The Pharma Innovation Journal 2023; SP-12(12): 1673-1678

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(12): 1673-1678

www.thepharmajournal.com
Received: 03-10-2023
Accepted: 08-11-2023

Saravanapriya G
Research Engineer & Head, ICAR, AICRP on EAAI, Sri Parasakthi College for Women, Courtallam, Tenkasi, Tamil Nadu, India

Shreelavaniya R
Research Assistant, ICAR, AICRP on EAAI, Sri Parasakthi College for Women, Courtallam, Tenkasi, Tamil Nadu, India

Corresponding Author:
Saravanapriya G
Research Engineer & Head, ICAR, AICRP on EAAI, Sri Parasakthi College for Women, Courtallam, Tenkasi, Tamil Nadu, India

Characterization of *Prosopis juliflora* and its products as a potential feedstock for energy generation

Saravanapriya G and Shreelavaniya R

Abstract
Prosopis juliflora (Seema Karuvelam in Tamil) is one of the ecologically important tree species, which is the native of arid and semi-arid zones of the world. The *Prosopis juliflora* is mainly used for fuel purpose because of its hardness, high calorific value, stable burning properties, easy propagation, non-perusable by livestock, adaptability in all kind of soils with production of huge biomass and resistant to droughts. It is also mentioned that the *Prosopis juliflora* is an introduced or established weeds and it rapidly spread everywhere in the country. Hence, useful utilization of this species as an alternative fuel for energy generation is crucial to be examined. This research was conducted to study the characteristics of *Prosopis juliflora* wood and its products such as *Prosopis juliflora* briquette and *Prosopis juliflora* biochar for energy generation. Proximate analysis, ultimate analysis and calorific values were analysed to determine its fuel properties. FTIR analysis was carried out to study the qualitative and quantitative components of biomass. Briquettes and biochar are having low ash content and increase in fixed carbon content was observed in biochar. The moisture content of *Prosopis juliflora* briquette and biochar was found to be 2.28% and 1.74% respectively, which is very less than raw *Prosopis juliflora* wood (8.3%). The results of proximate analysis showed decrease in volatile matter in briquette and biochar compared to woody biomass. The calorific value of biochar is higher compared to briquette and raw wood samples. The FTIR spectrum of *Prosopis juliflora* wood, briquette showed the functional groups such as hydroxyl group, carbonyl group, aromatic and alcohol rings, esters etc., but in case of biochar, these functional groups where several peaks were disappeared.

Keywords: *Prosopis juliflora*, briquette, biochar, proximate analysis, ultimate analysis, FTIR

1. Introduction
Prosopis juliflora is a tree species that grows about 15 m height and it has been introduced to many parts before 200 years as a drought resistant species and for soil conservation (Abdulahi *et al*. 2017) [1]. The rapid expansion of the *Prosopis juliflora* made it as a threat and causing major conservation problems in different parts of the country. This species can grow in wide range of soils and in extreme drought conditions. The features of *Prosopis juliflora* for fuel purpose are hardness, high calorific value, stable burning properties, easy propagation, non-perusable by livestock, adaptability in all kind of soils with production of huge biomass and resistant to droughts (Verma, 1987) [14]. *Prosopis juliflora* can grow under widely varying climatic conditions except at low temperatures. It would not require fertile lands for its growth, thus liberating such lands for subsistence farming (Alves, 1981) [2]. The *Prosopis juliflora* wood are bulky to carry, having poor shelf-life, requires higher transport costs, could not be stored in anticipation of higher prices and it is not preferred by customers if it contained thorns and thinner pieces. It also includes the effects on livestock health, dense thickets reducing access to water points, roads, infrastructure and agricultural lands, drying up of water sources. Moreover, it can be referred as one of the introduced, established, and encroached weeds, and now it spreads into almost the entire topography of India. Hence, a good utilization is required to make use of this species such as energy or fuel for the industries and improve land use pattern.
Prosopis juliflora is a source of lingo-cellulosic biomass and is used as a key substrate in the present study. The *Prosopis juliflora* commonly known as Seema karuvelam in Tamil is a species native to West Africa. It absorbs more than 4 liters of water to attain 1 kg of biomass, which reduces the availability of water in the cultivable land. It also absorbs humidity from the air where the groundwater availability is not sufficient.
During 1960's to face the fuel wood shortage and deforestation, the Tamil Nadu government sowed the seeds of *Prosopis juliflora* on the desert wastelands.

