Journal of Environmental Management 147 (2015) 132–139

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Evaluation of composition and performance of composts derived from guacamole production residues

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A R T I C L E I N F O

Article history:
Received 12 May 2014
Received in revised form
21 August 2014
Accepted 9 September 2014
Available online 29 September 2014

Keywords:
Avocado
Composting
Guacamole waste
Nursery growing media
Pruning residues

A B S T R A C T

The utilization of organic wastes to improve soils or for growth media components in local farms and nurseries can reduce the environmental pollution linked to waste disposal while increasing the sustainability of crop production. This approach could be applied to waste products generated from the production of guacamole (an emerging activity in the avocado production areas in mainland Spain), where appropriate treatment of this oily and doughy waste product has not been previously reported. The aim of this work is to study the feasibility of co-composting guacamole production residues (GR) with garden pruning waste (PW) as bulking agent, and the possible use of the compost produced depending on its quality. A windrow composting trial using three GR:PW ratios, 2:1, 1:2, and 1:7 was carried out. Temperature, moisture, organic matter, and C/N ratio were used to follow the evolution of the composting process during 7 months. After an additional 3-month curing period, composts were sieved to less than 10 mm and a set of European quality criteria was used to assess compost quality and intended use. In general, the 3 composting mixtures followed the classical process evolution, with minor differences among them. The 1:2 GR:PW ratio appeared most adequate for combining better process evolution and maximum GR ratio. Except for their high pH that limits their use as growing media component in some particular cases, the obtained composts fulfilled the more stringent European standards for commercial composts. Self-heating tests confirmed the high stability of the composts produced. The germination of cress by the direct contact method was satisfactory for composts GR:PW 1:2 and 1:7, showing no signs of toxicity. Avocado seedlings planted in substrates containing 67% of the GR:PW composts exhibited greater plant growth than those in the control treatment, and with no signs of phytotoxicity. The results open an interesting opportunity for the sustainable treatment of avocado fruit by-products derived from guacamole and avocado oil processing.

1. Introduction

Large quantities of liquid and solid residues are produced in the processing of fruits and vegetables that together can account for 93% of all residues generated by the food processing industry (Hang, 2004). This includes fruit and vegetable peels, seeds, pits, cakes, tofu whey, different kinds of process water, and wastewater treatment sludge. The liquid waste is usually disposed of in sewers, whereas most solid wastes are returned to the land for disposal, often illegally dumped, or recycled (Hang, 2004).

The rate of avocado (*Persea americana* Mill.) cultivation has been growing worldwide during the last decades with a total world production of 4.36 million tons in 2012, twice as much as in 1999 (FAOSTAT, 2014). Although avocados are usually consumed as fresh fruits, in salads and avocado-based cuisine, the consumption of minimally processed products, such as guacamole (a sauce made with mashed avocado pulp seasoned with various condiments), or the use of avocado oil for cosmetics and cooking is increasingly growing worldwide.

Avocado processing often generates significant amounts of wastes. In Mexico, the leading avocado producing country, 5% of the

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http://dx.doi.org/10.1016/j.jenvman.2014.09.016
0301-4797/

fruits produced in 2008 were destined for processing (mainly for guacamole) resulting in a total amount of approximately 20,000 tons of generated residues (Dorantes-Alvarez et al., 2012). The main reason for this is that the exocarp and seed accounts for up to 30% of the fruit dry weight in commercial avocado cultivars. Although these by-products could have commercial interest due to their richness in phytochemical substances (Bost et al., 2013), they are usually discarded causing problems with pollution at disposal sites.

In Spain, the only country in Europe with a significant commercial production of avocados, guacamole production is an emerging activity in avocado production areas. As a result of this activity, residues from guacamole production (GR), consisting of peels, seeds and pulp are increasing and, if not properly treated, could become a significant environmental concern.

Composting of organic wastes such as those derived from fruits and vegetables is considered one of the best treatment options from both an economic and an environmental point of view. The composting process reduces toxicity, volume, and moisture content of residues and transforms them into interesting sources of organic matter for agricultural use. Therefore, composting of GR could become an opportunity to increase the sustainability of the production of some local crops with good responses to organic amendments, including avocado. The results obtained could also be of interest for the treatment of residues produced from avocado oil extraction. Despite this interest, the composting of avocado guacamole and oil residues has not been reported. A likely reason for this may be that the doughy texture and oily composition of avocado residues makes their composting difficult.

The effectiveness of recycling residues as soil conditioners or fertilizers depends on their chemical (pH, soluble salts, C/N ratio, nutrient contents, heavy metals, and specific toxicants), physical (bulk density, hydrophysical properties, odour) and biological (presence of pathogens) properties, site characteristics, and the crop. The aim of this work was to study the feasibility of composting GR as a way to obtain high quality composts. The effect of the GR:PW volume ratio was also considered. Following the most recent guidelines to evaluate compost quality, selected chemical characteristics and standard European tests for compost characterization were used to evaluate several possible uses of GR-based compost.

