Bacillus属微生物による有機性廃棄物の効率的なコンポスト化技術

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論　　文　　要　　旨

＊ 論文内容の要旨を以下確認する。

審査委員長　　印

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論　文　題　目　：

Bacillus 属微生物による有機性廃棄物の効率的なコンポスト化技術

要　旨

1. はじめに

有機性廃棄物の処理は環境に負荷を与えており，かつ社会問題となっている．有機性廃棄物には，食品廃棄物や汚泥，家畜糞尿及び発電所取水口付近に付着するムラサキイガイなどがある．食品廃棄物の約 73%は焼却されており，水分含量が高いため焼却温度の低下を招き，包装材などに用いられる塩素系化合物共存下で焼却させると発ガン性の強いダイオキシン類が発生することが指摘されている．また，ムラサキイガイは，埋立や焼却により処分されてきた．埋立処分では腐敗による悪臭や溶出成分による土壌汚染が問題となる．焼却処分においては塩水を含んだ新聞紙であってもダイオキシン類が発生することが報告されており，海水を多量に含んだムラサキイガイも同様と言える．

したがって，食品廃棄物を焼却せず，微生物を用いて効率良く分解するコンポスト化技術の開発は，環境負荷低減のため大変重要である．既に，家畜糞尿の 90 %は数ヶ月かけて堆肥化され，リサイクルされている．しかし，現在までのコンポスト化技術は，自然発生や複数の微生物を用いているので再現性に乏しく，かつ生物に対する安全性が立証されておらず，処理する過程で温度が上昇するまでに 1～3 日と長くかかっている．

本研究では，問題を解決するために食品廃棄物分解能力の高い微生物を単離し，食品廃棄物の分解実験を行った．微生物を効率よく働かせるには機械の運転条件も重要であるので，空気量や攪拌速度についても検討を行った．さらに，微生物による海水を多量に含んだムラサキイガイの効率的なコンポスト化技術の構築を行った．

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2. 微生物を用いたオカラ分解とコンポストの安全性評価

土壌から単離した微生物から，魚を栄養源として分解能力の高い微生物一株を選択した．この微生物は *Bacillus* sp. と同定され，*Bacillus* sp. HR6 株（FERM P-14116）と命名した．食品廃棄物として入手が容易で，成分が比較的均一なオカラを以後の実験で使用した．*Bacillus* sp. HR6 株によるオカラ分解時の発生熱は *Bacillus subtilis* ATCC6051 株よりも高く，分解能力が高いことを示唆した．有機質処理装置を用いて *Bacillus* sp. HR6 株によるオカラ分解を行った結果，投入から 8～10 時間で発生熱が 70 ℃を超え，24 時間後に約 38 %の固形分が消失した．その時の空気量と攪拌速度は，それぞれ 2 ℓ /min･kg ，2 rpm であった．オカラ分解時の発生熱と有機質の消失から見る限り，オカラの分解には 24 時間で十分である．

オカラ分解物のクロマトグラフィー分析を行った結果，分子量 1500 以下の物質が，増加することが判明した．また，オカラ分解物の再利用を検討し，生物に対して安全であり，かつ土壌改良剤として有用であることが明らかとなった．なお，*Bacillus* sp. HR6 株の 16S rDNA 部分塩基配列解析の結果，*Bacillus subtilis* と非常に近縁な菌株であることが示唆された．

3. 微生物によるムラサキイガイ有機質の分解

ムラサキイガイの貝殻を破損して海水を放出させた後，*Bacillus* sp. HR6 株を用いて処理を行った．破砕後のムラサキイガイの水分含量は高かったため，オガクズを用いて水分調整を行った．*Bacillus* sp. HR6 株が活性する水分含量の最適値は 30 %であった．76 時間処理後，120.5 kg のムラサキイガイが，82.5 kg に減少した．分解過程で発生した二酸化炭素は 12.5 時間後，ピーク値 15,000 ppm を示し，発酵熱も 65 ℃となった．アンモニア発生濃度は 58 時間後，最大値 720 ppm を示した．オガクズを含むムラサキイガイ微生物処理品の C/ N 比は 22.6 であり，ムラサキイガイの C/ N 比が 5.9 であったことから，オガクズの主成分の繊維が C/ N 比を引き上げた．

ムラサキイガイ中の全有機質について微生物処理を行った．貝殻破砕により，海水を貝内部から流出させた．貝殻を含む残りの有機質は，微生物の活動に最適な水分含量 (約 30 %) に調整するため，圧搾処理を行った．各工程で生じた排水のけん濁有機質は，凝集・沈殿させて汚泥として回収した．洗浄・圧搾後に得られた固形有機質及び汚泥を *Bacillus* sp. HR6 株を用いて処理 (45 時間) した結果，固形有機質の 41 %，汚泥の 20 %が消失した．C/ N 比は，固形有機質処理品が処理前の 6.0 から 5.1 へ，汚泥処理品が 12.8 から 12.5 へとそれぞれ減少した．オガクズを添加せず処理することにより，C/ N 比が 22.6 から 5.1 へと改善され，かつコンポスト化が迅速に行うことができた．その結果，処理量の低減により装置の縮小が可能となった．

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4. むすび

本研究により，単一微生物 *Bacillus* sp. HR6 株を用いてオカラの分解を行うことにより，8~10 時間という短時間で発生熱が 70 ℃を超えることが確認された．オカラ処理品の生物に対する安全性と土壌改良剤としての有用性が明らかとなった．さらに，*Bacillus* sp. HR6 株による海水を多量に含んだムラサキイガイ有機性廃棄物の効率的なコンポスト化技術を確立することができた．

* Year of Degree Conferment
* Number of Degree Conferment

Abstract of Dissertation

* I hereby confirm the following abstract of the Dissertation

Chairperson the Examination Committee

Candidate	Kenji Maeda
Division	Maritime & Transportation Systems Science
Academic Advisor	Shinichi Nagata

Title of Dissertation :

Efficient Composting Technology of Organic Wastes by *Bacillus* sp.