But the introduction of this species resulted in a major ecological disaster of ground water depletion. Due to its invasive nature, the species became dominant species in major places. Now, the process of uprooting these trees is ordered by the Tamil Nadu government to prevent groundwater loss. The uprooted tree is generally dumped, burnt or left to decay. The seeds in the uprooted trees won't die and will germinate in the nearby areas wherever it is dumped. Burning of *Prosopis juliflora* as fuel wood is not an eco-friendly process, so *Prosopis juliflora* is considered to be a menacing environmental threat if it is left unutilized.

Prosopis juliflora can be effectively utilized as a biomass for energy generation. It is a hard plant that grows much faster in water scarce area and is ready for harvest in a period of 2-3 years itself. The harvested plant grows back to its original size in 16 to 18 months. The calorific value of Prosopis *juliflora* is nearly 3600 - 4000 kcal/kg, which making it as a most suitable biomass fuel (Saraswathi, 2016) [11]. It also has an advantage of low moisture and ash content that can be harnessed for various fuel applications (Sindhujarajan and Kamaraj, 2020) [13].

The utilization of this invasive weed as an alternative fuel for fossil fuels in the place of energy generation in the form of raw wood and briquette makes it as a valuable and contributing towards global warming reduction.

Similarly, *Prosopis juliflora* converted to biochar that contains carbon, oxygen, hydrogen, nitrogen, calcium, potassium etc., with high porous structure makes it as a valuable soil conditioner. (Ravi *et al*., 2022) [10].

2. Materials and Methods

2.1 Collection of Prosopis juliflora wood

Prosopis juliflora was collected from Tamil Nadu Agricultural University Campus, (11.0122° N, 76.9354° E) located at Coimbatore, Tamil Nadu, India. Prosopis juliflora is a thorny shrub 3-5 m or tree growing up to 15 m height. It has a thick rough grey-green bark that becomes scaly with age. The plants are often multi-stemmed and furnished with abundant large and very sharp thorns measuring up to 5 cm.

2.2 Briquette production

Prosopis juliflora consists of short stems with thorns and base large size stems. The short stems with thorns were shredded using the shredding machine and used for briquette production. The large stems were chopped in the small sized stems by manual size reduction and then shredded using the shredding machine. The briquette was produced using the shredded Prosopis juliflora stems in the briquetting machine at Dept. of REE, TNAU, Coimbatore.

2.3 Biochar production

The large woody stems of *Prosopis juliflora* was used for biochar production using the pyrolysis unit at Dept. of REE, TNAU, Coimbatore. Samples were air dried at room temperature to carry out the Biochar production. Biochar is produced from *Prosopis juliflora* through pyrolysis process at 450 °C for 2-3 hours. Pyrolysis is the process of chemical decomposition of an organic substance by burning in the absence of oxygen. The biochar obtained after pyrolysis was crushed and sieved through 2 mm size sieve for further analysis. The sieved biochar of *Prosopis juliflora* was kept in an oven at 60 °C for 48 hr to reduce the moisture content for storage. Finally, the biochar samples were stored in an airtight container for further analysis.

2.2 Characterization of *Prosopis juliflora* wood, briquette and biochar

The proximate analysis of *Prosopis juliflora* wood, briquette and biochar were carried out to determine the moisture, volatile matter, ash content and fixed carbon. The ultimate analysis was carried to determine the elemental composition such as carbon, hydrogen, oxygen and nitrogen content of the samples.

Moisture content of the samples were determined by heating the sample in a hot air oven at 103 ± 2 °C until constant weight is achieved (ASTM D 3173-87). The volatile content was determined by heating the sample at 650 °C for 10 min in muffle furnace (ASTM D 3175-89). Ash content was determined by heating the sample at 750 °C for 3 hours (ASTM D 3174-89). Fixed carbon was the amount of content that remains after complete volatilization.

The calorific value *Prosopis juliflor*a wood, briquette and biochar were carried out based on ASTM E-711 methodology. The elemental composition of the *Prosopis juliflor*a wood, briquette and biochar were estimated from the proximate analysis (Parikh *et al*., 2007) [8].