2. Materials and methods

2.1. Composting feedstock

The characteristics of raw materials used for composting are shown in Table 1. GR was obtained from Avomix Factory located in Vélez-Málaga (Málaga province, Spain). It consists of peels and seeds, with a reduced amount of plastic residues. As can be observed in Table 1, GR was a moist material, with a C/N ratio of 56 due to the abundance and large size of avocado seeds. PW was obtained from chipped pruning waste coming from private and public gardens in Vélez-Málaga. The PW was an abundant and heterogeneous residue, composed of several plant residues with palm and pine tree components being particularly apparent. The maximum particle size was 15 cm. At the time of starting the composting trial, this residue was slightly moistened due to rainfall. It presented a C/N ratio of 74 due to its woody character. This product was incorporated as a structuring agent to balance the mushy consistency of GR. Poultry manure (M) was also included in composting mixes as a source of available nitrogen for microorganisms. Aged manure was obtained from a nearby chicken egg farm; due to the previous storage period, this residue was rather mineralized having a high salinity (electrical conductivity), low organic matter (OM) content and a C/N ratio of 10.

Table 1
Characteristics of the composted materials: guacamole production solid residues (GR), green waste (PW) and poultry manure (M).

	Unit	GR	PW	M
Dry matter	g kg^{-1}	319.2 (4.2)[a]	606.2 (20.8)	745.9 (40.2)
BD[b]	g L^{-1}	230.2 (5.1)	103.8 (49.7)	670.3 (56.6)
pH 1:5 vol		7.06 (0.06)	6.40 (0.04)	7.83 (0.08)
EC[c] 1:5 vol	mS m^{-1}	83.3 (6.6)	39.0 (2.7)	611.3 (19.9)
OM[d]	g kg^{-1}	951.4 (5.3)	923.3 (17.7)	156.9 (11.0)
OC[e]	g kg^{-1}	551.8 (3.1)	535.5 (10.3)	91.0 (6.4)
Kjeldahl-N	g kg^{-1}	9.81 (0.33)	7.28 (0.48)	9.19 (0.60)
C/N		56.3 (1.6)	73.8 (5.5)	9.9 (0.3)

[a] Values in brackets are standard deviation, $n = 3$.
[b] Compacted bulk density on a dry matter basis.
[c] Electrical conductivity.
[d] Organic matter.
[e] Total organic carbon.

2.2. Composting piles

The selected system to carry out the trial was windrow composting. Three composting piles were prepared with the following volume ratios of the components described above: 2:1:0.125, 1:2:0.125, 1:7:1 for GR:PW:M respectively. The piles will be coded as GR2PW1, GR1PW2 and GR1PW7 for simplicity. The ratios with greater GR residue (2:1:0.125 and 1:2:0.125) were selected in order to maximize GR ratio in the compost. The mix 1:7:1 was assayed to assess the tolerance of the composting process to wide changes in feedstock ratios. Initially, the three mixes (including all particle sizes) showed similar C/N ratios: 46, 47 and 45 for GR2PW1, GR1PW2 and GR1PW7 respectively.

The dimensions of the piles were 4 m long, 2–3 m wide and 1.5 m high. The piles were built with the aid of a front-loading tractor using the shovel for the volumetric measurement of the wastes. The wastes were deposited on alternate layers of GR and PW, spraying the required volume of M on each layer. Water was gradually added onto each layer to avoid leaching. The residues were mixed and re-watered when turning over the piles. The experiment was initiated on May 4, 2012 and composting piles were turned 5 times on days 41, 83, 123, 167 and 220. A suitable time of turning was selected according to the evolution of the temperature within the piles, which were recorded every 2–3 days using a digital thermometer equipped with a 1 m long probe. The probe was inserted in 6 positions per pile, taking the temperature readings at 50 and 100 cm deep. After the last turning event, the composts were left for an additional 3-month curing period.

2.3. Compost sampling

Raw materials were sampled when the compost piles were built while compost samples were collected from each pile at the start of the composting experiment, after each turning of the piles, and at the end of the maturation period. Separate samples were collected in three positions per pile, making a trial pit and taking the sample in the whole depth. Each single sample was about 10 L. It was assumed that large pieces of wood and avocado seeds would slowly decompose during the composting trial. The samples corresponding to composting evolution and final product were separated into two size fractions using a 10 mm sieve. Both size fractions were weighed and analysed separately. If necessary, the complete sample composition was calculated from the weighted average. For whole samples of raw materials, all sized particles were analysed.