all physical property test durability, the cooking time of fuel briquette or time taken to turn ash and time taken to boil for 0.5L;1L and 2 litter water also carried out with so called 'Merichaye' briquette stove. The stove is designed and produced in Alternative Energy Development and Promotion Directorate of MOWIE, Ethiopia.

2.12 Bulk density*:* The bulk density of charcoal or fuel briquette charcoal were determined by filling briquette charcoal powder in to known volume or marked container like volumetric flask or measuring cylinder and measuring the weight of charcoal contained in the container. Then it computed as the weight of charcoal divided by the volume of the container and calculated using Equation 3 .5.

$$Bulk\ density = \frac{Mass\ of\ charcoal\ or\ produced\ briqutee\ \text{powder}}{Volume\ of\ container\ used} \dots Eq\ 3.5$$

2.13 Calorific value: The briquette specimens were analyzed by an adiabatic oxygen bomb Calorimeter Parr 6200 and with Bomb ID 39905 and M39889 were used for powdered fuel briquette charcoal calorific value determination.

The charcoal specimens were milled with 0.5-1gram of each as pellets then placed in a capsule and combusted in the oxygen bomb. The gross calorific value produced after combustion of sample was recorded in MJ and converted into calories per gram. The calorific value of fuel briquette charcoal is closely linked to its chemical composition, especially its fixed carbon content, and it therefore varies appreciably. The calorific value is measured using Bomb Calorimeter and in this case digital adiabatic bomb calorie meter with Parr 6200 Model with Bomb ID 39905 and M39889 were used for powdered *Lantana camara* L. charcoal and fuel briquette charcoal calorific value determination.The same procedure and instrument mentioned above used for Proximate, analysis and physical test were done for charcoal produced from root, stem and branch parts. Charcoal for checking its fuel potential in replacing other charcoal produced from different input like *Eucalyptus*, *Acacia*, Bamboo and other indigenous trees.

2.14 Combustion and heat efficiency test of Fuel Briquette charcoal: Combustion test was conducted to cheek properties of the produced fuel briquette such as flame color, production of dangerous spark formation, smoke and odor. The produced briquettes water boiling capacity or heat efficiency test was conducted by using measured amount of Water(one liter) and boiling and from this, predicted the practical cooking time for a better and efficient application or usage of the produced fuel briquette.

The combustion and boiling tests, for *Lantana camara* L. briquettes, were conducted using Merchayae -Stove (The "Merchaye" an improved briquette charcoal stove has an efficiency of more than 75% and a fuel saving stove compared with traditional charcoal stoves). The stove is popular among urban dwellers and now a day such briquette charcoal and stoves have been disseminated by many micro investor / entrepreneur / and energy sake holder in urban and rural part of Ethiopia.[4]

2.15 Data analysis: Data were gathered from laboratory analysis of briquette and bio oil produced from *Lantana camara*. These results were recorded, processed and analyzed using Microsoft excels. Descriptive statistics and chart graph were used to compare means and standard deviation (SD) of the result of analysis. All the analysis assays were done in triplicate (n=3).

III. Results And Discussion

3.1 The proximate analysis of fuel briquette*:*The quality determining parameter of briquette and charcoal produced from biomasses expressed in terms of proximate analysis and physical properties. Since, these parameters such as moisture content (MC), volatile matter (VM), ash content (AC), fixed carbon content (FC), calorific value (CV), bulk density (BD) and sulphur content (SC) were verifying the quality of briquette to decide for utilization . Hence, characterization of briquette for their proximate and physical properties is very important.[9]

From (Table 1)below the moisture content of all briquettes produced from stem of were lower than the moisture content of briquette produced from wood which has moisture content of 12%.[10]

Table1: Proximate analysis of briquette

Treatment	**Proximate analysis (%) Mean ± SD**			
	MC	**VM**	**AC**	**FCC**
Root briquette	7.56±0.19	18 ± 0.33	20.56±1.96	53.89±1.84
Stem briquette	2.67±0.58	21.11±1.92	23.56±1.93	52.77±0.39
Branch briquette	4.67±0.34	21.89±0.19	23.22±3.15	50.22±3.21
Leaves briquette	5 ±0.33	21.44±1.17	36 ±1.53	37.56±0.69

Data were means ± SD; MC=Moisture content;VM =Volatile matter; AC=Ash content; FCC=Fixed carbon contents.