The FTIR analysis, *Prosopis juliflor*a wood, briquette and biochar were used to determine the functional groups present for each temperature and biomass, especially carbons. FTIR spectra were recorded with 1.0 mg of powdered *Prosopis juliflor*a wood, briquette and biochar samples and observed in an FTIR – 6800 Attenuated Total Reflectant Unit (ATR pro one) sensor available at Dept. of Nano Science & Technology, TNAU, Coimbatore. Then all IR spectra of the samples were recorded over a wave number between 400 cm and 4000 cm, or the scanning speed used to detect the FTIR of the samples was maintained at a constant 1 cm. with a resolution factor of 4.

3. Results and Discussion

The results of the study on characteristics of the *Prosopis juliflor*a wood, briquette and biochar are presented and discussed here.

The proximate analysis of *Prosopis juliflora* wood, briquette and biochar was estimated and the results were given below:

Table 1: Proximate analysis of *Prosopis juliflora* wood, briquette and biochar

Sample	Moisture (%)	Volatile matter (%)	Fixed Carbon (%)	Ash (%)
*Prosopis juliflor*a wood	8.3	69.5	17.99	4.21
*Prosopis juliflor*a briquette	2.28	25.64	69.15	2.93
*Prosopis juliflor*a biochar	1.74	19.59	76.34	2.33

The moisture content of *Prosopis juliflora* briquette and biochar was found to be 2.28% and 1.74% respectively, which is very less than raw *Prosopis juliflora* wood (8.3%). This might be due to exposure of *Prosopis juliflora* wood to higher temperature while compression in briquetting machine and also in pyrolysis process. The moisture content of *Prosopis juliflora* biochar is 1.74%, which nearly coincides with the results of 1.21% and 1.49% reported by various authors named Shenbagavalli and Mahimairaha (2012) [12], Elangovan *et al*., (2022) [4] and Kathikeyan *et al*., (2019) [5].

The results of proximate analysis of *Prosopis juliflora* wood is comparable with the results obtained by Rajan *et al*., (2022) [9]. The results of proximate analysis showed decrease in volatile matter in briquette and biochar compared to woody biomass, which might be due to decomposition of cellulose and lignin during briquetting and biochar production process. Briquettes and biochar are having low ash content, which make it suitable for combustion process. An increase in fixed carbon content was observed in biochar because of increased devolatilization and it makes the biochar more suitable for combustion as fuel and it gives more heat energy during combustion.

The elemental composition of the *Prosopis juliflor*a wood, briquette and biochar was estimated and the results are given in Table 2.

Table 2: Elemental composition of *Prosopis juliflora* wood, briquette and biochar

Sample	Carbon (%)	Hydrogen (%)	Oxygen (%)	Nitrogen (%)
*Prosopis juliflor*a wood	40.69	5.24	38.55	15.52
*Prosopis juliflor*a briquette	51.85	5.18	33.22	9.75
*Prosopis juliflor*a biochar	60.8	5.18	32.53	1.49

The elemental composition of *Prosopis juliflora* wood coincides with the results reported by Mythili *et al*., (2013) [7]. The calorific value is the significant factor that provides the fuel quality of the sample for energy generation. The increase in calorific value of biochar is due to release of volatile matter during biochar production and increase in fixed carbon, which results in higher degree of carbonization.

