Indian Journal of Ecology (2023) 50(3): 796-798
DOI: https://doi.org/10.55362/IJE/2023/3971

Manuscript Number: 3971
NAAS Rating: 5.79

Fuel Bark Quality Evaluation of Commercial Tropical Tree Species: An Approach to Waste Utilization

K.R. Rathod, S.K. Sinha*, R.P. Gunaga and M.S. Sankanur
College of Forestry, Navsari Agricultural University, Navsari-396 450, India
**E-mail: sksinha@nau.in*

Abstract: The removal of bark from logs is creating major residue problem in wood-based industries. Bark contains high amount of lignin, extractives, ash, moisture and low amount of polysaccharides than wood. The most desirable properties for an optimal fuel quality of a lignocellulosic material are its high calorific value, high density, low ash and moisture content. Keeping in view of these points, an investigation was carried out to evaluate the fuel value index (FVI) of bark from ten commercial tropical tree species for their effective utilization. Total ten different tree species planted in NAU campus were selected for evaluation of FVI of bark based on their calorific value, basic density, moisture and ash content. The highest FVI of bark was recorded in *Casuarina equisetifolia* (156.80) and lowest in *Tectona grandis* (18.53). The most promising tree species for fuel bark quality were in the order of *Casuarina equisetifolia*, *Adina cordifolia* and *Acacia nilotica*. However, *Acacia auriculiformis* and *Mangifera indica* also recorded topper rank than other five species. Therefore, the waste bark of these tree species could be further utilized into the value-added product like briquettes.

Keywords: Bark, fuel value index, Ash, Basic density, Moisture content, Calorific value

Fuelwood accounts approximately 90 per cent of the total wood production in India. It is still the main source of energy in rural India which indicates the scarcity of substitutes and creates a lot of pressure on the forest resources in the country (Shrivastava and Saxena 2017). Bark is one of the few renewable energy resources after wood and has negligible sulphur content when compared to coal Corder (1976). Moreover, due to increase in the price of fossil fuels and its less availability, bark could become more important energy source in future. Currently lump of bark after removal from wood is creating major residue problem in many wood conversion industries such as sawmills, pulp mills and composite wood industries. The actual production of bark residue by these wood industries depends upon the use of different tree species. Bark occupies about 10 to 22 per cent of total log volume on a dry weight basis depending upon the size and type of tree species used in wood industries (Anonymous 2019). This bark residue creates a serious waste disposal problem unless it can be converted into value added product of high energy solid fuel like briquettes.

The proximate chemical composition of bark is much more extensive than wood. Tree bark contains high amount of lignin, extractives, ash and moisture and less amount of polysaccharides in comparison to wood (Harkin and Rowe 1971). The high amount of lignin and extractives increases the calorific value of wood whereas high amount of moisture and ash content decreases the calorific value (Lunguleasa and Spirchez 2017). Much of the data available in the literatures are related to fuelwood quality of stem and branches. However, limited information is available on fuel quality of bark. Keeping in view of these points, the present paper aims to study the fuel value index of bark from ten commercial tropical tree species for their effective utilization.

MATERIAL AND METHODS

Study site: Plantations established in Navsari Agricultural University (NAU), Navsari, Gujarat were selected for the present study. The area is situated at coastal region of South Gujarat at 20°95' N latitude, 75°90' E longitude and at an altitude of 12 m above the mean sea level. The climate of Navsari is tropical warm with fairly hot summer, moderately cold winter and warm humid monsoon. Monsoon starts from second week of June and ends in September and majority of precipitation occurs in the month of July and August, receiving from south-west monsoon. Average annual rainfall of this region is about 1600 mm. Hottest months are April and May; however, the coldest months are from December to February.

Sampling: Bark of size 10 cm x 5 cm from 10 commercial tropical tree species such as *Tectona grandis* L.f. (Teak), *Gmelina arborea* Roxb. (Gamhar), *Casuarina equisetifolia* L. (Saru), *Eucalyptus* sp. (Nilgiri), *Mangifera indica* L. (Mango), *Albizia procera* (Roxb.) Benth. (Killai), *Acacia nilotica* (L.) Willd. ex Delile (Babul), *Acacia auriculiformis* A. Cunn. ex Benth. (Bengali Babul), *Adina cordifolia* (Roxb.) Brandis (Haldu) and *Leucaena leucocephala* (Lam.) de Wit (Subabul) were sampled at the breast height. Bark from three trees of each species were sampled from 15-30 cm diameter class. Fresh weight of collected bark samples was immediately recorded and green volume of sample was measured by water displacement method. Afterwards, samples were dried in a forced-air convection oven at 100 ± 2°C till constant weight achieved. The dried samples were ground to pass through 4.7 mm mesh, pelleted and burnt in an oxygen bomb calorimeter to determine the calorific value. Moisture content was determined by oven-dry method and ash content by burning the powdered samples in a muffle furnace at 600°C for 4 hours. Basic density was calculated as oven-dry weight divided by green volume of the sample. Fuel value index (FVI) was calculated following Puri et al (1994),

$$\text{Fuel Value Index (FV)} = \frac{\text{Calorific value (MJ/kg)} \times \text{Basic density (g/cc)}}{\text{Moisture content (g/g)} \times \text{Ash content (g/g)}}$$

