Mediterranean Agricultural Wastes: As Renewable Source

Hakan Cay[1], Gozde Duman Tac[1], Gizem Balmuk[1], I. Cem Kantarli[2], Jale Yanik[1*]
[1]Ege University, Faculty of Science, Chemistry Department, Izmir,Turkey
[2]Ege University, Ataturk Medical Technology Vocational School, Izmir, Turkey
[*] Presenting author email: jale.yanik@ege.edu.tr
Keywords: biochar, pyrolysis, hydrothermal carbonization, combustion, steam gasification

Biomass, which is the waste streams from agriculture, forestry, and urban sources, are a potential source for renewable energy. It is considered to be 'carbon neutral' fuel. Biomass is transferred to different forms of energy by the thermochemical and biochemical processes. But, there are challenges in use of biomass as a fuel source, such as low bulk density (or energy density) and high cost associated with handling, transportation and storage. To overcome these downsides, the quality of biomass can be upgraded by pre-treatment processes. Among them, carbonization at low temperatures is an effective approach. It produces, at very low cost, the coal-like end product, which is a stable, homogeneous solid fuel with good characteristics in energy density, grindability and hydrophobicity. This solid biofuel (biochar) can be used as a replacement of coal in electricity and heat production and as input for gasification processes. The properties of biochars are varied with the feedstock source and production process (dry and wet carbonization). Dry carbonization (DC) is a low-temperature pyrolysis, in which the biomass is heated in an inert gas environment at 200-350 °C. Generally, 80-95% of the energy and 70-90% of the mass of the feedstock are retained in biochar. Biochar production via DC is restricted to biomass with low water content because of the high energy requirements of an unavoidable pre-drying process. On the contrary, HTC is a promising technology for the thermochemical conversion of wet biomass, which is often the case for waste materials, since it takes place in liquid subcritical water at 180-250 °C. Much work has been done to investigate biochars obtained from different feedstocks and using different process conditions (Tripathi et al. 2016). However, more efforts are required to better clarify the effects of peak temperature on biochar yield, physico-chemical properties, and performance as energy carrier.

Agricultural residues and agro-industrial wastes generated in many Mediterranean countries, especially by the olive oil and wine production chains, represent a valuable source of biomass. Vineyards produce vast amounts of agricultural residues, particularly vine shoots and leaves (1.4–2.0 tons of shoots per hectare of vine crop). The most abundant residue of the winemaking process is grape pomace, with around 12 Mt/year produced in the world. On the other hand, more than 8 Mha of olive trees are cultivated worldwide, over 90% of which in the Mediterranean basin and an average of 3 tons/ha of pruning is produced each year (Dermeche et al., 2013). To date, the management of the mentioned wastes has generally been viewed as a disposal problem, whereas it can become an opportunity for generating additional revenue if wastes are converted to biochar and used as an energy resource.

In this study, specific objectives were to: (1) optimize of both DC and HTC conditions for pruning residues from olive tree (OPR) and vineyards (PV) as based on mass yield and energy density, (2) compare the combustion and gasification characteristics of raw biomasses with their biochars ("pyrochar" as DC biochar and "hydrochar" as HTC biochar). For this purpose, both two residues were conducted at dry and wet carbonization process. DC experiments were carried out at different temperatures (200- 500°C) and times (60 and 120 min) under N_2 atmosphere. HTC experiments were carried out between 200-260 °C at 1:5 biomass:water ratio and for 0-240 min. The steam gasification of pruning residues and their biochars obtained under optimum conditions were performed using a downstream reactor at 850 °C. The combustion behaviour of pruning residues and biochars was comparatively determined by using thermogravimetric analysis.

Carbonization temperature was the most important parameter on product yield and energy content of biochars. By increasing temperature, the mass yield decreased while carbon content increased. In terms of mass yield and energy densification ratio, the temperature of 350 °C and the reaction time of 60 min were determined as optimum conditions for DC. In case of HTC, the temperature of 220 °C and the reaction time of 60 min were selected as optimum conditions. At optimum conditions, DC yielded the biochars having energy values of 26.47 MJ/kg and 28.37 MJ/kg and mass yields of 41 % and 37% for OPR and PV; respectively. On the other hand, HTC produced the biochar having energy values of 25.96 MJ/kg and 23.92 MJ/kg with a mass yield of 56 % for OPR and PV; respectively. According to Van Krevelen Diagram, most of biochars were in the similar range of coal area, bituminous coal for pyrochars and lignite for hydrochars.

Steam gasification of pruning residues and their biochars produced hydrogen rich gas. Pyrochars gave the highest hydrogen yield, which were 1625 mL H_2/g for OPR and 1995 for VP. Based on combustion studies, it was found that pyrochars and hydrochars had higher ignition temperature than raw biomasses while dry carbonization led to increase the burn out temperature. The combustion reactivity of OPR pyrochar was much higher than that of OPR and OPR hydrochar. On the contrary, pyrochar obtained from PV had the lowest combustion reactivity compared to PV and PV hydrochar.

As conclusion, the results obtained in this study showed that dry carbonization of pruning wastes appears to be promising process to provide benefits to energy sector as well as to protect environment.

Acknowledgement
The financial supports from TUBITAK (Project Contract No: 117M570) under the Eranet-Med2 Programme (Project Acronym: MEDWASTE) of the EU are gratefully acknowledged.

References

Dermeche S, Nadour M, Larroche C, Moulti-Mati F, Michaud P. Olive mill wastes: Biochemical characterizations and valorization strategies. Process Biochem 2013;48:1532–52.

Tripathi M, Sahu JN, Ganesan P. Effect of process parameters on production of biochar from biomass waste through pyrolysis: A review. Renew Sustain Energy Rev 2016;55:467–81.