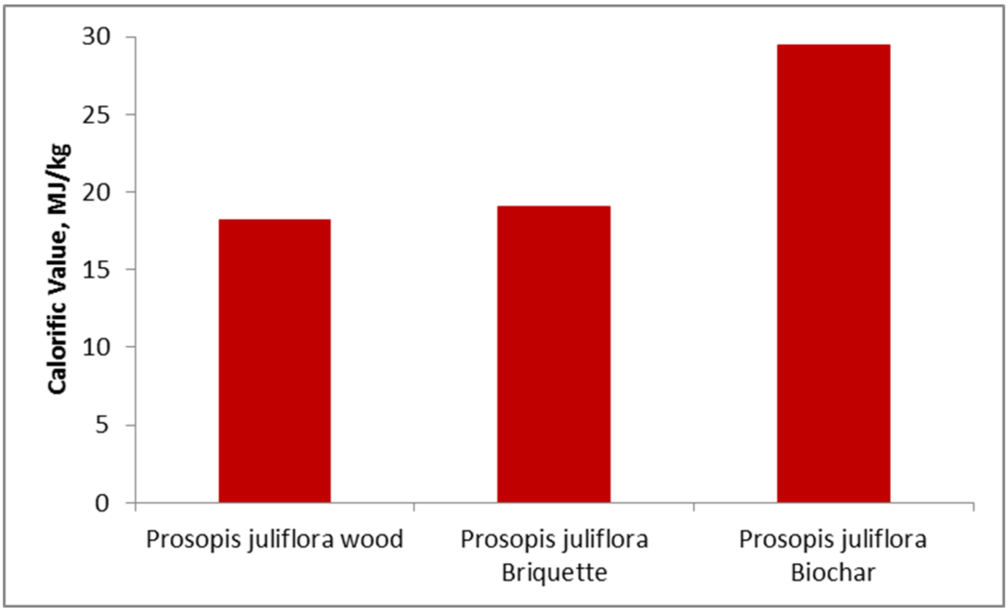

Fig 1: Calorific value of *Prosopis juliflora* wood, briquette and biochar

The calorific value of biochar is higher compared to briquette and raw wood samples. The calorific value of *Prosopis juliflora* wood was found to be 18.2 MJ/kg, which is similar to the result of 18.33 MJ/kg by Carneiro-Junior, J.A.d.M *et al*., (2021) [3]. The calorific value of *Prosopis juliflora* biochar was found to be 29.43 MJ/kg. Kumar and Chandrashekar (2016) [6] stated that the calorific value of *Prosopis juliflora* biochar ranged from 24.0 to 32.8 MJ/kg for varying the process temperature between 300 - 800°C. The obtained result for *Prosopis juliflora* biochar produced at 450 °C falls in this range.

The functional group in the *Prosopis juliflora* wood, briquette and biochar were obtained through Fourier-transform infrared spectroscopy (FTIR) analysis and the results of FTIR analysis of *Prosopis juliflora* wood, briquette and biochar is shown in the following fig. 2, 3 and 4. The spectrum of *Prosopis juliflora* wood, briquette showed the functional groups such as hydroxyl group, carbonyl group, aromatic and alcohol rings, esters etc., but in case of biochar, it was observed that the pyrolysis had an effect on these functional groups where several peaks were disappeared in the FTIR spectra of biochar.