The moisture content of the charcoal determine the physical properties of the briquettes consequently, if the moisture content is low the briquette will have resistance to biodegradation and less vulnerable to the attack of biological agents as well as not flexible to atmospheric conditions and moreover it becomes durable.[11]If briquette charcoal containing high of moisture content will lead to the swelling and the disintegration of the briquette charcoal.[12] Normally, the fresh charcoal from an opened kiln contains a very little moisture content, which is usually less than 1% but it can absorb the moisture content from the humidity of air itself rapidly with time, a gain of moisture even without any rain wetting and even the charcoal in well burned situation can take the moisture content about 5 to 10%.[13] [14]

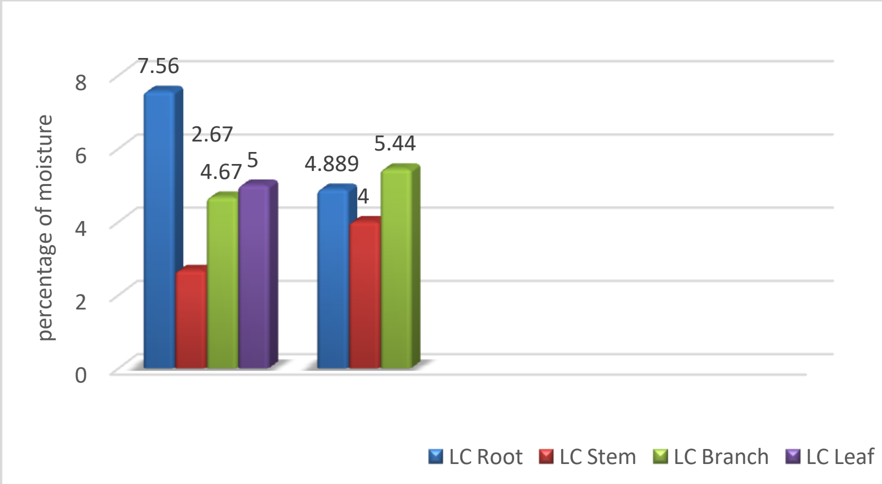

Figure 2:Moisture contents of the produced briquette and charcoal

The results from *Lantana camara L.* charcoal showed moisture contents of charcoal ranged 4% to 5.44 and its briquette moisture ranged 2.67% to 7.56%, which falls within the desirable criteria set by FAO.[13] Moisture contents of the charcoal also differed significantly between charcoal or briquette produced from different biomass species and as shown in Figure 2.(Table.2). The high moisture content gives the result of low calorific value and the lower the moisture content the higher will be it is calorific value.[15]

Table 2: Proximate analysis and physical analysis of charcoal produced from roots, stems and branches

Treatment (Briquette type)	Proximate analysis (%)Mean ± SD				Physical property Mean ± SD	
	MC	VM	AC	FC	CV(Cal/gm)	BD(g/cm)
Root	4.89 ± 0.38	14.±0.67	15.8± 0.18	65.6± 1.53	7483.99± 140.432	0.58±0.05
Stem	4.00± 0.67	13.± 1.35	15.78±0.51	66.44±0.01	7323.10± 37.24	0.44± 0.01
Branch	5.44± 0.19	16.78±0.0	12.89± 3.42	64.89±4.62	7222.66± 352.17	0.40± 0.01

Similarly, the volatile matter of all briquettes in this study(Table 1) is lower than the volatile matter of briquette produced from Coconut pith briquette and Sawdust briquette which have the matching values of 71and 60 %, respectively.[16]The higher the volatile matter implies the faster will be the ignition but with high smoke.[17]Hence the briquette produced in this study is contributing minimal indoor air pollution due to their small amount of smoke generation during combustion relatively as they compared with briquettes produced from Coconut pith and Sawdust.

