Renewable Energy 88 (2016) 185–191

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Characterization of pellets from mixing olive pomace and olive tree pruning

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ARTICLE INFO

Article history:
Received 9 June 2015
Received in revised form
1 October 2015
Accepted 11 November 2015
Available online 5 December 2015

Keywords:
Olive pomace
Pellet
Durability
Blends
Olive tree pruning

ABSTRACT

Olive pomace is an interesting agro-industrial byproduct that can be a potential raw material for densified biomass products. At first, 2-phase (2 PH) and 3-phase (3 PH) olive pomace pellets were analyzed in order to evaluate their quality in terms of the main parameters required by the European Standard EN 17225-6.

The characterization of the pure pellets has shown important problems because of out of limits values of nitrogen, durability and copper in the two olive pomace. To improve the properties of olive pomace pellets, the possibility of manufacturing pellets by mixing olive pomace and olive tree pruning (PR) was investigated.

Several blends at different weight ratios were analyzed in order to verify the effect of mixing on the pellet properties. It can be concluded that the physical properties of all mixtures are in compliance with the requirements of the standard.

In particular, two best blends in terms of physical, chemical and mechanical characteristics were identified as becoming potential fuel for combustion and gasification applications: 75PR252 PH (75% pruning and 25% 2-phase pomace) and 50PR503 PH (50% pruning and 50% 3-phase pomace).

1. Introduction

The energy dependency derived from the use of fossil fuels and the increasing environmental concerns, have prompted the need to develop an energy system with a more renewable energy percentage and a reduction of greenhouse gas emissions [1].

Among renewable energy sources, biomass is particularly interesting because it can be used for heat, electricity, and transportation [2] and it can also be stored, unlike other renewable energy sources [3]. In particular a rapid growth of the wood pellet, production and consumption for power and heating has been registered in the last years. According to the European Bioenergy Outlook 2013 [4], the world wood pellet production in 2013 is equal about to 24.5 Mton, of which about 50% is produced in the European countries. In terms of wood pellet consumption, European countries are the biggest consumers with about 80% of the total world consumption.

However, since only wood pellet from forestry residues have already successfully established technologies and markets, it seems to be interesting to focus on evaluating the pelletization of agro-industrial biomass, which is periodically collected and represents an interesting option for energy recovery, being an alternative to their disposal.

In particular, most byproducts from agriculture or agro-industrial processes are characterized by low bulk density and, therefore, cannot be efficiently transported over long distances to areas where they can be effectively employed.

There are also other important factors which make the energy use of agricultural residues difficult, as the local availability, since they are widespread over a relatively large area, and the costs of the treatments needed for their proper removal [1].

The olive oil industry is one of the agro-industrial activity that produces a significant amount of by-products. There are almost 900 million olive trees occupying over 10 million hectares worldwide, 98% of those are located in the Mediterranean Countries [5]. It can be assumed that 1 ha of olive tree produces about 2500 kg of olives and about 35 kg of olive pomace is obtained for 100 kg of treated olives [6]. Also olive, tree pruning are about 5% of the olive weight [7]. As regards the olive pomace, global annual production was

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http://dx.doi.org/10.1016/j.renene.2015.11.037

estimated to approach 400 million tons of dry matter [8].

As regards the olive pomace, today two kinds of process are mainly used to separate oil from olive pastes: the three-phase centrifugation system, which produces a relatively dry solid waste named three-phase pomace and a large volume of olive mill waste waters, and the two-phase system in which the extraction water injection is carried out only in the final vertical centrifugation step, reducing by one-third on average the volume of liquid effluent [9].

The management of these residues is widely considered as a big concern, due to their potential environmental impact on soil and water [10]. Actually several options were tested for olive mill solid waste management. The main uses reported in Literature [11] are: animal feed, biogas production, extraction of useful materials, fertilizers.

Densification by pelletizing can be an interesting option for increasing the bulk density of olive oil industry residues and their energetic employment.

However, the high oil content of the pomace reduces significantly the quality of the pellet and makes difficult the densification during the pelletizing process. According to Kalyan and Morey [12] the higher content of fat or oil in the feed before densification should not exceed 6.5%, to not affect the pellet durability. Therefore, it could be necessary to blend the olive pomace with other wood biomass to obtain suitable characteristics for an ideal pelletization.

