

Amino acid composition of composting cotton waste

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Abstract

Amino acids are an essential part of the active fraction of organic matter in compost which is associated with its capability to act as a fertilizer. Their composition might also be used as a means to assess composting processes. We studied the influence of composting conditions on the amino acid composition of two composts obtained from the same lignocellulosic substrate (cotton waste from carding). Samples of composting substrate were taken at the end of the thermophilic, mesophilic and curing phases of two different composting processes involving different C/N ratios, forced air ventilation (compost 1) and manual turning (compost 2). The total amino acid content increased with time in both processes, but was greater throughout the experiment in compost 1, reaching 145.19 g/kg after 85 days. The total concentration of neutral amino acids increased sharply during the first few days of composting and remained fairly constant after 40 days in both composts. In compost 2 the total concentration of acidic amino acids was more than twice the amount of total basic amino acids during the first stages of composting, and decreased afterwards. The relative molar distribution (RMD) of aspartic and glutamic acids decreased steadily with time in compost 2. A sharp increase (+140%) of the RMD of lysine was found in this compost at the end of the curing period. On the contrary, in compost 1, the RMD of aspartic acid increased during composting, while that of lysine dropped to ~50%. Changes in the amino acid composition were found to reflect the changes in the composition of the microbial population.

Keywords: Amino acids; Cotton waste; Compost analysis

1. Introduction

Large amounts of organic wastes are produced from the processing of agricultural crops in food and textile industries. Disposal of these large quantities of waste material causes serious environmental problems, and also loss of a valuable resource. Composting of agricultural wastes to obtain organic fertilizers or plant growing substrates, which could be used to replace peat, represents a useful alternative.

The problem of defining the quality of compost is still one of the major problems to be solved. Most of the works on the subject are concerned with the characterization of the stable (humified) fraction of the organic matter of compost. Although stabilization of organic matter is of the utmost importance, a good quality of compost also contains a biologically active fraction of organic matter. This fraction is associated with its capability to act as a fertilizer, that is, with the ability of compost to supply plant nutrients, such as nitrogen (N), through the mineralization of decomposable organic compounds.

Amino acids (AA) are an essential part of the

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active fraction of organic matter in soil, where together with amino sugars they constitute the acid soluble fraction of soil organic N.

Recently changes in soil organic matter quality were assessed by examining the relative molar distribution (RMD) of amino acids (Campbell et al., 1991a; 1991b). For compost, information on this subject is scarce and is mostly confined to the composition of water extracts (Chanyasak et al., 1982; Saviozzi et al., 1986) or to the total amount of hydrolyzable protein (Hammouda and Adams, 1986).

Like soil, amino acids in compost are derived from three main sources: the amino acid pool of the substrate, extracellular enzymes and from the cells of the dead and living microorganisms. The amino acid composition of a composting solid waste can therefore be related to the composition of the original amino acid pool of the material and to resynthesis. If the latter prevails, changes in the amino acid composition should reflect the changes in the composition of the microbial community during the different stages of the composting process.

In the present work we studied the changes in the total hydrolyzable amino acid concentration and their relative molar distribution in samples of composting cotton waste taken at the end of the thermophilic, mesophilic and curing phases of two widely different composting processes applied to the same lignocellulosic substrate. The aim of our work is to compare the influence of nitrogen availability and composting conditions on the amino acid content and RMD of compost. To this purpose the initial C/N ratio of the substrate was changed to 35 and 80 by adding oxamide (compost 1) and urea (compost 2), respectively.

2. Materials and methods

The lignocellulosic substrate used for composting was cotton waste from carding containing 14.2% lignin, 53.6% cellulose, 5.8% hemicellulose and 8.2% ash. The amino acid composition of the starting material is given in Table 1.