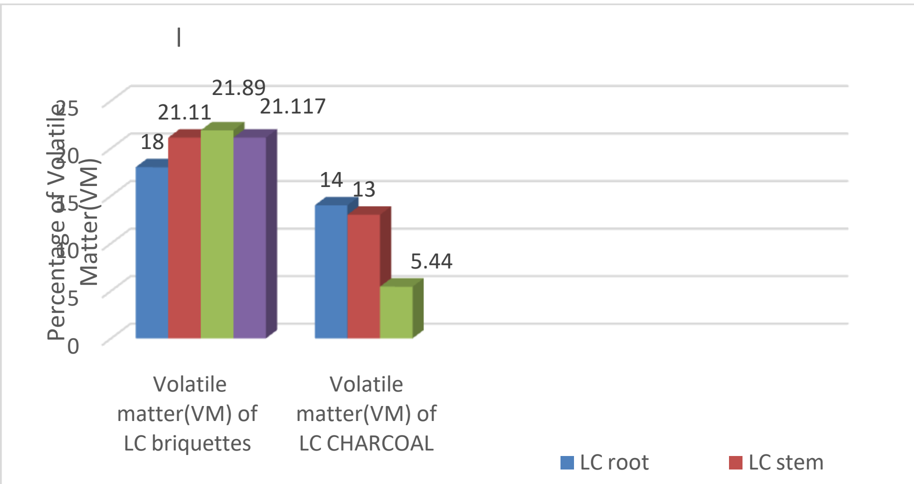

Figure 3: Volatile Matter contents of the produced briquette and charcoal

Volatile matter in charcoal can vary from a high value of 40% or more down to 5% or less than 5%.[15] Good quality charcoal should have volatile matter range from 20 to 25%.[13]As shown in Figure 3. the charcoal produce from *Lantana camara* L. in this study the highest volatile matter with 14 % and with lowest value 5.44% and its briquette ranged 18% to 21.89 %, which fall within the desirable criteria set by FAO.[13] On the other hand, FAO[15]indicate that the value of volatile matter of the charcoal produced from mixed tropical hardwood ranged from 17.1% and 23.6 and this also in line with all volatile matter result for this study (Table 1) .

The ash content of the briquettes (Figure 4) is higher than the ash content of briquette produced from elephant grass and spear grass which have the values of 4.35 and 6.09 %, respectively.[18]The higher ash content might be due to the binder type (clay soil) that were used.

