



Development of New Technology  
for the Utilization of Waste Shiitake Bedlogs



I.

Development of New Technology  
for the Utilization of Waste Shiitake Bedlogs

II.

1955  
7,000 가가 , 1990  
1,574 , 1993 2,580 , 가  
, 1992 441 1992 5%  
(489 )  
가  
가 , 1983 1 5.3g  
1992 62.7g 가 ( 1 735g )  
2000 95g, 2030 201g 가 .  
152,000m3 ,  
가 .  
가 ,  
가 .

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가가

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### Ⅲ.

1. 가

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- 3)

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- 6)

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가.

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4) ( : , 가 )

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1)

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3)

3.

가.

- 1)
- 2)
- 3)
- 4)

- 1)
- 2)
- 3)
- 4)
- 5)

가

- 1)
- 2)
- 3)

- 1)
- 2)

#### IV.

가 ,  
 , 가 ,  
 .  
 가 , 가  
 가 .

1.  
가. 가  
1. 가 , 가 ,  
 ,  
 1.20% , NFE(nitrogen free  
extract) 가 23.2% .

2. 가 18kg/cm<sup>2</sup> 22kg/cm<sup>2</sup> 24kg/cm<sup>2</sup>  
 , 22kg/cm<sup>2</sup>  
 , 가 18kg/cm<sup>2</sup> 가 ,  
 가 , pH가 3 가 ,  
 가 .

3. pH,  
( 가 )  
 . NDF



4. 가 , 가  
 가 , 50% 가  
 .

5. 가 , ( 0.8cm) 가  
 가 20% 30% 가 (color)  
 , 가 가 .

1. , 15  
 ( , S79215) , 2.5m3  
 . , 1m3 121kg (555  
 liter) , 1 ( 2 . 1 ) 1.2m3 145  
 kg(666 liter)  
 1 ( 2 . 1 ) 1m3 98kg(441 liter)  
 . 10 980kg (300 , 4,410  
 liter)

2. 가 가 ,  
 가 , 60% 가 1  
 , , 1 10  
 ( 60 ) , 10  
 가 .  
 , 가 66 15 ,  
 가 가 .



MDI 1) OH NCO NCO index , 가 ,  
 . PEG 400 , ( ) 1/3 PEG 400 가

가 2) 가 ,  
 180 , 가 1% 0.5% 가, 1% 150 가 가  
 , 80% 가 40% 가 90% 가

3) 0.6% 5 , 5% 가  
 30 , 3% 가 가  
 45kg/cm<sup>3</sup> 7 - 9% 가 38kg/cm<sup>3</sup> 가

4) 25- 45% isocyanate 60- 100%  
 , isocyanate 60%  
 가 가 , 45% 가

5) amine 1 pH 5 - 6 40 - 50% .  
 amine pH 5 - 6 가 가 50%  
 . NaOH 가 pH 가  
 5 가 .

2.

m3 150,000

가가 가

@ 가

@ 가

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가 가

150,000m3

가

가  
가

가

# SUMMARY

## **I. Development of ruminant fodders with Shiitake bedlogs**

A metabolism trial was conducted with three ruminally fistulated Corridale sheeps to examine the effect of replacement of rice straw with Shiitake bedlogs(SB) as a roughage source on fermentation characteristics, and degradation in the rumen and whole tract digestibility of diets. Six week feeding trial was also made with eight sheeps for two diets to observe the growth performance. Diets for metabolism trial were fed total mixed ration of 60% commercial concentrate and 40% roughage(as-fed basis) in which roughages were rice straw only(control), and 25%(SB-25) and 50%(SB-50) replacement of rice straw with SB(as-fed basis). Sheeps for feeding trial were confined to two pens and fed control or SB-50. Results obtained from the studies are summarized as follows:

Ruminal pH and ammonia-N concentration were not influenced by the replacement of rice straw with SB or replaced level of SB. Increased tendencies, however, were observed in total VFA production, and molar percent of propionic acid and butyric acid while acetic acid tended to decrease from SB feeding.

There were trends of increases in ruminal degradation and whole tract digestibility of dry matter, neutral detergent fiber and organic matter in diets in the rumen as affected by SB feeding. Feed intake, daily gain and feed efficiency were not influenced by the 50% replacement of rice straw with SB.