The two different composting processes considered in the present work involved either continuous forced air ventilation with high water con-

Table 1
Amino acid content and RMD of cotton waste

Amino Acid	mmol/100 g	RMD
Acidic		
Aspartic acid	0.052	9.34
Glutamic acid	0.045	8.08
Total acidic	0.097	17.42
Basic		
Histidine	0.005	0.90
Lysine	0.014	2.51
Arginine	0.013	2.33
Total basic	0.032	5.75
Neutral		
Threonine	0.021	3.77
Serine	0.040	7.18
Proline	0.033	5.93
Glycine	0.071	12.75
Alanine	0.053	9.52
Valine	0.037	6.64
Isoleucine	0.018	3.23
Leucine	0.029	5.21
Tyrosine	0.010	1.80
Phenylalanine	0.012	2.15
Total neutral	0.324	58.17
Sulphur containing		
Methionine	0.075	13.47
Cystine	0.029	5.21
Total sulphur	0.104	18.67

tent and low C/N ratio (compost 1) or manual turning with low water content and high C/N ratio (compost 2). The C/N ratio of cotton waste was adjusted to 35 with oxamide in compost 1 and to 80 with urea in compost 2. Details concerning temperatures, pH, weight losses and cellulose and hemicellulose decomposition as well as qualitative changes in the composition of extractable organic matter and humic substances are reported elsewhere (Baca et al., 1992). Samples were collected from the bulk of ~ 20 kg of composting substrate at the end of the thermophilic phase, after 20 days of composting, at the end of the mesophilic phase after 40 days of composting and at the end of the curing period after ~ 90 days. Compost samples were freeze dried and ground with a ball mill and stored at 5°C before analysis. Amino acids were analysed quantitatively by high

performance liquid chromatography (HPLC) using the Waters Pico-Tag Method with precolumn derivatization and phenylisothiocyanate (Cohen et al., 1989) after hydrolysis of ~ 0.5 g of ground compost samples in 15 ml 6 M HCl + 1% phenol for 24 h at 110°C. Nor-leucine was used as an internal standard.

3. Results and discussion

3.1. Total amino acid content

The total amino acid concentration of cotton waste increased very rapidly in both processes (Fig. 1). After only 3 days of composting the total amino acid content of compost 2 was already ~ 100 times that of the starting material (0.557 mmol/100 g). The increase was greater in compost 1 (87.5 mmol/100 g after 18 days) where the use of forced air ventilation caused a quicker decomposition of the substrate. This was illustrated by the steeper rise in temperature recorded

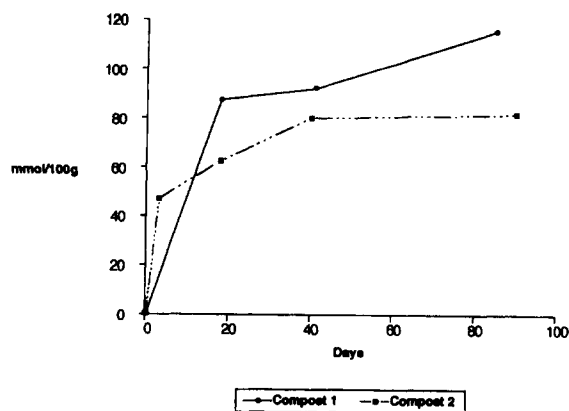


Fig. 1. Total hydrolyzable amino acid content of composting cotton waste: compost 1 (initial C/N = 35); compost 2 (initial C/N = 80).

in the bulk of the composting mass and by the higher weight loss observed during the first 20 days. The total amino acid concentration of com-