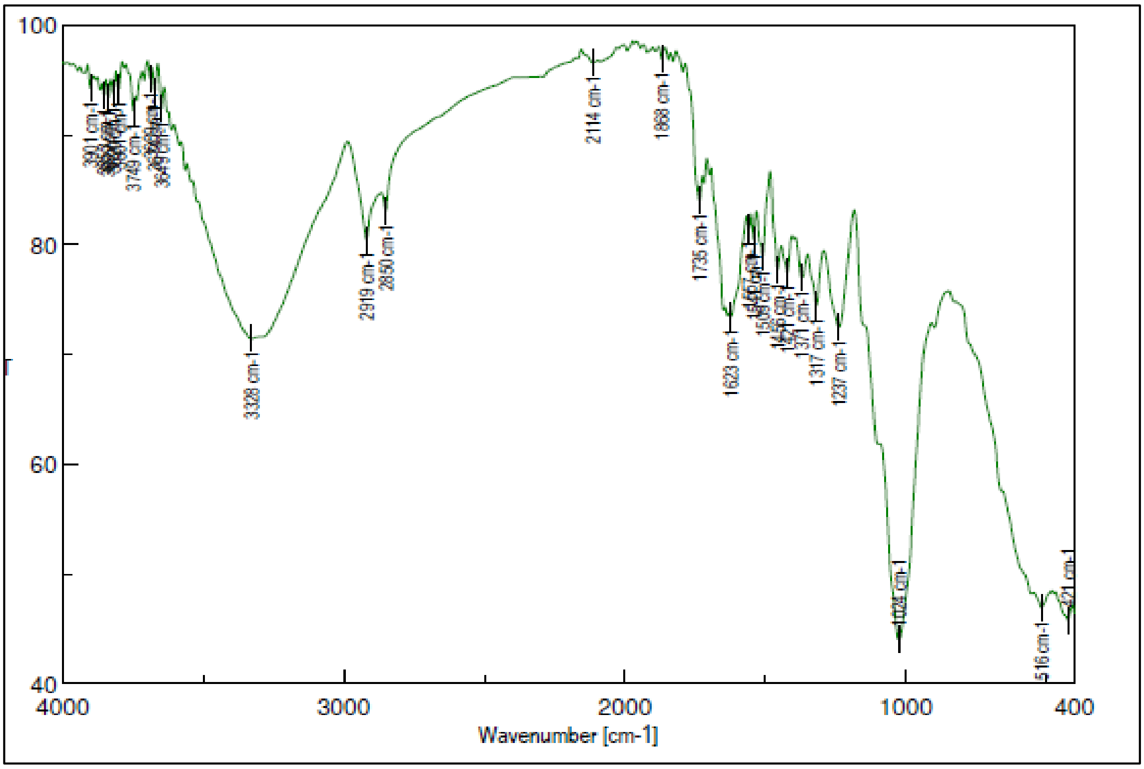

Fig 2: FTIR analysis of *Prosopis juliflora* Wood

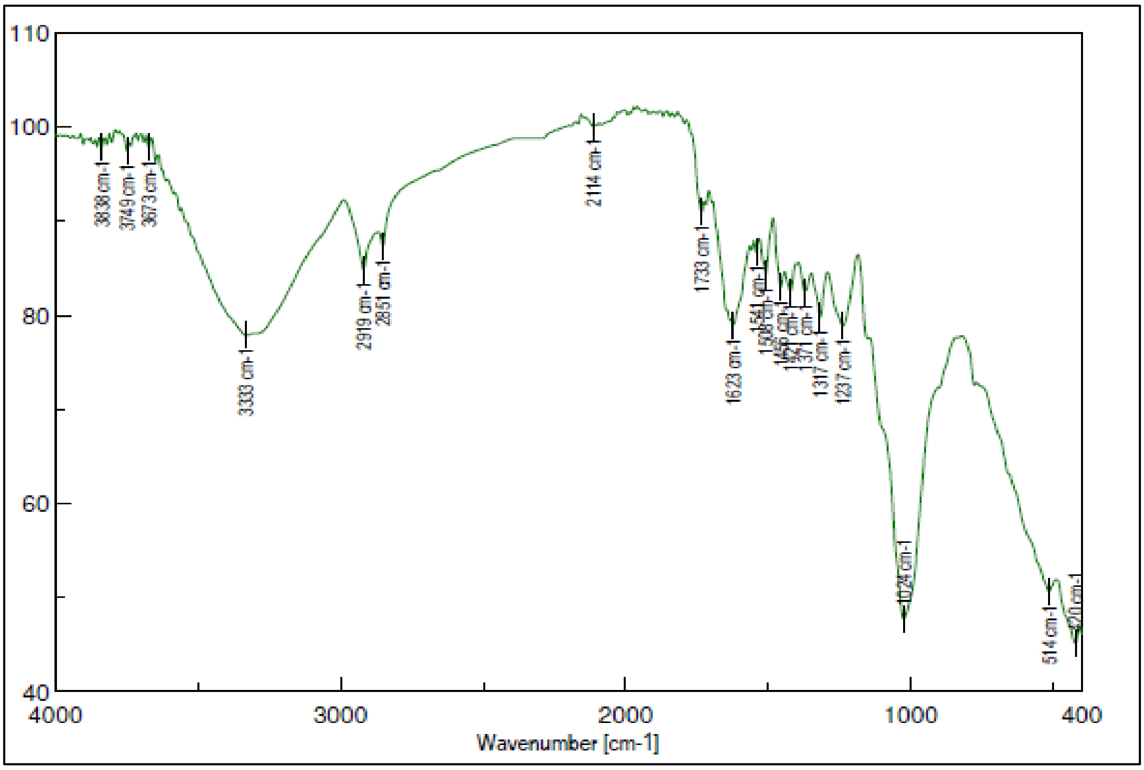

Fig 3: FTIR analysis of *Prosopis juliflora* Briquette

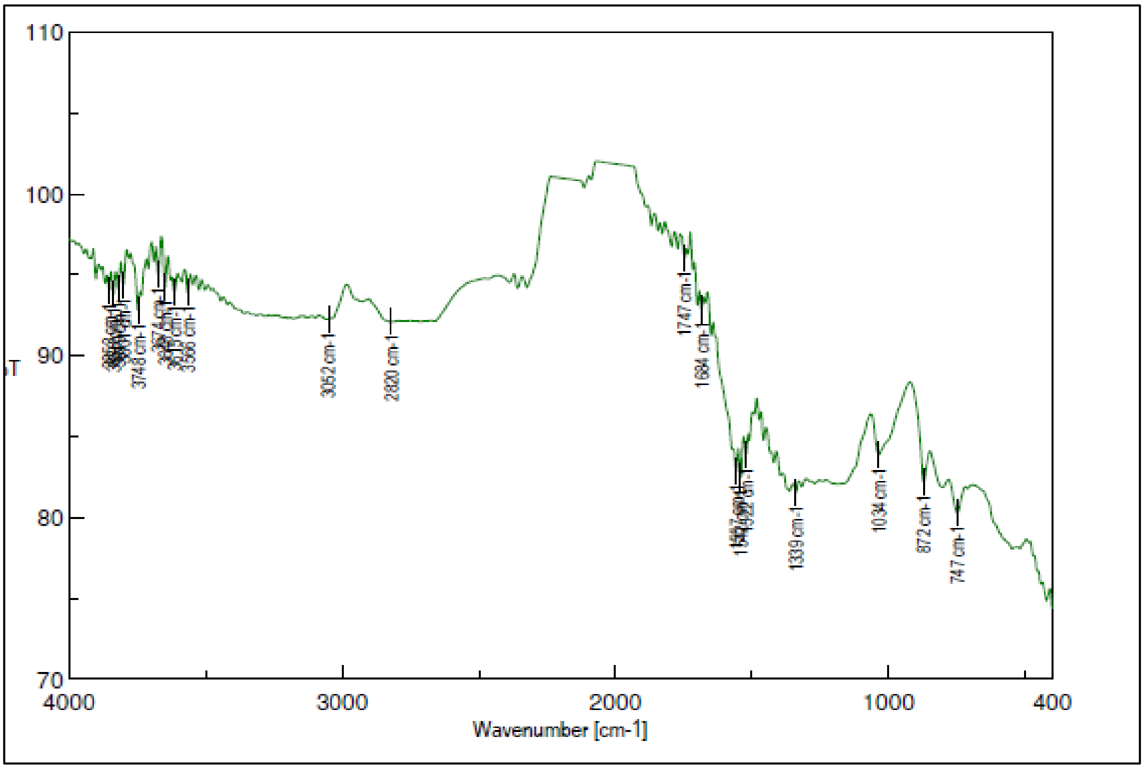

Fig 4: FTIR analysis of *Prosopis juliflora* Biochar

The peak obtained in the region between (3000–3700) corresponds to the OH stretch of water molecules of hydroxyl groups (OH) and phenols, this peak was observed in biomass and briquette samples but not in biochar where this disappearance of the OH group could be due to the dehydration of the components of cellulose and hemicellulose and to the release of volatile matter and moisture content during the pyrolysis process.

The peaks between (2800–2980) correspond to aliphatic C–H stretching vibration. However, the CH_2 group was identified in the spectra as CH_2 peaks at $2919 cm^{-1}$. The small peaks found in this region for the biochar samples could be attributed to the thermal degradation of the cellulose. Cellulose and hemicellulose allowed the destruction of aliphatic structures. The peaks between (1600 and 1800) are associated with a stretching of the C-O rings and the vibration of aromatic C = C valence but these peaks were not observed in the spectra of biochar due to the decomposition of volatile matter during the pyrolysis process.