**Key words:** Shiitake bedlogs, rice straw, sheep, ruminal fermentation, digestibility, growth performance, pellets

## **II. Manufacturing of organic composts from Shiitake bedlogs**

With increased utilization of chemical fertilizer, soil fertility is getting serious problem. As a result, using organic soil conditioner (woody wastes or sawdust compost) would be only solution to recover soil vitality.

In this study, manufacturing and characteristics of organic soil conditioner from Shiitake bedlogs (woody wastes) were studied. Also, to investigate the effect of continuous application of this bedlog compost on growth of plants, growth tests for radish and tree seedlings were done. The results are as follows ;

Analytical results of decayed and fresh wood materials showed almost same as its wood components. The mixing ratio of raw materials with the other filling materials is essential for the manufacturing as well as good quality of its compost during composting process. In this experiment, mixing 12kg of urea, 20kg of lime, 50kg of chicken shit, and small amount of fermentation aids corresponding to 1 ton of sawdust resulted good composts. Their moisture contents were adjusted to about 55%. Temperature of pile, in composting process, rose after 1 week and kept about above 60°C for certain period. They were turned two times, 14th and 33rd day, respectively, after piling.

This bedlog compost contained 81.7% of high organic matter, 1.4% of a little nitrogen, 6.75 of pH and 25 - 30 of C/N ratio. There were no harmful effect on germination and growth of plants, such as radish and softwood and hardwood seedlings. Concerned the effect of bedlog compost on soil temperature, the compost did not affect plant growth by changing soil temperature abruptly, but compensated the soil temperature such as a little increasing on the early morning, a little decreasing on the mid-day or afternoon (pm 2:00), and increasing on the early evening (pm 6:00).

**Key words:** Shiitake bed-logs, organic compost, fermentation, plant growth  
fermentation, Soil temperature, germination

### **III. Special planting media from organic composts of Shiitake bedlogs**

The availability of large quantities of waste woods including Shiitake bedlogs provides an impetus for investigating woody biomass potential uses. Polyurethane (PU) foams are prepared by reacting isocyanates and polyols, and are used widely in various fields. Success with the incorporation of plant components into PU formulations has been reported. Thus, lignocellulosic waste raw-materials have been added to PU foam formulations as replacements for synthetic polyols.

In this study PU foams were synthesized from non-modified woody materials, liquefied polyols, diisocyanate(MDI, catalyst, foaming stabilizer, and viscosity aids. The polyol content, isocyanate/hydroxyl group (NCO/OH) ratio, and water content were varied to evaluate their effects on the compression properties of the PU foams.

Less than 400 Molecular weight of PEG and 1 to 3 liquor to raw-material ratio were desirable for liquefying woody materials. Liquefying was increased with organic catalyst and raising reaction temperature more than 150 . Addition of starch enhanced liquefying woody materials. 40% addition of starch resulted in about 90% liquefying rates.

Foaming rates was increased with increasing moisture contents of liquefied wood. Moisture contents of 0.6% resulted in 5 times foaming rates, and five percents of moisture contents more than 30 time foaming rates. But, an increase in water content may result in a decrease in crosslinks between the wood polyol and isocyanate because the NCO/OH ratio is constant. Increasing moisture contents have significantly decreased density of PU foams. The optimum water content should be about 2.5% or less in this system.

Organic composts of Shiitake bedlogs as well as the other stuffs for planting media could be decayed by wood rotting fungi in nature. This fact suggests that woody material derived PU foams containing 25 to 30% may be biodegradable.

