

ORIGINAL ARTICLE

**PREPARATION OF CHARCOAL USING
AGRICULTURAL WASTES**

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Abstract

Background: Wood charcoal has been the primary fuel for cooking in Ethiopia because it is cheap and easily available. However, using wood charcoal has consequences on health and pollution because of smoking. This study aims at providing a biomass as an alternative to wood charcoal using agricultural wastes (dry leaves, coffee husk, sugarcane trash, grass, etc) converted into charcoal briquettes to provide much needed source of cheap fuel that is cleaner in burning.

Methods: Simple extruder machine is used as die to make the briquette charcoal. Moreover, an effective carbonizer to change the agricultural waste into charcoal and an effective stove to burn and use the charcoal for cooking is used.

Results: The manual extruder machine has a capacity of pressing 30kg/hr and the carbonizer converts 15kg of input agricultural wastes into 5kg of burned charcoal with in 25 minutes. The stove is effective so that three meals are cooked at a time using 100g briquette charcoal.

Conclusion: As compared to wood charcoal the charcoal briquette produced from agricultural wastes are economical, environmentally friendly, healthy (no smoke at all) and reduce impact of deforestation.

Key words: Pollution, deforestation, extruder, carbonizer, wood charcoal, briquette charcoal, agricultural wastes, pyrolysis

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INTRODUCTION

The large scale use of commercial energy has led to better quality of life; however it has also created many problems. Perhaps the most serious of these are the harmful effect on the environment and climate changes which both have consequences on human health and pollution. Also it is now clear that the fossil fuel era of non-renewable resources is gradually coming to an end, oil will be first to be depleted, followed by natural gas and coal. Energy problem is very serious and the main objective is now to find solution to match demand and supply of energy sources. Therefore the need for conserving energy and developing alternative energy is a must.

Biomass is plentifully available in the rural regions. It is already being used by the rural people as a major source of energy, mainly in cooking food, which constitutes almost over 90% of the total energy consumption (1). Assuming that the population of Ethiopia are about 82(2) million in Ethiopia, 90% of the population in Ethiopia lives in rural area (3), and assuming that each family consists of five persons and uses annually about 3 tones of

biomass as fuel, one comes to the figure of about 44.28 million tones of biomass utilized annually only for domestic cooking in rural areas only. The urban populations of Ethiopia (10%) are also uses biomass and assuming that 78% of the urban population uses this biomass as a fuel, one comes to the figure of 3.84 million tones of biomass as fuel. There is also a third dimension to fuel use, and that is the pollution arising due to burning of biomass. As cooking is done within the confines of a house, the pollution caused by cooking fires is generally not taken very seriously. But according to statistics published by the World Health Organization, annually about 500,000 women and children die prematurely in India due to air pollution caused by cooking fires in rural households (4). Considering the fact that almost 90% of our population is in rural areas, giving the rural women a cleanly burning biofuel is a major task.

One way of tackling the pollution and health problems of the consumers of wood charcoal is producing briquette charcoal using agricultural wastes by making simple extruder and effective carbonizer.

Agricultural waste is an ideal source of charcoal. When one harvests any crop, one generally harvests only grain, fruits, coffee, pods, and tubers. This constitutes only about 30 to 40% of the total biomass. This means that about 60 to 70 % of the total agricultural biomass is the waste biomass produced annually in Ethiopia. A small part of it is used as fodder for cattle, but the rest is just wasted. The produced char is healthy, environmental-friendly and economical. The stove is also effective enough, which can cook the meal for five persons, using just 100 g of our char briquettes.

SIGNIFICANCE OF THE RESEARCH

Some of the benefits of using agricultural wastes, such as sugarcane trash, grass, and saw dust and so on, as an alternative cooking fuel are described as follows: Unlike wood, briquette charcoal is a smokeless fuel. The smoke produced by wood fires in an indoor cooking environment can lead to multiple respiratory illnesses (5,6,7). Instead of burning agricultural wastes in the fields, using the wastes as a fuel source slows the advance of deforestation by eliminating the need to cut down trees for fuel wood.

