Composts derived from agri-food sludge and pruning wastes from Mediterranean orchards: obtaining and agronomic valorisation in organic farming production

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Introduction

Currently, there is an increasing generation of wastes coming from the agriculture and the agri-food industry. In the Mediterranean areas, pruning wastes from orchards constitute an important environmental problem due to the important amount in volume of these wastes, the lack of pre-treatment and specific treatment facilities that usually conclude in the burning of these wastes, which implies several environmental impacts such as CO_2 emissions, the increase in the fire risk and the loss of resources in terms of energy, nutrient and organic matter. On the other hand, the incentive of the wastewater treatment processes has made worse the storage and management problems of the sludge generated after wastewater treatment, especially in the agri-food sector where the production and thus, the wastewater generation has risen in the last years, increasing the generation of sludge and thus, making difficult its management (Morales *et al*., 2016). Thus, the co-composting of the orchard pruning wastes with agri-food sludge can constitute a feasible alternative not only to manage and recycle these organic wastes, but also to obtain added-value materials that can be reintroduced in the agricultural sector, constituting a win-win strategy based on the circular economy concept. Therefore, this work studied the co-composting process of two composts prepared using agri-food sludge, different pruning wastes coming from Mediterranean orchards (khaki and pomegranate pruning) and a mixture of cow-sheep manure, and their effect on the yield of two crops (lettuce and melon) cultivated on real agronomic conditions in an organic farming system.

Material and methods

Composting experiment

Two composting piles were prepared using an agri-food sludge coming from a citric juice industry (CAS), different pruning wastes obtained from two Mediterranean orchard crops (pomegranate pruning (PP) and khaki pruning (KP) and a mixture of cattle and sheep manure (CSM). The mixtures were composted using forced aeration and mechanical turning. The percentages of the initial materials used to prepare the composting piles, on a fresh weight basis were the following:

Pile C1: 30 % CAS + 60 % KP + 10 % CSM
Pile C2: 30 % CAS + 60 % PP + 10 % CSM

Three mechanical turnings were carried out during the composting process, which was considered finished when during 10 consecutive days after a whirl the difference between the pile temperature and the ambient temperature was ≤ 10ºC. Then, composts were left to mature over a period of a month, approximately. The moisture of the piles was controlled weekly by adding the necessary amount of water to obtain a moisture content not less than 40%. The piles were sampled in three occasions corresponding the samples to the initial stage, thermophilic phase, end of the bio-oxidative stage and maturity phase of composting. Subsequently, the samples were processed and analysed according to the methods described by Bustamante *et al*. (2012). The germination index (GI) was calculated using seeds of *Lepidium sativum* L. (Zucconi *et al.*, 1981). All the analyses were made in triplicate.

Agronomic validation

Two field experiments using different crops (lettuce and melon) cultivated under organic farming practices were conducted at the facilities of Experimental Station of the Fundación Cajamar placed in Paiporta (Valencia), Spain. The treatments established in both experiments were the following: control soil without amendment (Control) and the two composts from agri-food wastes (C1 and C2). The treatments were incorporated as a single application dose of 30 t/ha in plots arranged in a randomised complete block design with three replicates per treatment. In the first experiment, after the incorporation of the treatments, melon (*Cucumis melo* var. Piel de Sapo) was sown in all plots, while in the second experiment, Romaine lettuce (*Lactuca sativa* L. var. longifolia) was sown after the incorporation of the treatments. The effects of the different treatments on the crop yield and quality parameters were also studied.

Results and discussion

The temperature profile in both composting mixtures showed an adequate evolution of this parameter, with a good development of the bio-oxidative stage of the process, which lasted 56 days in both composting piles, maintaining thermophilic values more than two weeks, which guarantees the maximum pathogen reduction according to the European requirements on compost sanitation (Vico *et al*., 2018). This behaviour was reflected in the significant losses of organic matter in both piles (48 % and 58 % for C1 and C2, respectively).

Regarding the physico-chemical and chemical properties, both mixtures showed a decrease of the pH and an increase of the electrical conductivity values, as well as a decrease of the organic matter concentrations, observing the lowest contents in the pile C2 at the end of bio-oxidative phase. In both piles, the nitrogen concentrations increased, showing the compost C2 the highest concentrations at the end of the process (Table 1).

Table 1. Main properties of the composts (data expressed on a dry weight basis).

	Compost C1	Compost C2
pH	7.9	7.3
EC (dS/m)	2.96	4.91
Organic matter (%)	71.4	73.6
TOC/TN	13.1	9.5
Total N (%)	2.9	3.8
P_2O_5 (%)	3.4	4.9
K_2O (%)	1.0	1.4
Germination index (%)	99	89

EC: electrical conductivity; TN: total N; TOC: total organic C.

Both composts verified the criteria established by the Spanish and European legislations (Gavilanes-Terán *et al*., 2016), showed a suitable maturity degree with absence of phytotoxicity, showed in the high values (< 50%) of the germination index and a significant fertilising value, with high contents of nitrogen and phosphorous (Table 1). Concerning the field experiments developed, the treatments with the composts C1 and C2 produced a commercial yield of lettuce statistically similar to that obtained with the Control treatment without amendment. However, the composts C1 and C2 induced higher commercial yields and a good organoleptic fruit quality in the melon crop than the Control treatment, the commercial yields between both composts being statically similar.

Conclusions

The co-composting of orchard pruning wastes with agri-food sludge has been proved as a viable alternative method to manage and valorise these organic wastes and to obtain added-value organic materials with suitable physico-chemical and chemical properties, good degree of maturity and a fertilising value, reflected in the good commercial yield obtained for lettuce and melon under organic farming management.

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References

Bustamante, M.A., Alburquerque, J.A., Restrepo, A.P., de la Fuente, C., Paredes, C., Moral, R., Bernal, M.P., 2012. Co-composting of the solid fraction of anaerobic digestates, to obtain added-value materials for use in agriculture. Biomass Bioenergy 43, 26–35.

Gavilanes-Terán, I., Jara-Samaniego, J., Idrovo-Novillo, J., Bustamante, M.A., Moral, R., Paredes, C., 2016. Windrow composting as horticultural waste management strategy - A case study in Ecuador. Waste Management 48, 127-134.

Morales, A.B., Bustamante, M.A., Marhuenda-Egea, F.C., Moral, R., Ros, M., Pascual, J.A., 2016. Agri-food sludge management using different co-composting strategies: study of the added value of the composts obtained. J. Clean. Prod. 121, 186–197.

Vico, A., Pérez-Murcia, M.D., Bustamante, M.A., Agulló, E., Marhuenda-Egea, F.C., Sáez, J.A., Paredes, C., Pérez-Espinosa, A., Moral, R., 2018. Valorization of date palm (*Phoenix dactylifera* L.) pruning biomass by co-composting with urban and agri-food sludge. Journal of Environmental Management 226, 408-415.

Zucconi, F., Pera, A., Forte, M., de Bertoldi, M., 1981. Evaluating toxicity of immature compost. Biocycle 22, 54–57.