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Maturity Evaluation of Pig Manure Compost by Constituents of Organic Matter Influenced by Microbial Activity

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Regarding to maturity evaluation of pig manure compost mixed with saw dust, change of constituents of organic matter influenced by microbial activities were investigated. Throughout the two stages of active composting period, we obtained a lot of data related to compost stabilization. However, we found out that only a couple of parameters could be used for adequate evaluation of compost. We, therefore, decided that total sugar and reducing sugar could be used for the reasonable standard criteria of maturity during composting process, even though some enzyme activities by phosphates and cellulase reactions were obtained and compared. Because the other parameters such as contents of lignin, cellulose, and organic acids were difficult to be used for maturity evaluation of pig manure compost.

Key words: *maturity evaluation, compost, microbial activity.*

Compost has been used widely among farmers from ancient ages, and in these days it would be newly focused in view point of organic farming and recycling of organic wastes. The interest of organic fertilizer was being increased by pig farming industry in Korea, because the production of animal manure rapidly increased to 15 million M/T in 1996, as well as the domestic demand of compost of about 6.5 million. Therefore. the proper composting and other recycling methods which were based on quality evaluation standard for commercial composts should be developed to protect our environment and vulanable agricultural system.

Therefore, a number of studies for evaluation of compost maturity have been conducted during last few decades. They may be grouped into five categories such as physical tests, microbial activity parameters, measuring metabolic activity, biomass count, and observation of the easily biodegradable constituents.

Levi-Minzi *et al.*[1)] investigated the contents of lignin, cellulose and hemicellulose from fresh and matured farmyard manure, and Riffaldi *et al.*[2)] also studied some chemical parameters including cellulose, hemicellulose, lignin and phenols for evaluating compost maturity. Sugahara and Inoko[3)] also reported the humus composition and humic acid characterization by UV/vis spectroscopy in order to investigate the rotting and maturing process of city refuse compost. On the other hand De Nobili *et al.*[4)] compared the ratio between non-humified and humified fractions during composting. Saviozzi *et al.*[2)] suggested humification index is the most appropriate standard for compost maturity. And Garcia *et al.*[5,6)] studied contents and characterization of humic acid during compost process.

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Harada *et al.*[7)] mentioned the ratio of the carbon in reducing sugar to the total carbon could be useful parameter for estimating the degree of maturity of city refuse compost. Also Garcia *et al.*[8)] studied with four different kinds of composts and soluble sugar contents decreased in accordance with composting period. Chino *et al.*[9)] studied some enzyme activities such as cellulase and protease during composting period, and Shin and Lee[10)] also studied changes of cellulase, phosphatase, urease and amylase activities during composting process.

Since Hertelendy[11)] developed a technique to determine qualitatively the degree of maturity or the state of humification of compost, and Inoko.[12)] Among these evaluation methods ever developed, the circular chromatography test modified by Morel *et al.*[13)] and Lim *et al.*[14)] turned to be not suitable for evaluating the maturity of beef-cattle manure compost with sawdust because this method was only useful to determine the maturity of food refuse compost.[15)]

Referred to these previous evaluation technologies, some biochemical parameters by microbial activity such as contents of organic acid, total sugar, reducing sugar, and activity of some enzymes were selected and investigated to be set for the possible index for maturity evaluation during composting process and in the same time some organic matter parameters such as contents of cellulose and lignin, changes of OD of alkaline extracts were compared. Analysis were done by NIR and circular paper chromatograph method.

Materials and Methods

Composting and sampling. Composting process was carried out two stages of 20 days of active composting period and 100 days of stabilizing period at Sinheung Farm located in Yeonmueup, Nonsansi, Chungnam. Agitated bed composting system was used for active composting and 0.3 m^3 of plastic tank used for stabilization. Mixing ratio of pig manure to sawdust was 2 : 0.37 (v/v) and initial water content of mixture was adjusted to about 65%.

Samples, passed through 1mm sieve for analysis, were collected at 80 cm depth on 1, 4, 10, 20, 30, 50, 80 and 120 days after composting

Analytical methods. All reagents used in this experiment were higher grades of Jensei GR, Sigma GR and HPLC grade of T.J.Baker. Analysis were done by refrigerated centrifuge (CR20132 Type, Hitachi), Gas liquid chromatograph (DS6200, Do-Nam System), Diode Array spectrophotometer (HP8452), Near Infrared spectrophotometer (model 6500, NIR system).