Many authors investigated the use of different biomass blends as fuel for energy production: Liu et al. [13] studied the quality of pellets resulting from the mixing of bamboo and rice straw while Mediavilla et al. analyzed the pelletizing properties of blends including vine shoots and cork [14]. The behavior of domestic boilers fed with different types of agro-pellets was studied by Verma et al. [15] and Gonzàlez et al. [16] carried out a comparative study on the performance of tomato, olive stone, and cardoon residues.

However, to the best of our knowledge, the effect of mixing olive tree pruning and olive pomace on the pellet properties was not investigated in the Literature before. Therefore, the aim of the paper is to analyze the mechanical, chemical and physical properties of the pellets produced from olive tree pruning (PR), olive pomace, from two (2 PH) and three phase (3 PH) centrifugation system, and their blends at different mixture ratios. Furthermore, the quality parameters are discussed and compared with the technical standard EN 17225-6 [17] to check if the samples meet the requirements established for graded non-woody pellets.

2. Materials and methods

2.1. Raw materials

Olive mill husk from two and three phase decanter, collected from local manufactures from Central Italy regions and olive tree pruning, collected from orchards located in central Italy (Toscana and Umbria) were used in this study. Exhausted olive mill husk was not considered because actually in Italy the production of olive husk oil is decreasing due to the very low quality of the oil, if compared to the more valuable extra virgin olive oil, derived from mechanical extraction.

The initial moisture content of the raw materials was about 47.4%, 57.2% and 72.9% for PR, 2 PH and 3 PH, respectively.

2.2. Materials preparation

Due to the high moisture content, raw materials were dried before grinding. Drying of 2 PH and 3 PH was performed in wintertime using a greenhouse provided by a heating system and putting the raw materials in thin layers over heated beds, waiting for natural drying. To speed up the drying process 2 PH and 3 PH were periodically turned by hand (at least once per day).

OP was previously mechanically chipped using an 8hp XL MTD wood chipper before drying that was performed in the same environment.

When both raw materials reached moisture content below 20%, they were ground using an ultra centrifugal mill (mod. ZM200, Retsch) and sieved in order to obtain a particle size lower than 4 mm (diameter).

The fraction size distribution of three representative 50 g samples for each material was analyzed by manual sieving on a stack of sieves arranged from the largest to the smallest opening. The sieving procedure terminated when no further notable passing took place. The sieve sizes 3150, 2800, 2000, 1400, 1000, 500 and 250 μm were used. The fraction size distribution of the milled material is reported in Table 1.

Subsequently, the samples were subjected to an air drying process during the time necessary to attain an equilibrium moisture content (approximately 17%).

In order to observe the behavior in densification of residues, as well as its characteristics, a classification of the samples was established, based on the percentage in weight of the components of each one of the mixtures. Therefore, the following blends were considered:

- 1002 PH: composed only by 2 PH;
- 1003 PH: composed only by 3 PH;
- 100 PR: composed only by PR;
- 75PR252 PH: 75% olive tree pruning and 25% two-phase olive pomace;
- 50PR502 PH: 50% olive tree pruning and 50% two-phase olive pomace;
- 25PR752 PH: 25% olive tree pruning and 75% two-phase olive pomace;
- 75PR253 PH: 75% olive tree pruning and 25% three-phase olive pomace;
- 50PR503 PH: 50% olive tree pruning and 50% three-phase olive pomace;
- 25PR753 PH: 25% olive tree pruning and 75% three-phase olive pomace.

2.3. Densification of the raw materials

The pellets were then manufactured using laboratory pellet mill (Betasystem srl), was used to perform pelletizing tests. This pelletizer has a nominal power of 1.7 kW. The feed material is pressed through open-ended cylindrical holes die made in the periphery of a series of rings. Two small rotating rolls push the feed material into the die holes from inside of the ring towards the

Table 1
Fraction size distribution of the milled materials.

Fraction (mm)	Weight (%) of the sample		
	Pr	2 PH	3 PH
>3.15	0.00	0.00	0.00
2.80÷3.15	0.12	0.05	0.08
2.00÷2.80	1.45	1.98	1.78
1.40÷2.00	11.15	8.27	7.58
1.00÷1.40	17.56	24.95	22.56
0.50÷1.00	48.54	47.94	50.17
0.25÷0.50	14.16	9.97	12.34
<0.25	7.02	6.84	5.50