Table 2
Amino acid composition and RMD of compost 1

Amino acid	18 days		41 days		85 days	
	mmol/100 g	RMD	mmol/100 g	RMD	mmol/100 g	RMD
Acidic						
Aspartic acid	4.29	4.90	2.85	3.09	14.41	12.47
Glutamic acid	9.77	11.17	9.04	9.81	13.52	11.70
Basic						
Histidine	1.59	1.82	2.91	3.16	2.13	1.84
Lysine	7.37	8.42	9.01	9.77	4.48	3.88
Arginine	4.07	4.65	3.86	4.19	5.87	5.08
Neutral						
Threonine	5.30	6.06	4.75	5.15	6.88	5.95
Serine	6.09	6.96	7.47	8.10	8.25	7.14
Proline	5.48	6.26	6.23	6.76	5.76	4.98
Glycine	10.18	11.63	11.73	12.72	11.27	9.75
Alanine	9.64	11.02	9.81	10.64	11.04	9.55
Valine	8.21	9.38	7.84	8.50	8.20	7.10
Isoleucine	4.23	4.83	4.39	4.76	5.68	4.92
Leucine	6.96	7.95	7.24	7.85	8.80	7.62
Tyrosine	2.38	2.72	2.60	2.82	3.52	3.05
Phenylalanine	0.95	1.09	1.29	1.40	4.57	3.95
Sulphur containing						
Methionine	0.83	0.95	0.61	0.66	0.86	0.74
Cystine	0.16	0.18	0.57	0.62	0.31	0.27

post 1 remained greater than that of compost 2 throughout the thermophilic and mesophilic phases (20–40 days) and reached its highest value (145.19 g/kg of compost dry wt.) at the end of the curing period (85 days of composting). At this stage the total amino acid content of compost 1 was ~50% greater than that of compost 2. At the end of the curing period, the overall weight loss was approximately the same in both composts, indicating that the overall biological activity such as can be estimated by the decomposition of the substrate was approximately the same, irrespective of the composting conditions. The greater nitrogen availability in compost 1, which had an initial C/N ratio of 35, had, therefore, a fundamental influence on the total amino acid content of the compost.

In soil leaf litter the amounts of amino acids decrease with advancing humification (Lähdesmäki and Piispanen, 1989) indicating that decomposition overcomes resynthesis: in compost microbial synthesis prevails so that the total amino acid content increases (Hammouda and Adams, 1987).

As the increase in the total concentration of amino acids in the composting cotton waste shows, the destructive degradation of the original amino acid pool was very soon overcome by the natural synthesis of amino acids in growing thermophilic microorganisms. Changes in the amino acid composition of compost therefore reflect changes in the composition of the microbial population from thermophilic (50–60°C) to mesophilic (40–30°C) microorganisms.

3.2. RMD of compost

In soil the only amino acids that showed significant effects of management practices on RMD were aspartic acid, arginine and leucine (Campbell et al., 1991a). No attempts to identify which microorganism types were associated with these changes were made.

In compost 1, the relative molar concentration of lysine decreased (Table 2), after 85 days of composting, to ~50% of the amount found at the end of the mesophilic phase, while the relative total acidic amino acid concentration increased sharply because of a 3-fold increase in

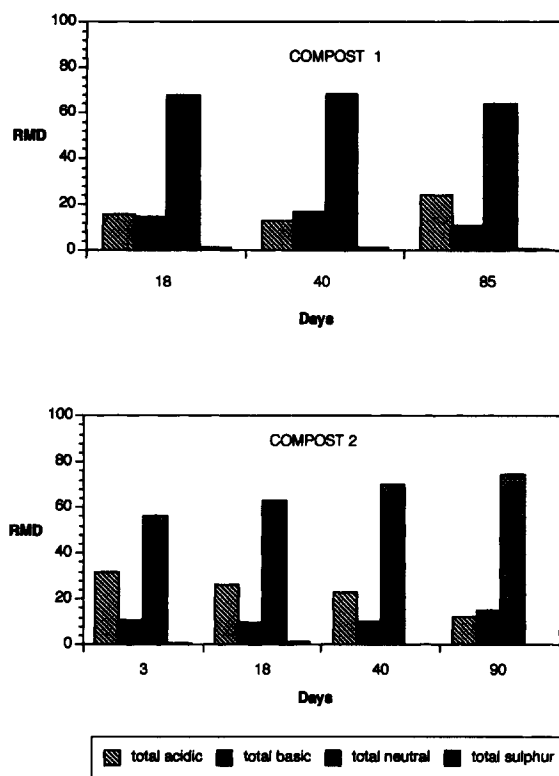


Fig. 2. RMD of total acidic, total neutral and total basic amino acids in composting cotton waste.

the relative molar concentration of aspartic acid.