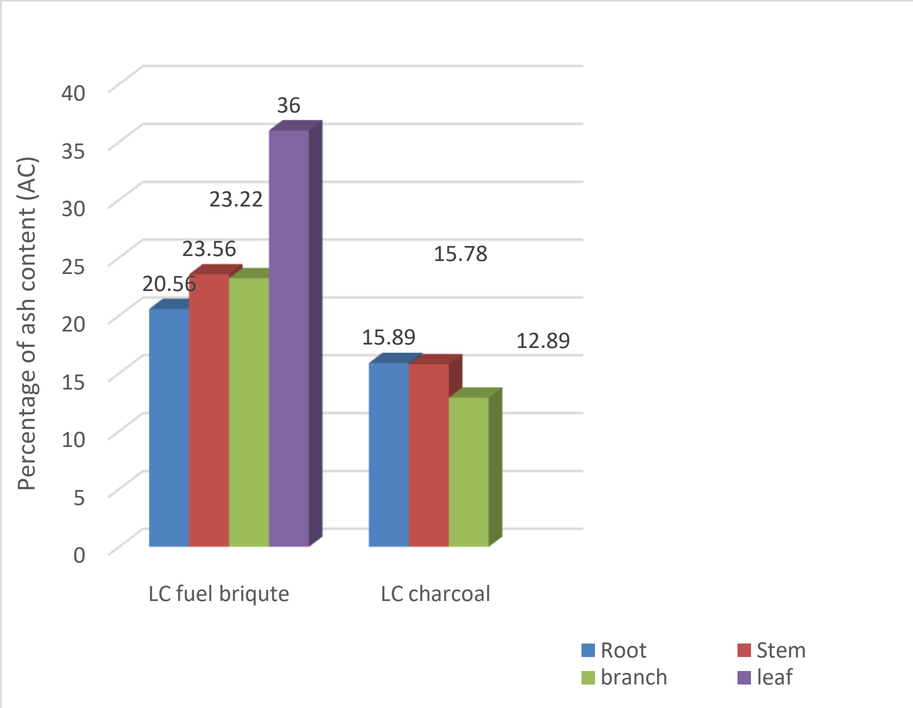

Figure 4: Ash contents of the produced briquette and charcoal

In this study Clay soil was used which is non-combustible during ignition and this is why high amount of ash content was found. The lower the ash content the better will be the briquette for utilization and the higher the ash content the higher will be the formation of dust and it affect the combustion efficiency and from the bar graph it's possible to observe leaves briquette with higher Ash value meaning low quality fuel as compared to branch, stem and root briquette.[19]Fixed carbon contents of the briquette is the solid combustible residue that remains after the briquettes were heated and the volatile matter was removed. The fixed carbon contents of briquettes in this study is greater than the fixed carbon content of briquette produced from wood which have the equivalent value of 1.6%reported by Malatji *et al.*[10]

Fixed carbon content of the charcoal and briquette produced in this study also differed significantly between charcoal and briquette produced from different part of lantana camara L. The high fixed carbon content gives the result of high calorific value.[15] It seems true where the produced fuel briquette and charcoal had higher fixed carbon content of 53.89 and 65.6and had the higher gross calorific value of 6525.54 and 7,483.99 cal/g ,respectively.

The fixed carbon of charcoal ranges from a low of approximately 64.89% to a high of around 67%.[15] Thus the charcoal contains mainly of carbon. FAO[15] recommended that the charcoal produced from tropical hardwood had fixed carbon ranged 68.6% and 69.8% (Table 2) and Fig.5.

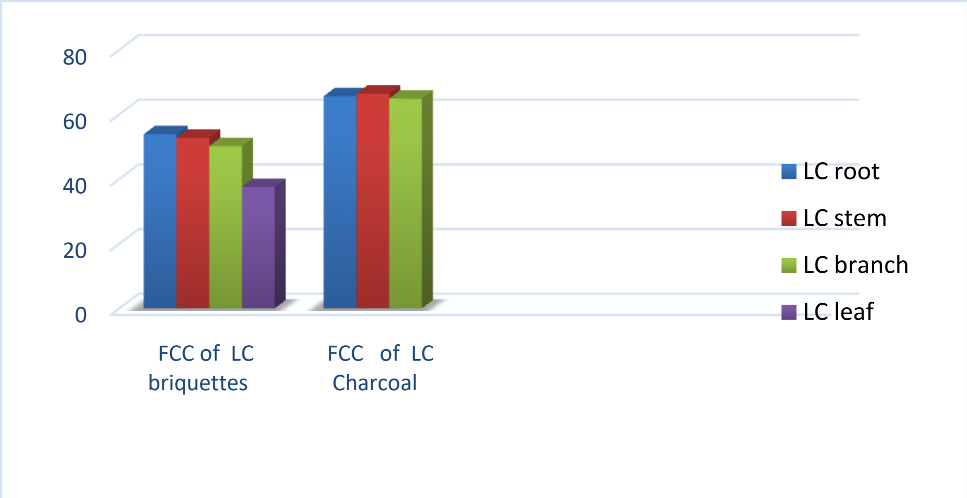

Figure 5: Fixed carbon content of the produce briquettes and charcoal

3.2 Physical property of the produced fuel briquette: The calorific value determines the energy content of a fuel and it is the property of biomass fuel that rely on the chemical composition and moisture content of the material[20] as well as it is the most important fuel property determining parameter of the fuel.[21]However, the calorific value of all fuel briquettes for this study was greater than the calorific value of briquette produced from saw dust that have the equivalent value of 4,820 cal/g reported by Akowuah *et al*.[19]

As shown in Fig. 6 bellow for calorific value of the produce briquette which increase in similar manner with that of its fixed carbon content as compare to Figure 6 and there is also similar trend increment with bulk density and calorific value (Table 2 and 3).