Charcoal is viewed as an advanced fuel in because of its clean-burning nature and the fact that it can be stored for long periods of time without degradation. Therefore, a micro- enterprise can be formed around the production of charcoal derived from agricultural waste. By turning something that was previously little used into a means by which to produce income, the wealth of individual entrepreneurs and the country in general is increased. Since it is a good technology, India also used charcoal produced from sugar cane trash (8).

The usage of energy from biomass, most commonly obtained through fire. The energy from agricultural waste biomass (crops, grass, residues, etc) can be harnessed through the process of combustion, which allows the material to be carbonized. Carbonization takes place when organic matter is raised to high temperatures in the absence of oxygen.

The following are main stages that exist in the biomass combustion process: The moisture embedded in the solid biomass must be removed before carbonization can take place. This can be achieved with drying prior to burning. If water remains, then the energy required to remove it is obtained by the burning of some of the biomass material inside the carbonizer

itself. This decreases the amount of material that can be converted into useful charcoal. The biomass then undergoes pyrolysis, which is the chemical decomposition of organic matter in the absence of oxygen. Pyrolysis leads to carbonization of the materials. A high temperature is necessary for pyrolysis, but because agro-waste is both your fuel and the material that is being carbonized, a balance must be reached between the two objectives (creating heat and creating charcoal fines). Hence, air flow must be carefully restricted at the optimum time (when the proper temperature is reached, ~ 270 °C) (9) so that the majority of agro-waste remains unburned, ready to be converted into charcoal. It takes approximately 45min-1hr to be turned to charcoal. Generally there is little study done here in Ethiopia on conversion of agro-wastes into charcoal and effect of wood charcoal on human health and pollution impact. This study aims at providing a biomass as an alternative to wood charcoal using agricultural wastes converted into charcoal briquettes to provide much needed source of cheap fuel that is cleaner in burning.

OBJECTIVES OF THE RESEARCH

This study aims at providing a biomass as an alternative to wood charcoal using agricultural wastes converted into charcoal briquettes to provide much needed source of cheap fuel that is cleaner in burning. It is also intended to create awareness of agricultural wastes briquettes technology and to make use of the technology by small scale.

MATERIALS AND METHODS

Design consideration of the carbonizer

Charcoal is a carbon substance that remains when organic matter is heated to a high temperature in a low-oxygen environment. It is designed and manufactured by the author that the carbonizer provides a means of creating this low-oxygen environment. The carbonizer is made of cylindrical oil drum with two conical shapes made of sheet metals that are welded at the bottom in such cases the upper part has 24 holes for removal of smokes and the lower one with no holes so the path of the smoke is upwards using the inserted cylindrical pipe at the middle of the carbonizer which is welded with the two conical shapes. Then it is covered at the top after inserting the dried agricultural wastes. The biomass is

tightly packed into the inner drum and fired biomass). In this method 30 % of for 45 minutes to 1hr (depending upon the carbonized char can be obtained. Fig (1).



Fig.1. Carbonizer, Extruder and agro-wastes (grass, sugarcane trash, coffee husk, dry leaves, etc.)

Preparation of the binder

The binder material is used for strengthening the briquettes and for every 30 kg of total weight of carbonized charcoal powder; prepare a binder mixture by adding 1.5 to 2 kg of a special mud (Merere cheka in Amharic) and a little

water based on the weight of the raw materials.

Mixing

Mix such that every particle of carbonized charcoal material is coated with binder. It

will enhance charcoal adhesion and produce identical briquettes. Fig (2).



Fig.2. Carbonized charcoal mixed with the binder

Extruder machine

The charcoal extruder is designed and manufactured to make a small size of 20mm diameter and produce six briquette charcoal at a time. The case and parts of the extruder are made from sheet metals and angle iron. To support the person while working with the extruder fly wheel made of concrete and sheet metal steel is added at free end of the extruder. The extruder is a screw type press, made of a sheet metal which is welded on a

solid steel shaft, designed to produce high density briquette. After feeding the mixed char into the screw type extruder one can

rotate the handle which is attached to the fly wheel. In this case, the raw material is mixed in a well manner and at the same time it is transported to the end of the extruder. Since the end of the extruder is a type of circular die with six holes, the materials can be pressed against those holes to produce a compact and uniform size briquettes. The mixing time and rpm of the extruder depends on the person who works on the machine. Fig (3).