The trend of the relative molar distribution of the single amino acids was more regular in compost 2 (manual turning) notwithstanding the fact that temperatures occasionally surpassed 70°C, with the temperature curve showing a saw-toothed pattern from day 1 to day 35 because of the poor temperature control (Baca et al., 1992). Total acidic amino acids decreased during the curing period, reducing their relative molar concentration of ~36% of the initial value after 90 days of composting (Fig. 2). The relative molar distribution of aspartic and glutamic acids decreased steadily with time (Table 3). During the same period the total neutral amino acids increased ~28% while the relative molar concentration of basic amino acids remained fairly constant. Only lysine increased sharply (141%) at the end of the curing period.

Campbell et al. (1991b) found that addition of

Table 3
Amino acid composition and RMD of compost 2

Amino acid	3 days		18 days		41 days		85 days	
	mmol/100 g	RMD	mmol/100 g	RMD	mmol/100 g	RMD	mmol/100 g	RMD
Acidic								
Aspartic acid	7.94	16.80	8.25	13.16	9.13	11.75	2.60	3.25
Glutamic acid	7.23	15.30	8.21	13.09	8.77	11.28	7.10	8.88
Basic								
Histidine	0.80	1.69	1.13	1.80	1.39	1.79	1.38	1.73
Lysine	2.06	4.36	2.24	3.56	2.93	3.77	7.25	9.07
Arginine	2.13	4.51	2.89	4.61	3.38	4.35	3.68	4.60
Neutral								
Threonine	0.03	0.06	4.52	7.21	4.04	5.20	5.05	6.32
Serine	3.36	7.11	5.15	8.21	5.63	7.24	5.74	7.18
Proline	2.84	6.01	3.27	5.21	3.92	5.04	4.93	6.17
Glycine	4.53	9.59	6.05	9.65	11.65	14.99	9.38	11.73
Alanine	4.59	9.71	4.73	7.54	7.17	9.23	8.97	11.22
Valine	3.83	8.10	4.71	7.51	5.49	7.06	7.45	9.32
Isoleucine	0.24	0.51	2.58	4.11	3.51	4.52	3.95	4.94
Leucine	3.76	7.98	4.33	6.91	5.53	7.12	6.83	8.54
Tyrosine	1.53	3.24	1.88	3.00	2.30	2.96	4.45	5.57
Phenylalanine	1.96	4.15	2.08	3.32	2.91	3.74	1.02	1.28
Sulphur containing								
Methionine	0.34	0.74	0.56	0.89	0.05	0.06	0.03	0.04
Cystine	0.07	0.15	0.13	0.21	0.02	0.03	0.15	0.19

N as ammonium nitrate to the top soil reduced the RMD of total acidic AA, while increasing that of the total neutral and total basic AA. In our experiment the RMD of total acidic AA increased with time in compost 1 (initial C/N = 35), reaching 24.17% after 85 days. On the contrary, a decreasing trend was observed in compost 2 (initial C/N = 80).

The relative molar distribution of amino acids of compost 1 at the end of the curing period was very close to that of a well stabilized microbial population such as that found in an organic matter rich soil (Campbell et al., 1991a; 1991b). The same similarity with the relative molar distribution (RMD) of amino acids of organic soils was reached in the process involving manual turning (compost 2), after only 18 days. Although it may be premature, the fact that at the end of the thermophilic phase humic substances extracted from compost 2 had already achieved a degree of

complexity, which was reached by humic substances extracted from compost 1 only after 85 days (Baca et al., 1992), suggests that this might not be a pure coincidence. At present our data are insufficient to indicate whether the amino acid composition can be used to assess compost maturity or composting processes. It is possible however that amino acid composition may be useful for compost characterization.

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