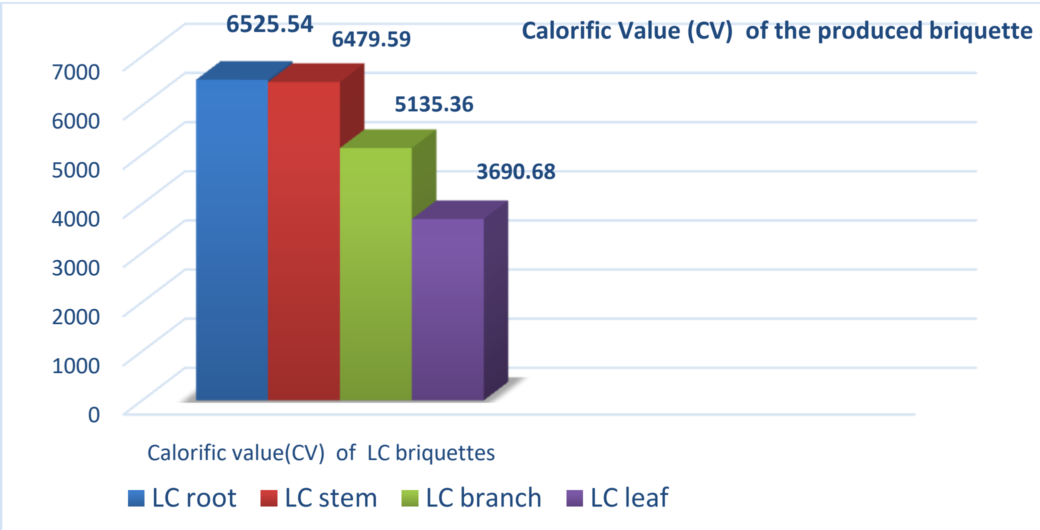

Figure 6: Calorific value (CV) of the produced LC briquette

Table 3: Physical property ofbriquettes produced from root, stem, branch and leaves

Treatment	Physical property Mean ± SD	
	CV (Cal/gm)	BD (g/cm3)
Root briquette	6525.54± 250.03	0.48 ± 0.01*
Stem briquette	6479.59±1004.51	0.44± 0.02*
Branch briquette.	5135.36 ± 150.29	0.43± 0.01*
Leave briquette	3690.68 ± 182.32	0.39± 0.01*

*

BD calculation Volume measured by using 50ml measuring cylinder; Data were means ± SD; CV=Calorific value content

If compared to the charcoal produced in this study from root, stem and branch had only 65.6%, 66.44% and 64.89%, respectively. The charcoal for domestic use is recommended that it should contain less than 80.5%

of fixed carbon, while the industrial charcoal is recommended to have 86.7% of fixed carbon.[15] On the other hand, the quality smokeless domestic wood charcoal has been specified to consist 75% of fixed carbon or more than this,[22] while the industrial wood charcoal has been specified to contain not less than 85% of fixed carbon.

The other most important property of briquettes is the bulk density. The bulk density of charcoal briquettes mainly depends on the type of briquetting technology than on the raw material itself and hence briquettes made using mechanized units like Beehive briquette machine produce briquettes with higher bulk density than manual briquetting

Density is one of the important parameters that directly affect the fuel quality of a feedstock. The species having higher density are preferred as fuel because of its high-energy content per unit volume and its slow burning property.[23] This can be realized by comparing result in (Table 3)and the two bar charting (Fig.7) and also by comparing density result in (Table 2) for the produced charcoal within its fixed carbon content and calorific value.