Briquetting

Briquetting is one of several compaction technologies to form a product of higher bulk density, lower moisture content, and uniform size shape, and material properties. The charcoal mixture is made into briquettes using extruder machine. The extruder machine is constructed as part of this research work.



Fig.3. Extruder Machine

Drying and packing

The briquettes were collected in a tray dried under the sunlight for about 1-2 days, packed and sealed in plastic bags. The moisture must be removed by sun from the briquette otherwise it is difficult for burning and reduces efficiency of burning. Fig (4).

Cooker

The cooker, which is adopted from India and modified with clay and stainless steel

for our country, in which char briquettes are used as fuel. The cooking device has a body which is made of clay with a built-in charcoal brazier (container for fire). The brazier takes just about 90-100 gm of the briquettes. The vessel (made of stainless steel) takes three pots, so that three meals can be cooked simultaneously. The housewife starts the fire, places the cooking vessel on the brazier. The food is ready in about 45 min-1 hr, by which time the char briquettes have burnt themselves out and the fire has extinguished itself. Fig (5).



Fig.4. Drying and packaging



Fig.5. Charcoal brazier

RESULTS

The carbonizer was designed in order to produce 5kg briquette charcoal from 15kg of inputs (agricultural wastes, grass, sugarcane trash and dry leaves is used in this experiment) and burns for about 25minutes. The manual extruder has a capacity of pressing 30kg/hr. The carbon content of briquette charcoal could be varied from 80% to as high as 82% or above by adjusting the carbonization condition, which depends on the amount and dryness of the input material to the Carbonizer.

Since it loses its smoke inside the carbonizer during carbonization the briquette charcoal doesn't have smoke and burns cleanly due to very low sulfur content. The heating value of the briquette charcoal varies from 7,150 to 7,300 kcal with a density of 970kg/m³. Since it has a good heating value and higher density while briquetting it burns for about 2-3 hrs. The stove can cook three meals at a time using 100g briquette charcoal. (Table 1).

Table 1: Characteristics of the briquette charcoal, capacity of extruder, carbonizer and cooker

Characteristics	Value
Capacity of the carbonizer	
Mass of input agricultural wastes (Kg)	15
Mass of output charcoal produced (Kg)	5
Capacity of the Extruder machine	
Mass of Input mixed char (Kg)	30
Time to make 30Kg briquette charcoal (hr)	1
Characteristics of briquettes	
Moisture (%)	7.2-7.9
Volatile Matter (%)	12.5-14
Fixed Carbon (%)	80-82
Ash (%)	3.5-7.5
Sulfur (%)	0.0
Heating Value [kcal/kg]	7,150-7,300
Density [kg/m ³]	975

Table 2. Comparison of wood charcoal and briquette charcoal making process

Briquette charcoal	Wood charcoal
No need of digging a ground to prepare shallow pit of charring	Digging
Mobile (Its mobility allows working at a spot of harvesting, farmstead and anywhere)	Not mobile
It is not fire hazardous	Sometimes it is fire hazardous
It is safe in the view of health factor	It is not safe

Table 3: Comparison of briquette charcoal and wood charcoal

Briquette charcoal	Wood charcoal
Smokeless	Smoke
It exhibits faster heat release and greater heat value	Less heat release and smaller heat value
Low production cost when compared to purchase price of wood charcoal at local market	High production cost
Reduce impact of deforestation	Enhance deforestation impact
It can burn for long time (2-3 hr)	It can burn for short time (1-2)

DISCUSSION

The charcoal produced from agricultural wastes have more benefits from economical, health and environmental point of view.

