COMPOSTING "ALPERUJO", THE MAIN BY-PRODUCT OF THE SPANISH OLIVE OIL INDUSTRY

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ABSTRACT

"Alperujo" (AL) is the main by-product of the Spanish olive oil extraction industry. It is an acidic and pollutant solid material, which may be transformed into organic fertilisers by composting. In the study described, Grape stalk (GS) was added to AL as a bulking agent in an attempt to increase its porosity and improve the oxygen supply during composting. Several parameters were used to monitor the composting process: temperature, pH, total organic matter, total nitrogen, C/N ratio, fats, water-soluble organic carbon, carbohydrates and phenols, as well as the phytoxicity of the substrate. During the process, they all decreased, except temperature and pH. The composting performance was decisively influenced by the bulking agent added, as well as by the mechanical turning which reduced compaction, and homogenised and re-inoculated the substrate.
Keywords*: *Olive-mill by-product, Composting, Bulking agent, Organic fertilisers.

INTRODUCTION

The prolific production of olive oil in Spain and the introduction of a new technology for its extraction (two-phase centrifugation system) have lead to the yearly generation of not less than four million tons of a pollutant solid by-product called "alperujo" (AL). AL is an acidic material, rich in organic matter, potassium and nitrogen, but also containing fats and water-soluble carbohydrates and phenols (Alburquerque et al., 2004), which may be ecologically and economically transformed into organic fertilisers by composting. Due to its high moisture content and small particle size, several experiments have been carried out (Madejón et al., 1998; Cegarra et al., 2000; Filippi et al., 2002.) to demonstrate the effectiveness of adding supplementary waste materials as bulking agents for its composting. In our experiment, grape stalk (GS) was added to AL as a bulking agent in an attempt to increase its low porosity and improve the necessary oxygen supply during composting.

MATERIALS AND METHODS

The main characteristics of the AL and GS, are reported in Table 1. A pile of 2,600 kg, approximately 2 m wide, 3 m long and 1.5 m high, was prepared by mixing AL with GS plus urea (to decrease the C/N ratio of the mixture) in the following proportion on a fresh weight basis (dry weight basis in brackets): 94.6% AL + 5% GS + 0.4% urea (87/12/1). The mixture was composted for thirty-four weeks using forced ventilation (Rutgers strategy, Finstein et al, 1985) and a ceiling temperature of 55ºC. During the first three months, ventilation periods of one minute followed by another five in repose were used; thereafter, ventilation was reduced to thirty seconds every thirty minutes. The pile was also turned during the fourth, tenth and twenty-first week to improve both substrate homogeneity and oxygen supply and its moisture kept at 40-55% by adding the necessary amount of water with overhead sprinklers.

Electrical conductivity (EC) and pH, organic matter content (OM), lignin, organic carbon

(C), total nitrogen (N), P, K, Ca, Mg, Fe, Cu, Mn and Zn, total fat content, water-soluble organic carbon (WSC), water-soluble phenols (WSPH), water-soluble carbohydrates (WSCH) and germination index (GI) were determined according to the methods previously described by Paredes et al. (2002) and Alburquerque et al. (2004).

Table 1. *Characteristics of the raw materials, "alperujo" (AL) and grape stalk (GS), and the mature compost obtained (dry weight basis).*

Parameters	AL	GS	Compost
Moisture (% f.w.)	63.9	5.9	36.6
EC[a] (dS m^{-1})	4.12	4.24	3.17
pH[a]	5.20	4.40	8.49
OM (g kg^{-1})	948.0	934.1	896.0
Lignin (g kg^{-1})	323.0	362.3	430.4
C (g kg^{-1})	515.0	480.7	470.6
N (g kg^{-1})	8.9	8.0	22.7
C/N ratio	57.9	60.1	20.7
P (g kg^{-1})	1.1	0.6	1.6
K (g kg^{-1})	25.3	20.0	37.0
Ca (g kg^{-1})	1.7	6.3	11.3
Mg (g kg^{-1})	0.8	1.5	2.3
Fe (mg kg^{-1})	201	204	624
Cu (mg kg^{-1})	16	17	24
Mn (mg kg^{-1})	5	14	38
Zn (mg kg^{-1})	13	6	40
GI (%)	nd	nd	83

[a] water extract 1:10.
nd: not determined.

RESULTS AND DISCUSSION

The temperature of the pile remained below 25 ^{o}C during the first four weeks (Fig. 1), probably because the forced ventilation was unable to induce suitable aerobic conditions in the composting substrate. For this reason, the pile was turned on day 30, resulting in a rapid increase in temperature to 55 ^{o}C. A less pronounced rise in temperature occurred after the second turning and no important changes in temperature were detected after the third turning. The long activation phase observed was probably related with the initial low porosity of the substrate, due to the high water content and low particle size of AL, which led to compaction and hindered airflow. Moreover, GS could not absorb the initial excess water of AL, which reduced the free air pores.