RESULTS AND DISCUSSION

The moisture content (58.3 to 298.0%), basic density (0.277 to 0.600 g/cc), ash content (5.3 to 13.0%) and FVI (18.53 to 156.80) of bark varied significantly except calorific value (14.97 to 17.66 MJ/kg) which did not show a statistically significant difference (Table 1). High moisture content (> 150%) and low basic density (< 350 g/cc) were in the bark of *Albizia procera*, *Gmelina arborea*, *Tectona grandis* and *Eucalyptus* spp. The higher (> 10%) ash content was recorded in the bark of *Tectona grandis*, *Eucalyptus* spp. and *Acacia nilotica* than other studied species. However, high calorific value (>16 MJ/kg) was in *Albizia procera*, *Adina cordifolia*, *Gmelina arborea*, *Acacia nilotica, Acacia auriculiformis* and *Mangifera indica*. Puri et al (1994) recorded similar trend of variation for calorific value of bark in *Acacia nilotica* (19.47 MJ/kg)*, Acacia auriculiformis* (19.40 MJ/kg) and *Casuarina equisetifolia* (19.73 MJ/kg) which were higher than the value reported in the present study (Table 1).

For evaluating an ideal fuel value of lignocellulosic material, high calorific value, high density, low ash content and low moisture content are the most desirable characteristics (Bhatt and Todaria 1990). FVI of ten species showed highly negative relationship with moisture content and positive relationship with basic density (Fig. 1). Out of ten species evaluated, the bark of *Casuarina equisetifolia*, *Acacia nilotica, Adina cordifolia*, *Acacia auriculiformis* and *Mangifera indica* were found to have higher fuel value (FVI >75) than other species and it may mainly be due to high basic density and low moisture content. Since, the bark of *Albizia procera* contained the highest calorific value (17.66 MJ/kg) but due to its very high moisture content (298.0%), low basic density (0.277 g/cc) and average ash content (8.5%), was comparatively less suitable for fuel value (low FVI) as compared to *Casuarina equisetifolia*, *Acacia nilotica* and *Adina cordifolia*. Deka et al (2014) also reported highest calorific value in *Albizia procera* (20.64 MJ/kg) but also very high FVI (630.08) which could be due to lower moisture content and low ash content of their samples. Similarly, bark of *Tectona grandis* and *Eucalyptus* spp*.* also had high moisture content, low basic density and high ash content and they were thus less acceptable as fuel due to very low FVI (Table 1). Similar results are also reported for FVI of bark in *T. grandis* by Prasaningtyas and Sulistyo (2014). *Gmelina arborea*, although having high calorific value (17.23 MJ/kg) and low ash content (5.5%), had high moisture content (217.8%) and low basic density (0.327 g/cc) and therefore, was less suitable for fuel purpose. However, *Leucaena leucocephala* had moderately high basic density (0.427 g/cc) and average ash content but because of low calorific value (15.94 MJ/kg) and moderately high moisture content (154.6%), hence, was less suitable for fuel. Shanavas and Mohan Kumar (2003) also reported similar calorific value (15.57 MJ/kg) in the bark of *Leucaena leucocephala* and

Table 1. Fuel value characteristics of bark often tree species (Mean±SD)

Tree species	Moisture (%)	Basic density (g/cc)	Ash (%)	Calorific value (MJ/kg)	FVI
T. grandis	200.7±14.79	0.310±0.04	13.0±1.73	15.00±0.49	18.53±6.46
G. arborea	217.8±49.48	0.327±0.06	5.5±0.53	17.23±0.67	51.11±24.67
C.equisetifolia	88.3±11.61	0.600±0.06	7.0±0.01	15.79±0.27	156.80±36.27
Eucalyptus spp.	197.2±16.35	0.300±0.05	11.3±0.01	14.97±0.96	19.74±0.64
M. indica	117.1±11.68	0.447±0.04	10.6±4.75	16.22±1.81	77.74±61.62
A. procera	298.0±100.87	0.277±0.09	8.5±0.55	17.66±2.32	22.18±14.56
A. nilotica	58.3±11.29	0.580±0.03	11.3±2.21	16.94±0.72	156.21±36.67
A. auriculiformis	124.6±15.81	0.440±0.01	7.2±0.12	16.69±2.34	81.54±2.42
A. cordifolia	151.4±30.40	0.417±0.04	5.3±1.48	17.55±0.96	96.71±27.83
L. leucocephala	154.6±10.35	0.427±0.01	8.7±0.58	15.94±0.92	50.98±5.37
CD (p=0.05)	65.96	0.082	3.14	NS	48.90