Analysis of cellulose and lignin was followed by Seo,[9] total sugar reducing sugar, organic acids were analysed by A.O.A.C. method, OD value of alkaline extracts by Watanabe and Kurihara (1982), circular paperchromatographic test by Inoko[12], and direct scanning of 2 g sample by Near Infrared spectroscopy.

For other components, following methods were used: Amylase, cellulase, xylanase activity,[17] phosphatase activity,[18] and urease activity.[19]

Results and Discussion

Cellulose and lignin. Fig. 1 showed the changes of cellulose and lignin contents during the composting process of pig manure. Cellulose content was about 24% at the 1st day, and then decreased to only 1% during active composting stage, it continuously decreased during stabilization period and recorded 18% at 120 days after composting. On the other hand lignin content was continuously increased to about 2-fold of the initial content at 120 days after composting. We assumed that this was caused by transformation of cellulose and hemicellulose into sugars and lignin which were not easily decomposed. From these results it turned to be not reasonable to be used for the maturity evaluation index because the contents of these components in compost could be variable depending on the initial contents of cellulose and lignin and the given mixing ratio of pig manure and saw dust.

Total sugar and reducing sugar. The changes of total and reducing sugar contents in Fig. 2 showed that total sugar content approached to the maximum at 20 days after active composting period, and then decreased continuously until 120 days. Reducing sugar also showed a similar pattern of the changes of total sugar content. Especially at the 20 day total sugar and reducing sugar contents were almost the same, indicating that the most of sugar contents in compost were composed of reducing sugar.

Harada *et al.*[7] reported the reducing sugar contents increased continuously during the first week of the

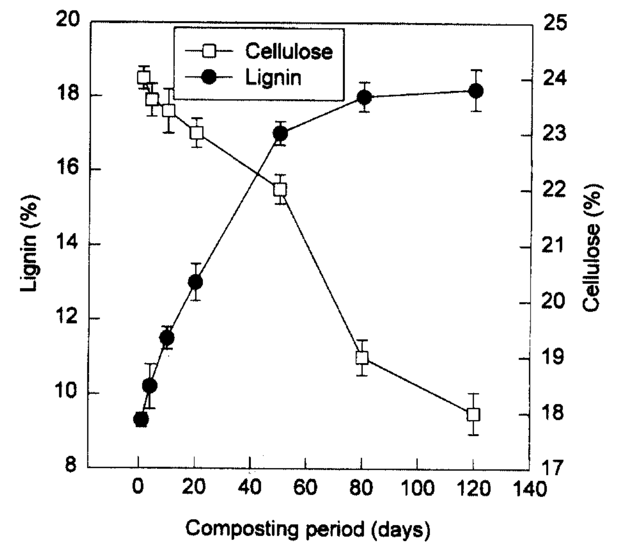

Fig. 1. Changes of cellulose and lignin during the composting period.

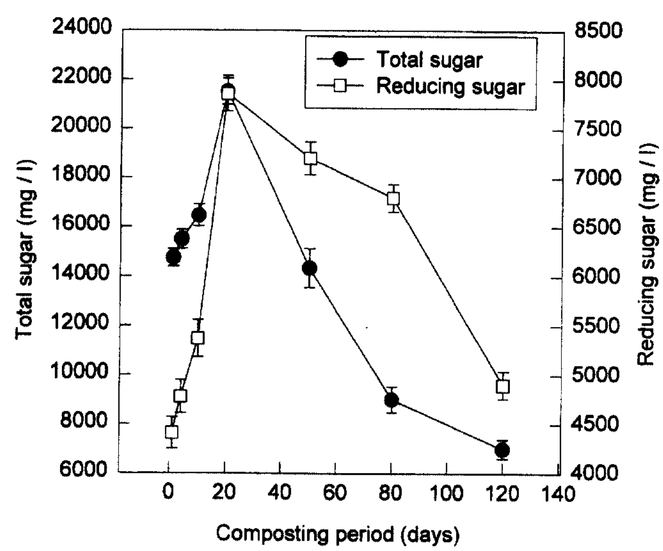

Fig. 2. Changes of total sugar and reducing sugar during the composting period.

composting. But it was gradually decreased until reaching to stabilized state besides rapid decrease during the second week. And Garcia *et al.*[20] mentioned that soluble sugar contents in water extract of municipal sludge compost could be used as a good standard of composting.

These reports and investigation obtained from our experiment the change of sugar contents could be used for the index of evaluation of compost processing, although it was not easy to use as the standard index of maturity evaluation for final compost.