**Key words:** Polyurethane foam, polyol, isocyanate, liquefaction, organic compost, degradation, plant media



# CONTENTS

Summary (Korean) -----	
Summary (English) -----	xi
Chapter I. Development of ruminant fodders with Shiitake bedlogs -----	1
1. Introduction -----	1
2. Materials and Experimentals -----	2
2.1 Preparation of materials -----	2
2.2 Composition analysis -----	2
2.3 Fodder analysis -----	2
2.4 Manufacturing autohydrolysis apparatus and autohydrolysis of woody samples -----	3
2.5 Special treatment for digestibility and high N containing ruminant fodders -----	3
2.6 Feeding of ruminants -----	4
2.7 Feeding manuals for sheeps -----	7
2.8 Development of woody combined pellet fodders -----	8
3. Results and Discussion -----	9
3.1 Fodder values of Shiitake bedlogs -----	9
3.2 Design and manufacturing of autohydrolysis apparatus -----	11
3.3 Operation of autohydrolysis apparatus -----	13
3.4 Autohydrolysis -----	13
3.5 Fodder values of autohydrolyzed Shiitake bedlogs -----	17
3.6 Digestibility improvement of autohydrolyzed Shiitake bedlogs by chemical treatment -----	21
3.7 Production of Special fodders by enzyme and microorganisms -----	23
3.8 Feeding of ruminants -----	24
3.9 Feeding manuals for sheeps -----	33
3.10 Development of woody combined pellet fodders -----	38
4. Conclusions -----	42
<Literatures cited> -----	44

<b>Chapter II. Manufacturing of organic composts from Shi itake bed logs -----</b>	<b>46</b>
1. Introduction -----	46
2. Materials and Experimentals -----	48
2.1 Preparation of materials -----	48
2.2 Composting house -----	49
2.3 Mixing and fermentation for organic composts -----	50
2.4 Composition analysis of the organic composts and its practical application -----	52
2.5 Fertilizing effects -----	52
3. Results and Discussion -----	54
3.1 Process for sawdusts manufacturing -----	54
3.2 Fermentation process -----	54
3.3 Composition analysis of the organic composts and its practical application -----	57
3.4 Planting of deciduous and coniferous trees -----	62
3.5 Effect of organic composts on soil temperature -----	62
3.6 Fertilizing effects -----	66
3.7 Growth of seeding trees -----	70
4. Conclusions-----	72
<Literatures cited> -----	73

Chapter III. Special planting media from organic composts of Shiitake bedlogs -----	75
1. Introduction -----	75
2. Data surveying on adhesives manufacturing for planting media -----	76
2.1 Surveying contents -----	76
2.2 Surveying methods and results -----	76
3. Materials and Experimentals -----	79
3.1 Materials -----	79
3.2 Liquefaction method -----	79
3.3 Foaming method -----	79
4. Results and Discussion -----	80
4.1 Factors affecting on liquefaction -----	80
4.2 Foaming of liquefied woods -----	84
5. Conclusions -----	89
<Literatures cited> -----	90

-----		
Summary	-----	xi
1	가 -----	1
1	-----	1
2	-----	2
1.	-----	2
2.	-----	2
3.	-----	2
4.	가 가 -----	3
5.	-----	3
6.	가 -----	4
7.	-----	7
8.	-----	8
3	-----	9
1.	가 -----	9
2.	가 -----	11
3.	가 -----	13
4.	가 -----	13
5.	가 -----	17
6.	-----	21
7.	-----	23
8.	가 -----	24
9.	-----	33
10.	-----	38
4	-----	42
<	> -----	44

2	-----	46
1	-----	46
2	-----	48
1.	-----	48
2.	-----	49
3.	-----	50
4.	-----	52
5.	-----	52
3	-----	54
1.	-----	54
2.	-----	54
3.	-----	57
4.	-----	62
5.	-----	62
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3	.	75
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1.		76
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3		79
1.		79
2.		79
3.		79
4		80
1.		80
2.		84
5		89
<	>	90

1 가

1

가 가 12), 3) *Trichoderma*, 4)  
가 가 , 5)  
가 가 .

가 ,  
가 , 6 - 13) 15,16), 가 17),  
18,19) 가 .

가 , 1,100 가 가 가  
가 가 가 가 가

가 가 가 Green Round  
가 .

가 , 가 가 가  
가 ,

, 가  
 , 가  
 가 가  
 가가 가  
 , 가  
 가  
 ( 가 )  
 , 가 가  
 ( ) 가 가 가

2

1.

2.

40- 60mesh

3.

