Co-composting of winery-distillery wastes with orange juice waste

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Abstract

The production of wine and citric juice generates great quantities of wastes, especially in the Mediterranean area, where its treatment and disposal are becoming important environmental problems. The aim of this work was to study the viability of co-composting exhausted grape marc (EGM) with orange juice solid waste (OSW), as well as the effect on the compost quality of the pH correction of the mixtures. Two piles were prepared with mixtures of EGM and OSW, with the only difference of the pH correction, and were composted by the turning system. During the composting process, different parameters, including temperature, pH, electrical conductivity (EC), organic matter (OM), C/N ratio, humic acid-like C (C_{HA}), fulvic acid-like C (C_{FA}) and the germination index (GI) of the mixtures were studied. The composting process was affected by the pH correction, showing the pile with pH correction higher temperatures and a longer thermophilic phase.

Keywords: winery-distillery wastes, citrus waste, compost, pH correction

Introduction

Recently, the increasing agro-industrial production has derived in an important rise of the wastes generated by this activity, the wine industry and the citrus industry being some of the principal agro-food industries in Europe, especially in the Mediterranean area, where the waste generation has been increased.

Worldwide total citrus production was of 94793.1×10^3 tons during 2004/2005 period, 28.1% being used for processing (FAO, 2007). In the citric juice production, a solid residue (mainly formed by peel, membranes and seeds and rejected whole fruits) and a semi-solid residue in the form of juice centrifugation pulp were obtained as waste products (Tripodo et al., 2004). The amount of residue obtained from the fruits could be estimated at 50% of the original whole fruit mass (Cohn and Cohn, 1997). In general, these wastes show an acidic pH, are rich in sugars, fibres and other residual substances, and they cause many economic and severe environmental problems because of their fermentability, due to they are amounted to several tons per day in medium-size processing plant (Tripodo et al., 2004).

On the other hand, exhausted grape marc (EGM) is a solid waste obtained after the process of obtaining alcohol and calcium tartrate in the distillery from by-products generated during the wine-making activities (Bustamante et al., 2007). This waste is produced in great amounts in the Mediterranean countries, where its treatment and disposal are becoming important environmental problems, mainly due to their seasonal character that difficult their management, not optimised yet. Despite the richness of these residues in organic matter and macronutrients, such as K, important factors in soil fertility, the presence of polyphenols, compounds related to phytotoxic and antimicrobial effects, makes it necessary conditioning treatments before using these residues with an agricultural purpose (Bustamante et al., 2008). Composting could constitute a viable alternative to manage this type of wastes, not only treating and reducing the volume of these wastes,

but also producing compost with several characteristics that make them adequate as soil conditioner and fertiliser, as well as soil-borne and foliar plant pathogen suppressor (van Heerden et al., 2002).

Therefore, the objective of this experiment is to study the viability of co-composting exhausted grape marc (EGM) with orange juice solid waste (OSW), as well as the effect on the compost quality of the pH correction of the mixtures.

Material and methods

Composting procedure

In this experiment, two different piles (Pile 1 and Pile 2) were prepared with mixtures of EGM and OSW, with the only difference of the CaO addition to the pile 2 for pH correction. The main characteristics of the starting materials were: pH 5.6, 2.14 dS m^{-1} electrical conductivity (EC), 72.7% organic matter (OM), 55.3 % total organic carbon (C_{org}) and 2.11 % total nitrogen (N_T), for EGM; pH 3.9, 1.91 dS m^{-1} (EC), 94.7% organic matter (OM), 47.4 % total organic carbon (C_{org}) and 1.14 % total nitrogen (N_T), for OSW. The piles (about 200 kg each pile) were composted in a domestic thermo-composter (85 cm high with a 70 x 70 cm base and a 350 L volume). The aeration of the mixtures was natural (the air went through the holes in the base of the composter) and by turnings. The moisture of the piles was controlled weekly by adding the necessary amount of deionised water to obtain a moisture content not less than 40 %, avoiding leachates. The bio-oxidative phase of composting was considered finished when the temperature was close to the atmospheric value and re-heating did not occur. The piles were sampled approximately every 2 weeks during the bio-oxidative phase and after the maturation period. Each sample was divided into two parts, one of which was air-dried and ground to 0.5 mm for analysis and the other was immediately frozen and kept for later analysis.

Analytical methods

In the starting materials and the composting samples, electrical conductivity (EC) and pH were analysed in a 1:10 (w/v) water-soluble extract. The dry matter of the samples was determined after 12 h at 105ºC. Organic matter (OM) was assessed by determining the loss-on ignition at 430ºC for 24 h (Navarro et al., 1993). Total nitrogen (N_T), total organic carbon (C_{org}), 0.1 M NaOH-extractable organic carbon (C_{EX}) and fulvic acid-like carbon (C_{FA}) were determined by the methods described by Paredes et al. (2001). The C_{HA} was calculated by subtracting the C_{FA} from the C_{EX}. The germination index (GI) was calculated using seeds of *Lepidium sativum* L. (Zucconi et al., 1981).