Organic acids. During compost processing organic acids, toxic for growth of plants, were produced by decomposition of sugar derived from carbohydrates.

The changes of organic acids during composting period showed that production of organic acids were active in early stage of composting (Table 1). At the initial stage organic

Table 1. Changes of organic acids during composting period. (unit: mg/l)

Organic acids	Day of composting					
	1	4	20	50	80	120
Acetic acide	4000	3200	1200	<50	<50	<50
Butyric acid	2000	400	<50	<50	<50	<50
Isobutyric acid	500	<50	<50	<50	<50	<50
Propionic acid	7800	7400	5300	6200	5400	2000
Valeric acid	300	<50	<50	<50	<50	<50
Isovaleric acid	500	<50	<50	<50	<50	<50

acids produced were in the order of propionic>acetic> butyric>isobutyric≅isovaleric>valeric acid. Among the organic acids recovered from the decomposition of pig manure isobutyric, and valeric acids were sharply decreased and disappeared at the 4th day after starting compost. On the other hand the rest of organic acids were rarely detected from 20 day after composting except propionic and acetic acids which were gradually decreased even after 50 days after composting.

Devleeschauwer *et al.*[21] reported over 300 mg/L of acetic acid was harmful to plant growth, And Chanyask *et al.*[1] investigated that propionic and n-butyric acids except acetic acid were not only existed in unmatured compost. but also were toxic to the plant growth. It was proved by the results of the germination index test which showed a similar results of Devleeschauwer *et al.*[21] and Chanyask *et al.*[22] Neverthless the contents of these organic acids which were known to be harmful to plant growth decreased below the unharmful level while compost proceeded for a long time. Therefore, the compost used should be processed at least 80 days of stabilization period that the harmful organic acids could not be produced when it was applied in soils.

Photometric changes of alkaline extracts. Color of alkaline extract of compost could be brown to dark brown in proportion to composting period. Morel *et al.*[13] suggested the rapid and convenient method for evaluation of composting was achieved by measuring OD at 450 nm of 600 nm for color of the humic compounds extracted with 0.1 M-$Na_4P_2O_5$. This method could be used a supplementary method to possible analysis for the results of circular paper method.

Fig 3. showed the results of OD of alkaline extracts. OD of alkaline extract was 0.27 at 1 day after active composting period. It reached 0.84 and 0.97 at 20 days and 80 days, whereas decreased to 0.87 at 120 days after treatment. Increase of OD was influenced by the most of chromophore groups such as conjugated double bond which could be produced by lignin decomposition.

Presumably, it could be possible to be used as one of the simple standard index of composting know composting process, as far as we developed the incise color differentiation based on the row materials of compost and water contents.

Circular paper chromatography method. The results of circular paper chromatography did not reveal the special differences during whole composting period. At the 1st day the front of developing zone was comparably regular smooth line, and this trend continued to 120 days after composting.

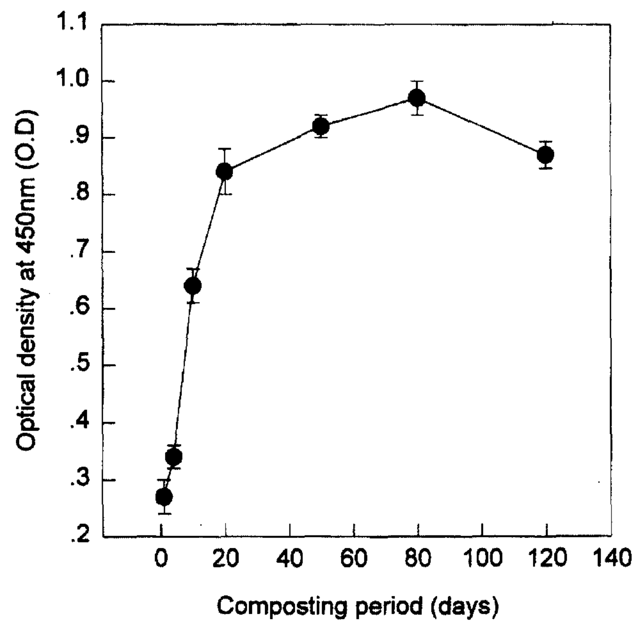

Fig. 3. Change of optical density at 450 nm of the alkaline extracts during the composting period.