The pH was initially acidic and hardly increased during the first month of composting, and neither did the temperature. After the first turning, the pH increased from 5.5 to 7.3, gradually reaching values of between 8 and 9. The loss of OM reached a constant value of approximately 50% after the eighteenth week, the lowest losses coinciding with the persistent acidity and low temperatures at the initial phase of composting.

The N content generally increased during composting, which could be attributed to a concentration effect as a consequence of the reduction of pile weight as OM was mineralised, while a subsequent fall in the C/N ratio was observed from 37 at the beginning of the process to 21 at the end (data not shown). The WSC and WSCH contents clearly decreased during composting, revealing their availability for microbial metabolism. The former decreased rapidly until the tenth week; the latter, on the other hand, only decreased sharply during the first four weeks, coinciding with the low substrate temperatures, and then decreased more gradually until the eighteenth week. After this time and until the end of composting, the values remained nearly constant at around 4 and 1%, respectively.

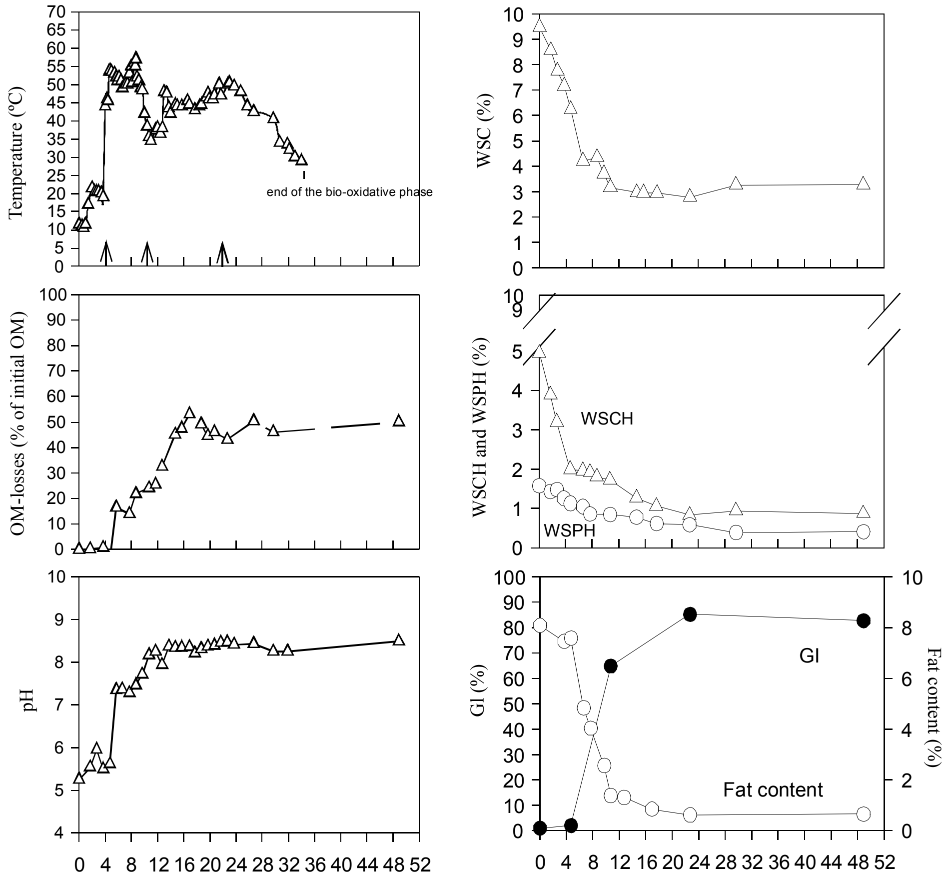

Figure 1*. Temperature profile (arrows indicate turnings), organic matter loss, pH and changes in water-soluble organic fractions, fat content and germination index (GI) during composting.*

Phenolic compounds have been seen to contribute to the phytotoxicity of olive-mill wastes (Capasso et al., 1992) as also to their antimicrobial properties (Pérez et al., 1992). In our substrate, the decrease in WSPH was evident during the first eight weeks but continued declining gradually until the thirtieth week, mainly coinciding with the active phase of composting. The total fat content evolved from the starting value of 8.0% to about 0.7%, the slowest fat degradation rate occurring at the beginning of the process, coinciding with the delayed evolution in pH, low temperatures and the difficulties of substrate aeration. Furthermore, the fat content only started to clearly decrease after the first turning. As shown by the increasing GI values, the high initial phytotoxicity level decreased during composting, coinciding with the above mentioned decline of fats and WSPH.

The non-phytotoxic mature compost obtained was rich in OM (Table 1), nearly half being composed of lignin, which is considered an important precursor of soil humic substances. It also had acceptable potassium and nitrogen contents, the latter mainly in organic form and, thus, presumably not very available for plant nutrition, while the levels of other macro and micronutrients was rather low.

CONCLUSIONS

The addition of grape stalk to "alperujo" decisively influenced its composting performance, although the process still needed mechanical turning even when periodical powerful ventilation was supplied to the composting mass. The benefits gained from turning were presumably connected with reducing the compaction of the substrate, as well as with any homogenisation and re-inoculation effects.

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