Results and discussion

As Figure 1 shows, the thermophilic phase (temperature > 40ºC) was longer in the pile with pH correction, this pile (Pile 2) reaching the highest temperature values. The more acidic character of the pile 1 influenced the evolution of the thermophilic phase of the composting process, due to the presence of initial low pH values in the mixture diminish the thermophilic action (Sundberg et al., 2004).

In both piles, an increase in the pH values was observed (Fig. 2), probably due to the degradation of acid-type compounds, such as carboxylic and phenolic groups, as well as the mineralisation of compounds, such as proteins, amino acids and peptides to ammonia, throughout the organic matter decomposition, as it is shown in the decrease of the OM (Table 1). The EC values were higher in the pile with pH correction, possibly due to the addition of the salt of calcium (Fig. 2). The EC evolution showed a high variability during the composting process in both piles, increasing slightly at the end of the process. In

addition, the organic matter degradation also produced a fall of the C/N ratio, the values reached being below 20, suggesting that both composts showed an acceptable degree of maturation (Golueke, 1981).

Figure 1. Temperature profile of the pile 1 and pile 2. Arrows indicate turnings for pile 1 (bold type arrows) and for pile 2

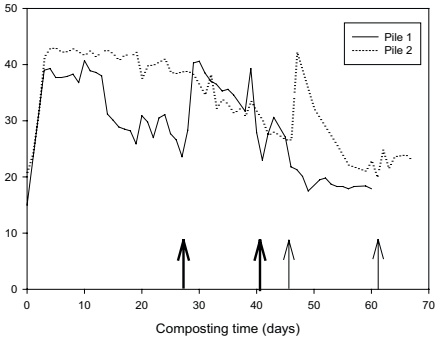

Figure 2. Evolution of the pH (a) and the electrical conductivity (b) in the piles1 and 2

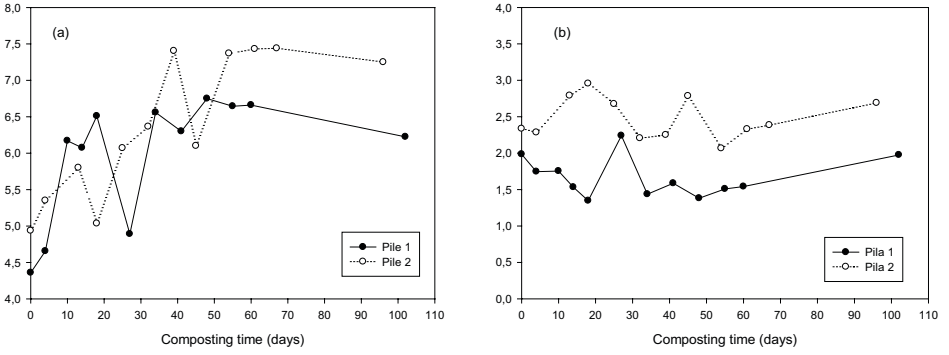

Table 1. Evolution of some parameters during the composting process

Pile 1: EGM + OSW without pH correction					
Days	OM (%)	C/N	CAH (%)	CFA (%)	GI (%)
0	95.5	25,3	2.87	9.36	0
10	93.8	20,4	6.71	4.72	2.9
34	93.7	18,8	7.19	2.36	62.7
60	93.1	17,8	4.99	2.73	84.6
102	92.3	19,8	4.97	2.05	72.9
Pile 2: EGM + OSW with pH correction					
Days	OM (%)	C/N	CAH (%)	CFA (%)	GI (%)
0	94.1	28.7	2.39	8.58	0
13	92.8	22.4	6.06	4.52	45.6
39	91.0	16.4	4.25	2.69	89.2
67	89.9	16.6	3.89	1.92	89.6
96	90.3	19.3	3.68	1.41	79.1

EGM: exhausted grape marc; OSW orange juice solid waste; OM organic matter;
CHA: humic acid-like C; CFA fulvic-like C; GI: germination index

The fulvic acid-like C content fell during composting in both piles (Table 1), while the humic acid-like C content increased, indicating the degradation of easily bio-degradable organic compounds associated with the fulvic acid fraction and the humification of the organic matter. The germination index (GI) values increased in both piles throughout the composting process (Table 1), from very low values initially to values higher than 50 %, indicating a significant reduction of the phytotoxicity and an acceptable level of germination in the composts obtained (Zucconi et al., 1981).

Conclusions

The pH correction influenced in the evolution of the composting process of winery-distillery wastes with orange juice waste, especially in the development of the thermophilic phase, which was longer and with higher temperature values than the pile without correction. However, both composts obtained showed an adequate evolution of the humic fraction, the C/N ratio and a total absence of phytotoxicity.

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