Abstract

1. Introduction

The processing of an organic waste is giving a stress to the environment and thus this is one of serious social problems. There are organic wastes such as food wastes, sludge's, feces of livestock, blue mussels that adhere near the intake of the cooled seawater at the power plants. At present about 73 % of food wastes are incinerated. Huge amount of water in food wastes causes the temperature of combustion in the chamber to decrease, which may lead the synthesis of highly toxic and carcinogenic compounds like dioxin when food wastes are burned with the compounds containing chlorine atom in packing material. Moreover, blue mussels have been processed by reclamation and incineration. The problem of reclamation disposal is the occurrence of bad smell due to the decay and the soil pollution by dissolved organic substances. Furthermore, it was also reported that dioxin will be possibly occurred when the newspaper containing salt was burned.

Therefore the development of the composting technology that efficiently decomposes by microorganism is very important to reduce the environmental stresses without incinerating the food waste. Until now about 90 % of livestock feces are laid for several months to make the compost, which is reused as soil fertilizer. However, the composting technology is lacking in reproducibility because of dependence on spontaneous generation or plural microorganisms and

the safety to creatures is not yet proved. Before temperature rises in the process of composting, it will have started for a long time with 1 - 3 days.

To solve the problem, we isolated microorganism that has the high capability for the decomposition of food wastes. In this connection, we tried to carry out the experiment that decomposes food waste using sole microorganism to obtain the safety to creatures as well as the high reproducibility. Since the operation conditions for machinery were also important to increase the activity of microorganism, the amount of air and the mixing speed were also examined in detail. In addition, we set it as the purpose of research to establish the efficient microbial decomposition processing of blue mussels including huge amount of seawater.

2. Microbial Decomposition of Bean Curd Refuse and Safety Evaluation of Compost

Sole microorganism that can decompose fishes in a short time was chosen from several kinds of microorganisms isolated from soil. This microorganism was identified as *Bacillus* sp. and we named it as *Bacillus* sp. HR6 (FERM P-14116).

Since the acquisition was easy and the ingredient was comparatively uniform, bean curd refuse was used as food waste in the following experiments. The heat generated in bean curd refuse decomposed by *Bacillus* sp. HR6 was higher than that of *Bacillus subtilis* ATCC 6051, while *Bacillus* sp. HR6 had a higher decomposition capability. We carried out the decomposition of bean curd refuse by *Bacillus* sp. HR6 in an organic waste decomposition machine. As a result, about 38% of the solid substances disappeared after 24 hours. Through the decomposition, heat generation of more than 70 ℃ was observed after 8 - 10 hours. The operation parameters of the machine was as follows: the air delivered was 2 ℓ /min/kg of bean curd refuse and the mixing speed was 2 rpm. Therefore, we judged that it was enough to decompose the bean curd refuse within 24 hours from generation of the heat and disappearance of organic matters.

Chromatographic analysis of bean curd refuse decomposed by *Bacillus* sp. HR6 showed that the amount of substance 1500 of molecular weight or less increased. Furthermore, it was proved that the products decomposed from bean curd refuse were safe to creatures and useful as a soil fertilizer. In addition, the analysis of the partial 16S rDNA sequencing of *Bacillus* sp. HR6 suggested that this bacterium is placed in a near position with *Bacillus subtilis*.

3. Microbial Decomposition for Organic Matter of Blue Mussels Taken from Sea Water

Blue mussels containing shells were decomposed by *Bacillus* sp. HR6 after treatment with smashing machine. We had to add sawdust to organic matter of blue mussels to adjust the water content to 30 % because *Bacillus* sp. HR6 is activated in such water content condition. Net weight of 120.5 kg was reduced to 82.5 kg after 76 hours of decomposition. Concentrations of

generated carbon dioxide and ammonia showed the peak values of 15,000 and 720 ppm after 12.5 and 58 hours, respectively. At 12.5 hours, the heat generation (as well as the generation of carbon dioxide) showed the peak value of 65 ℃. The ratio of total amounts of carbon and nitrogen was 22.6 after 76 hours of decomposition. The ratio of carbon and nitrogen in blue mussels was 5.9, which was attributed to the presence of fiber in sawdust.

All organic matters of blue mussels were decomposed by the strain of *Bacillus* sp. HR6. Seawater trapped in the shells was discharged by smashing shells. The water content of solid organic matter including broken shells was reduced around 30 % by using the present machine. Wasted water obtained in each processing was gathered, and flocculating agents were added to recover the organic matters as sludge. Solid organic matters and sludge were applied to the detection of decomposition. After 45 hours, 41 % (w/w) in solid organic matter and 20 % (w/w) in sludge were disappeared. Total carbon and nitrogen ratios were reduced from 6.0 to 5.1 for the solid organic matter and from 12.8 to 12.5 for the sludge, respectively. The carbon and nitrogen ratio has been improved from 22.6 to 5.1 by the ability make moisture adjustment without adding sawdust, and processing of compost was able to carried out quickly. Furthermore, the machine became small and small by the reduction of the sample amount.

4. Conclusion

According to the results of the present study, the heat generation of more than 70 ℃ was observed after 8 - 10 hours through the decomposition of bean curd refuse by *Bacillus* sp. HR6. The compost obtained was proved to be safe to creatures and useful as a soil fertilizer. Furthermore, we established the composting technology that decomposes efficiently the blue mussels involved in seawater by *Bacillus* sp. HR6.