Implications on health

Unlike wood charcoal, this briquette charcoal is a smokeless fuel, due to the fact that during carbonization its smoke disappears. The smoke produced by wood charcoal fires in an indoor cooking environment can lead to multiple respiratory illnesses [6,7,8]. It is also one means of getting rid of solid wastes which is hazardous for health. Normally some agro wastes can be used for various purposes, like as a fodder, compost or other puposes. But it is difficult to say that there is no agro wastes in Ethiopia which can be left and used for briquetting process. It is possible to use almost all wastes for preparation of charcoal including waste banana leaf. The output of the charcoal can vary from one waste to the other. One the other hand, some solid agricultural wastes resists biodegradation and therefore can not be used as a direct fertilizer. It can't be used as fodder, as it is highly indigestible. It is bulky and low density biomass, so it can not be easily removed from the field,

and also can not be used as fuel. Chopped agricultural wastes can not be used as a fuel directly, because it produces a lot of smoke. Also it requires a very high expenditure of energy to compress. On the other hand, it is well known that organic matter can be charred. The char briquettes are more efficient in burning with no smoke at all.

Implications on the environment

Instead of burning agricultural wastes in the fields, using the wastes as a fuel source slows the advance of deforestation by eliminating the need to cut down trees for fuel wood. The other advantage is that since there is no smoke while burning, smoke pollution is reduced for the environment.

Implications on the economy

Briquette charcoal is viewed as an advanced fuel because of its clean burning nature and the fact it can be stored for long periods of time without degradation. Therefore, a micro enterprise can be formed. Any entrepreneur can create briquette from agricultural wastes and sell them in a local market for personal income. In this way, more money stays within the

community rather than being exported for foreign fuels. By turning something that was previously unused into a means by which to produce income, the wealth of individual entrepreneurs and the country in general is increased.

Economic feasibility

The capital cost of the project is around 9,000 thousand Ethiopian Birr, this is to mean it is not difficult to start up with in a short period of time. In addition to that it is also not difficult to scale up the project in such a manner to spread the technology to every society.

CONCLUSION AND RECOMMENDATIONS

To date agricultural wastes (grass, dry leaves, sugarcane trash, etc) which are produced in huge quantities had been put to little use. This research involves conversion of agricultural wastes to char, by an environment friendly, continuous batch process, briquetting of the char into a solid fuel form and use of an efficient, clean and user-friendly stove ideally suited for the briquettes as fuel. The techno-economic feasibility of each link has been tested. The manufacturing technologies involved in each step are easy to implement in rural

areas, and therefore it is also provides new income generating opportunities in rural areas. The technology has a great potential for converting waste biomass into a superior fuel for household use, in an affordable, efficient and environment-friendly manner. The above mentioned advantages is greater as compared to the open fire technique which is used for various purposes, like drying of seeds, removal of insects from the hut, etc in rural parts of Ethiopia. The University should work hard towards disseminating this technology for society. Much more efforts must be made to establish the use these biomass resources and national research institutions should work hard in promoting and improving this briquetting technology.

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REFERENCES

1. Mekonnen, A. 1999. "Rural Household Biomass Fuel Production and Consumption in Ethiopia: A Case Study". *Journal of Forest economics* 1(1): 69-79.
2. Claudia Sori, Ethiopia demographics profile, Source: CIA World Factbook Retrieved from http://www.indexmundi.com/ethiopia/demographics_profile.html, December 18, 2008.
3. Gebremedhin <http://www.bioenergy-lamnet.org/publications/source/merge/PPT-WG4-3-LAMNET-WS> Morelia, 3rd Issue (June 2003).
4. A.D.Karve, "Biomass as energy source (appropriate rural technology)", India, August 27, 2005
5. Warwick, Hugh and Alison Doig. "Smoke-the Killer in the kitchen". ITD publishing, publishing, Lonson, 2004.
6. Bouros D. and Samiou Maria F., Short-term effects of wood smoke exposure on the respiratory system among charcoal production workers, ISSN 0012-3692 CODEN CHETBF, 2001, vol. 119, n^o 4, pp. 1260-1265 (24 ref.).
7. Da. Costa JL, Navarro A, Neves JB, Martin M., Household wood and charcoal smoke increases risk of otitis media in childhood in Maputo, 2004 Jun; 33(3): 573-8.
8. A. D. Karve, "Briquette Charcoal from Sugarcane Trash", Pune, India 2006.
9. "Making Charcoal: The Retort Method". Volunteers in Technical Assistance, 1815 North Lynn St, Suite 200, Box 12438, Arlington, VA 22209. 1980. ISBN 0-86619-07