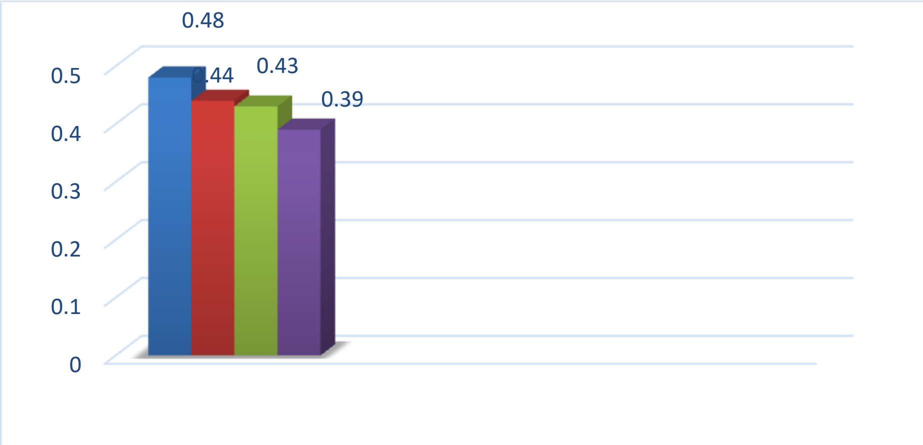

Figure7: Bulk density of the produced briquette

The value for bulk density (g/cm^3) of *Lantana camara* L. biomass were found to range from0.39± 0.01 to 0.48 ± 0.01, almost in line with the result for stem and branch which ranged from 0.497 to 0.520 g/cm^3 and all results were much higher than that of *Eupatorium*with bulk density 0.330 g/cm^3.[24]

3.3Weight-based carbonization efficiency: The carbonization efficiency can be affected with many factor like moisture content of the input sample or *Lantana camara L.* weed, number of air hole in the kiln that regulate the amount of air for the proper carbonization and cooling and personal skill.

Oneof this all factor, moisture of the sun dried sample, it’s also showed with 1a and 1band have direct effect with the quality and quantity of fuel charcoal or fuel briquette production.

The percentage of moisture on sun dry leaves sample were found 9.33 % ±0.87and with this value the carbonization efficiency of the metal kiln were found 25.72% ±2.9 (Table 4 in appendices) and this the percentage of moisture value result were within the range 15% -35% and this is in line with.[10]

Table 4: Carbonization efficiency of metal kiln on weight based for *Lantana camara*L.weed input

Description	Input/weight Kg/ Mean ± SD	Carbonized output /weight kg/ Mean ± SD	Carbonization Efficiency (%) Mean ± SD
Root part	39.07± 1.11	10.39± 0.97	26.57± 2.19
Stem part	36.34± 2.63	11.34± 0.73	26.61± 1.38
Branch	28.03± 1.81	6.32± 0.83	21.61± 1.47
Leaves part	15.48± 1.15	3.94± 0.17	25.72±2.93

Data were means ± SD

Weight based carbonization efficiency (based on charcoal yield) is a percentage rate expressing the ratio between the weight of Lantana camara L. weed root, stem, branch or leaf or leak with trunk charcoal output to the weight of the air-dry, Lantana camara L. weed root, stem, branch or leaf with trunk input. For instance, the typical yield of brick or metal kiln (15% moisture sample content) is about 30%[4] and carbonization efficiency results were presented in above table 4.

The percentage range of carbonization efficiency (based on charcoal yield) were with minimum value 21.61± 1.47 for the branch and maximum value 26.61± 1.38 for stem part of *Lantana camara* L and similar finding for carbonization efficiency of metal kiln to get high charcoal yield.[25][26] This also have impact on the quality and quantity charcoal or briquette produced from biomasses.[9]

3.4Standardization of calorie meter: Standardization of the calorie meter used in this study for Gross heat value determination of the produced charcoal and briquette charcoal were done by using one gram pellet of graded benzoic acid and its run for ten Standardization and the corrected temperature raise determined from the observed data, the equivalent energy value(EE value),sample ID, weight of sample or benzoic acid, initial and final temperatures, sulphur content of sample, spike weight and the gross heat value with the required unit MJ/Kg or Cal/g Were obtained as an output.