Hertelendy[11] said the reason of the smooth form on the chromatographic paper was the humus produced during composting. He also mentioned that the ring shape was found at marginal circle at the first step of active composting period, and the needle form was generated at the second step of humus production period, and at the third step the needle form could be clear and be spread to the radiative direction. Inoko[12] and Lim *et al.*[14] reported that production of amino acids, sugars, phenolic compounds, which were synthesized various amines, carbonyl compounds, and melanoid compounds by condensation at the high temperature. were increased with decomposition of organic matters by the activity of microorganisms. They said that those synthesized compounds found to be the saw-tooth shape on the paper. Considered these results related to the circular paper chromatography, the composting degree by this method for compost of pig manure could not be desirable.

In this experiment Near Infrared (NIR) spectroscopy was

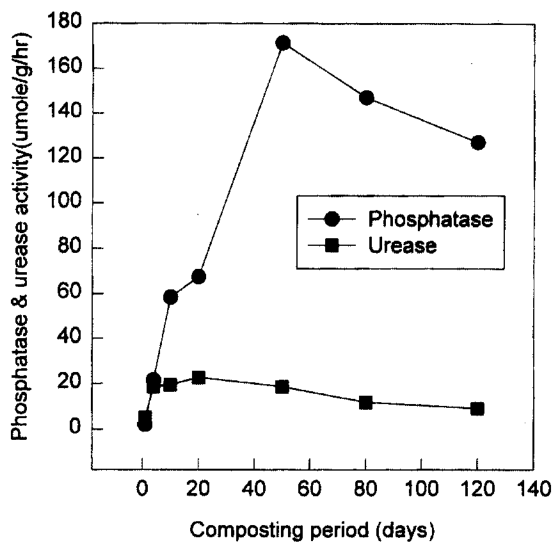

Fig. 4. Changes in activity of phophatase and urease during the compositing period.

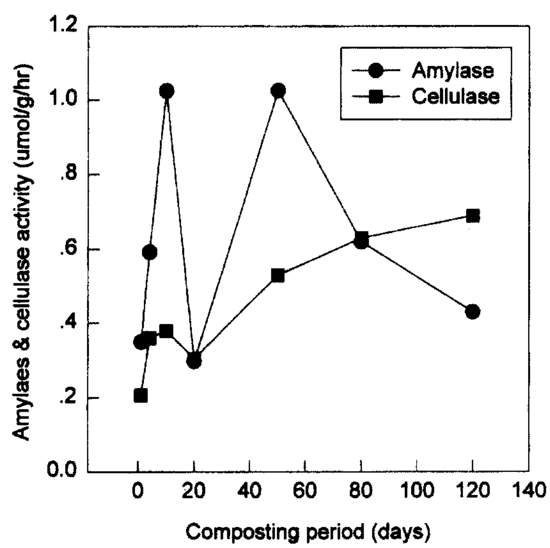

Fig. 5. Changes in activity of amylase and cellulase during the composting period.

used for the evaluation of composting degree at the two ranges of 1400-1500 nm and 1900-2000 nm. Some absorption bands were found that the latter was increased during composting period. Sugahara and Inoko[3] used NIR for the evaluation of composting degree, and found the humic acid contents was between ranges of 1700-1600 cm^{-1} and 1550-1500 cm^{-1}. It seemed to be caused by the carboxyl group absorbtion at 1630 cm^{-1}, and some alcoholic compounds with carbonyl bond at 1550 cm^{-1}. Nevertheless, this method could be further defined to precisely apply for the compost evaluation throughout more basic research.

Changes of enzyme activities. Changes of some enzyme activities during composting period were shown at Figs 4 and 5. In Fig 4, the phosphatase activity increased to 50 days after composting and then decreased gradually. A similar result was observed for the urease activity, showing that slightly increased during active composting periods and slowly decreased until 120 days after composting. Garcia *et al.*[9] discussed that phosphatase affected the p-cycle which could be transformed from organic-p into inorganic-p, and the decomposition of organic matters.

In Fig. 5, the amylase activity showed repeated increase and decrease depending on the composting period as follow: rapid increase after composting and decrease to the starting level at 20 days after composting, and increase up to 50 day and then gradual decrease after 50 days. Cellulase activity increased gradually during the stabilizing period. This trend seemed to be from the late decomposition of cellulase at the early stages of composting.

From this results it could be assumed that amylase activity increased quickly from the early stage of composting, and maintained due to the increased activity when the moisture contents readjusted at the 20 th day. Consequently the changes of some enzyme activities could not be enough to use on evaluation standard for composting, because these contents analyzed could be abruptly changed by the given condition such as temperature and moisture conditions.

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