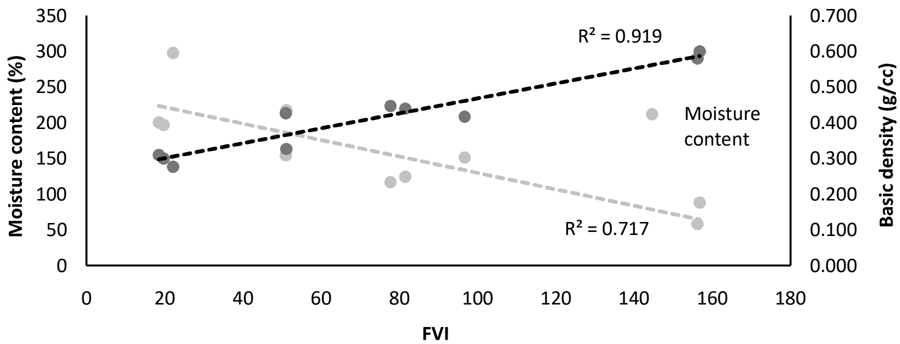

Fig. 1. Relationship between FVI with moisture content and basic density of bark of ten tree species

Table 2. Fuel value ranking of bark of ten commercial tropical tree species using calorific value, density, ash, moisture and fuel value index (FVI) (Mean±SD)

Tree species	Moisture (%)	Basic density (g/cc)	Ash (%)	Calorific value (MJ/kg)	FVI	Total	Rank
T. grandis	8	8	10	9	10	45	10
G. arborea	9	7	2	3	6	27	6
C. equisetifolia	2	1	3	8	1	15	1
Eucalyptus spp.	7	9	8	10	9	43	9
M. indica	3	3	7	6	5	24	5
A. procera	10	10	5	1	8	34	8
A. nilotica	1	2	9	4	2	18	3
A. auriculiformis	4	4	4	5	4	21	4
A. cordifolia	5	6	1	2	3	17	2
L. leucocephala	6	5	6	7	7	31	7

slightly higher calorific value (17.52 MJ/kg) in *Eucalyptus tereticornis*. Therefore, low moisture content, high basic density, moderately high calorific value and average ash content of bark played important role in determining the high fuel value.

CONCLUSION

The maximum fuel bark quality was evaluated in *Casuarina equisetifolia* followed by *Adina cordifolia* and *Acacia nilotica*. However, *Acacia auriculiformis* and *Mangifera indica* also ranked in the higher range than other five species. Therefore, the waste bark of these tree species could be further utilized into the value-added products like briquettes.

ACKNOWLEDGMENT

Authors are grateful to NAHEP- CAAST sub-project on Secondary Agriculture funded by ICAR, New Delhi and World Bank for financial support to undertake this research work.

Received 03 February, 2023; Accepted 15 May, 2023

REFERENCES

Anonymous 2019. *The potential use of wood residues for energy generation.* http://www.fao.org/3/t0269e/t0269e08.htm (Assessed on 13 December 2019).

Deka D, Sedai P and Chutia RS 2014. Investigating woods and barks of some indigenous tree species in north-east India for fuel value analysis. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* **36**(17): 1913-1920.

Lunguleasa A and Spirchez C 2017. Characteristics of waste bark combustion. *Environmental Engineering and Management Journal* **16**(3): 685-694.

Prasaningtyas A and Sulistyo J 2014. Study of provenance and site variability on calorific value and other fuel properties of Teak stem. *Wood Research Journal* **5**(1): 23-28.

Puri S, Singh S and Bhushan B 1994. Fuelwood value index in components of ten tree species of arid region in India. *Industrial Crops and Products* **3**: 69-74.

Shanavas A and Mohan Kumar B 2003. Fuel wood characteristics of tree species in homegardens of Kerala, India. *Agroforestry Systems* **58**: 11-24.

Shrivastava S and Saxena AK 2017. *Wood is good: But is India doing enough to meet its present and future needs*. A status report by Centre for Science and Environment 45p.