3.5. Combustion and heat efficiency test of fuel briquette: Production of high quality charcoal briquettes demands that a suitable binder is used and sufficient pressure. Such that the physical characteristics are comparable with or even are better than wood charcoal. In mechanized units starch is the preferred binder as it has very good binding property and also when combusted produce no smell or smoke but using clay as binder will yield much more clean and low cost fuel briquette than starch or molasses one.

The result for combustion test, flame and heat efficiency test of the produced Lantana camara fuel briquette confirmed that there is no smoke (smoke free) except at a startup. No spark formation,, no soot production, no smell or odor and strong heat which can boil half a liter water in less than 10 minute ; one liter water in less than 15 minute and two liter water with less than 25 minute, respectively. As shown in the Table 5 the time taken to boil a given amount of water vary with the type of briquette made of and as its highly related with the calorific value of the briquette and its density and also time taken to turn to ash shows the durability of the produced briquette.

Table 5: Comparative Time taken to boil Water; conducted using Lakech -stove

Description Briquette type	Average time taken to boil(0.5L) Water in Minutes)	Average time taken to boil one litter Water in Minutes	Average time taken to boil two litters(2L) Water in Minutes	Average time taken to turn to Ash (Hour & Minutes)	Average Calorific Value for triplicate fuel briquette test (Cal/gm)
Root briquette	3±0.97	9± 1.5	15± 2.05	4hr and 23 Min ± 0.08	6525.54± 250.03
Stem briquette	4± 1.05	10 ± 2.75	17± 0.95	4hr and17 min ± 0.34	6479.59±1004.51
Branch briquette	6± 0.75	13± 2.08	20± 1.25	3hr and 31min± 0.16	5135.36 ± 150.29
Leaves with trunk briquette	7± 0.85	15± 1.75	23± 2	2.hrand 58min ± 0.37	3690.68 ± 182.0

Data were means ± SD

This result shows that the heat strength (boiling capacity) vary with the type of briquette made off root ,stem ,branch or leaves and this also highly related with the bulk density; which is directly related with the calorific value of the briquette. Time taken to turn to ash shows the durability of the produced *Lantana camara* L fuel briquette that it can be used for cooking, which took too longtime cooking, especially in Ethiopian traditional food like 'Doro wot' that need almost more than 3hr such fuel briquette can be used.Since once the briquette fired it is not possible to quit the fire for any moment since its used long period time cooking for about 3 to 4 hr. and these proper cooking time must be known to managing in proper energy consumption. Therefore; durability fuel briquette is its one advantage than other form of fuel charcoal furthermore predicting the practical cooking time is the important aspect in energy efficient way utilization and for a better way utilization and efficient application or usage of the produced *Lantana camara* L.fuel briquette and from practical cooking study done. Up on practical cooking laboratory experiment done, once the fuel briquette fired it is not possible to quit the fire for moment, there for, knowing the proper cooking time enable to minimize energy loss and even save money and time.

III. Conclusions

This study showed that Charcoal and briquette produced from *Lantana camara* .L. (root, stem, branches and leaf) were found as quality sources of energy. as, all charcoal and briquettes have higher caloric value 7483.99±140.432 , 6525.54± 250.03, high fixed carbon content 66.44±0.01 and 53.89±1.84, low volatile matter13.± 1.35 and 18±0.33,respectively, low moisture4.00± 0.67 and 2.67±0.58,and low ash contents12.89± 3.42 and 20.56±1.96. Similarly, utilization of *Lantana camara*. L as source of energy in terms of briquette production deliver clean energy that reduce indoor air pollution and respirator infectious disease that occurred due to the release of smoke during cooking. Besides, can solve the rural and urban household energy by supplying a clean renewable energy and reduce forest degradation.

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