4. Conclusions

Briquette and biochar production from *Prosopis juliflora* wood is a viable option for utilization of *Prosopis juliflora* as a feedstock for energy generation. The proximate, ultimate analysis and heating value of the *Prosopis juliflora* wood, briquette and biochar showed that the wood is more suitable for energy generation compared to other application. The lower moisture content of *Prosopis juliflora* briquette and biochar along with less ash content enhances the quality of briquette and biochar compared to *Prosopis juliflora* wood in thermal application. Hence, in order to reduce the propagation of uprooted *Prosopis juliflora*, utilization of it as a potential feedstock for energy generation in the form of briquette and biochar is the environment friendly option and potential alternative fuel in rural areas and small scale agro industries. Moreover, Biochar from *Prosopis juliflora* can be effectively utilized as a soil amendment, which improves the physical and biological properties of soils.

5. Acknowledgments

The authors acknowledge the financial support from ICAR - AICRP on EAAI for carrying out this research. The authors also express their sincere gratitude to Dept. of Renewable energy Engineering and Dept. of Nano Science & Technology, TNAU, Coimbatore for their physical and infrastructural assistance.

6. References

1. Abdulahi MM, Ute JA, Regasa T. *Prosopis juliflora* L: Distribution, impacts and available control methods in Ethiopia. Tropical and Subtropical Agroecosystems. 2017;20(1):75-89.
2. Alves JL, Hamburgo D, Melo D, Arcoverde MS, Alves GD. Internal structure of plant, fruit, seed, and pollen morphology of *Prosopis juliflora* (Sw) D. C. In: Proceedings of Second International Conference on The Current State of Knowledge on Prosopis Juliflora, 1988.
3. Carneiro-Junior JAdM, de Oliveira GF, Alves CT, Andrade HMC, Beisl Vieira de Melo SA, Torres EA. Valorization of *Prosopis juliflora* Woody Biomass in Northeast Brazilian through Dry Torrefaction. Energies. 2021, 14(3465).
4. Elangovan R, Rangasami SRS, Murugaragavan R, Sekaran NC. Characteristics of biochar: A review. The Pharma Innovation. 2022;11(12):243-246.
5. Karthikeyan G, Karthikeyan S, Suganya K, Kamaludeen Sara PB. Characterization of Biochar derived from wood biomass of *Prosopis juliflora*. Madras Agricultural Journal. 2019;106(4-6):374-378.
6. Kumar R, Chandrashekar N. Study on fuelwood and carbonization characteristics of *Prosopis juliflora*. Journal of the Indian Academy of Wood Science. 2016;13(2):101-107. https://doi.org/10.1007/s13196-016-0171-9

7. Mythili R, Venkatachalam P, Subramanian P, Uma D. Characterization of bioresidues for biooil production through pyrolysis. Bioresource Technology. 2013;138:71-78. https://doi.org/10.1016/j.biortech.2013.03.161.
8. Parikh J, Channiwala SA, Ghosal GK. A correlation for calculating elemental composition from proximate analysis of biomass materials. Fuel. 2007;86:1710-1719. https://doi.org/10.1016/j.fuel.2006.12.029
9. Rajan SS, Sekar I, Divya MP, Parthiban KT, Sudhagar RJ. Suitability of invasive species for briquette production: *Lantana camara* and *Prosopis juliflora*. The Pharma Innovation. 2022;11(7):530-533. https://doi.org/10.22271/tpi.2022.v11.i7g.13689
10. Ravi KN, Ramesha MN, Dupdal R, Vijayan B, Prabhavathi M, Naik BS. Potential use of invasive *Prosopis juliflora* plant for biochar production in semi-arid zones of Karnaataka. Soil and Water Conservation Bulletin. 2022;7:42-46.
11. Saraswathi K, Chandrasekaran S. Biomass yielding potential of naturally regenerated *Prosopis Juliflora* tree stands at three varied ecosystems in southern districts of Tamil Nadu, India. Environ. Sci pollut Res Int. 2016;23(10):9440-9447.
12. Shenbagavalli S, Mahimairaja S. Production and Characterization of Biochar from different biological wastes. International journal of Plant, Animal and Environmental Sciences. 2012;2(1):197-201.
13. Sindhujarajan S, Kamaraj S. Effective utilization of *Prosopis juliflora* for cooking purposed through gasification technology. International Journal of Engineering Research & Technology. 2020;9(4):714-716.
14. Verma DPS. Wastelands development a case for *Prosopis juliflora*. Indian Forester. 1987;113(8):529-540.