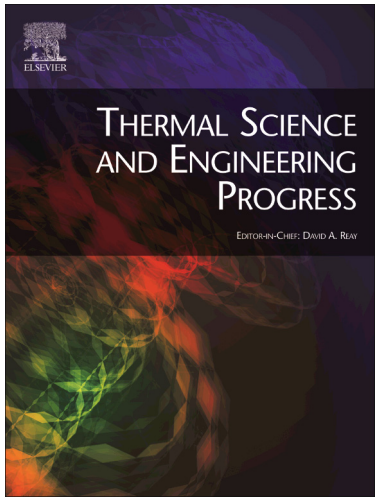

Anaerobic digestion of ensiled orange peel waste: preliminary batch results

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PII: S2451-9049(17)30339-6
DOI: https://doi.org/10.1016/j.tsep.2017.12.011
Reference: TSEP 109

To appear in: *Thermal Science and Engineering Progress*

Received Date: 2 October 2017
Revised Date: 6 December 2017
Accepted Date: 30 December 2017

Please cite this article as: P.S. Calabrò, M.F. Panzera, Anaerobic digestion of ensiled orange peel waste: preliminary batch results, *Thermal Science and Engineering Progress* (2017), doi: https://doi.org/10.1016/j.tsep.2017.12.011

Anaerobic digestion of ensiled orange peel waste: preliminary batch results

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ABSTRACT

According to the official data, oranges are one of the most cultivated fruit in the world and the major part of them are used in industrial processes to produce juices, jams and other products. From these processes, huge amounts of residues are produced and among them the most abundant is orange peel waste (OPW). One promising option in the management of OPW is represented by anaerobic digestion for methane production. The aim of this paper is to analyse the effects of ensiling (a form of storage used to overcome the problem of OPW seasonal production) on bio-methane production, also evaluating the influence of bacteria adaptation to the substrate at lab scale. Two sets of batch experiments were carried out, the first evaluated the methane potential of OPW ensiled up to 37 days. The highest production was registered for samples of OPW ensiled for 37 days, with a value of 365 Nml CH_4/g VS. The second set of the batch test was aimed at verifying the effect of the adaptation of the inoculum. OPW ensiled for 7 days inoculated with sludge already adapted to the substrate yielded 513.7 Nml CH_4/g VS versus 187.2 Nml CH_4/g VS of the corresponding test using non adapted inoculum.

Keywords: Anaerobic Digestion Process, Bacteria adaptation, Biogas, Ensiling, Methane, Orange Peel Waste

1. INTRODUCTION

Biorefinery is a technological process through which biomass can be transformed into biofuels, energy and chemical products, producing hardly any residues with a lower environmental impact. Biofuels are one of the main results of this process and many different biomasses can be used to obtain them. Because of the growing biofuels demands, the focus is on finding biomasses which prevent conflicts with food production: with this aim, second generation biofuels are produced from waste biomasses or from substrates which cannot be used as human food.

Among these kinds of products, according to the official data, a relevant role in the global market is represented by oranges. They are the most cultivated fruit in the world, with more than 71 Mt that were produced globally in 2013 [1]. About 70% of them is used in industrial processes to obtain juices, jams and other products, rendering huge quantities of residues corresponding to 50-60% of the processed fruit [2]. These residues are mainly constituted by orange peel waste (OPW) and mainly contain seeds (0-9%), peels (60-75%) and membrane residues (23-33%). OPW is characterized by a water content of higher than 80% and is acid (pH 3-5), due to the presence of organic acids and D-limonene, which is the main component of essential oils, kept in small glands in the external peel of the fruit.

OPW can be used fresh or processed (pressed or dried), depending on its final usage. It is generally used fresh as cattle feed [3], for its positive effects on lactation cows, while processed OPW can be used in many ways to produce fertilizers, pectin, ethanol, essential oils, etc. [4]. The latter products have an important economic value and they are usually obtained through extraction or distillation of the fruit peel to be used in cosmetic, food or medical industries. However, OPW management is based on different factors which influence its economic sustainability, such as its high content of water, which often makes dehydration necessary, the cost of transport and storage and the fruit seasonal spread.

Among all possible uses, the anaerobic digestion to produce a biogas rich in methane [5-16] is one of the most promising. The anaerobic digestion is a biochemical process based on the decomposition of complex organic substances in the biomass into a (bio)gas, mainly composed of methane (50-70%) and carbon dioxide (30-40%), and used as a biofuel. From these processes the digestate is obtained too: it is the main effluent of the digestion and it is generally used as a fertilizer or amendant thanks to its beneficial effect on soil.

However, the main problems linked to OPW use in anaerobic digestion are the high content of D-limonene (toxic for the bacteria) and its seasonal spread, because oranges can only be processed during their production period. To solve this problem, a possibility is storing OPW using ensiling, a technique generally used for fodders [17-18]. It is based on