가 ㉠ AOAC ㉡



4. 가 가

가 Stainless steel (SS 316) , ,  
 60 liter  
 80kg/cm2 , 3 liter 가  
 80kg/cm2 , 40kg/cm2  
 50 liter ,  
 10kg/cm2 .  
 300g( ) , 18kg/cm2 22kg/cm2  
 24kg/cm2 3, 6, 9 , 가

5.

가.

10mesh 10kg  
 (Ca(OH)<sub>2</sub> 1kg , 80 1 가 1 3 3 .

가 (1, 3, 5% )  
 가 .

5 - 10mesh 1kg 0.3%  
 가 가 0.1 M sodium acetate 40 72

, *Pleurotus ostreatus*, *Ganoderma lucidum* *Trametes versicolor*,

*Phanerochaete chrysosporium*, *Agrocybe cylindracea* 등 5종을 이용하여 5개월 배양후 조사료가치를 분석하였다.

## 6. 반추가축 사양실험

### 가. 면양 사양실험

자기가수분해 처리한 폐골목 조사료 급여가 면양의 반추위내 발효성상, 분해율 및 전장소화율에 미치는 효과를 검토하기 위하여 아래와 같이 실험하였다.

- ① 시험동물 : 반추위 fistula가 장착된 Corridale 수면양 3두(평균 체중 48kg)를 시험동물로 이용하였다(사진 1-1 참조).
- ② 시험장소 : 충북대학교 축산학과 반추영양생리 실험실에서 실시하였다.
- ③ 시험설계 : 본 연구는 3두의 면양을 대상으로 3종류의 시험사료를 3 periods에 걸쳐 실시하는 3 x 3 Latin Square design을 적용

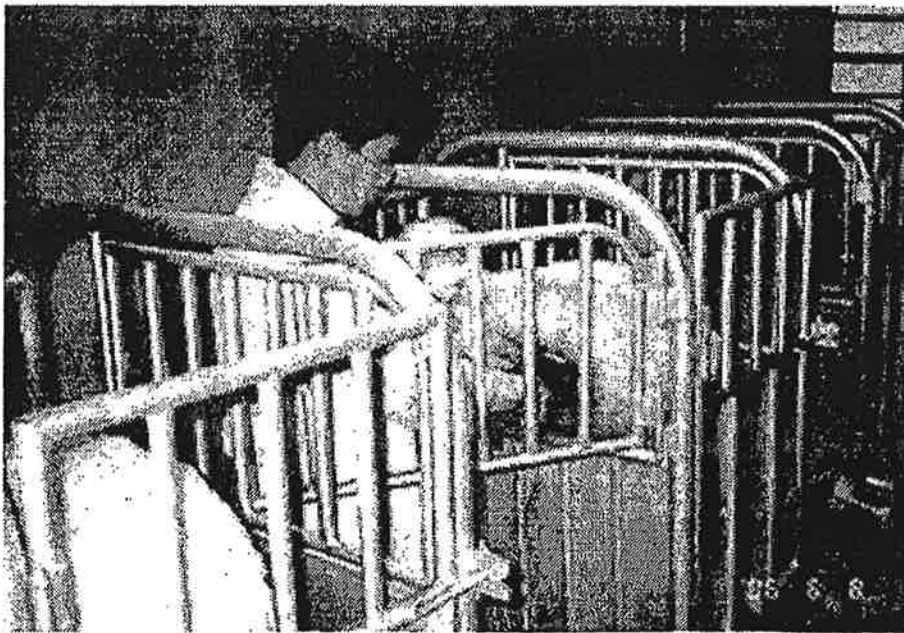


Photo 1-1. Digestibility experiment of roughage using Fistula.

:  
 i) 1 - (Control).  
 ii) 2 - 1 (Autohydrolyzed Shiitake bedlog, SB 75 : 25 (as-fed basis) (SB- 25).  
 iii) 3 - 1 50 : 50 (as-fed basis) (SB- 50).  
 : Period 10 (7 , 3 ), 30 .  
 :  
 ( ) 6 : 4 ,  
 1 1,100g (as-fed basis) 2 (09:00h 18:00h).  
 :  
 2 , period (09:00) 0.5, 2, 5, 8 4 (fistula)  
 (pH) . 4 cheeze cloth Fawcett Scott(1960) 24 . 25% n-phosphoric acid 4 : 1 (15,000 rpm, 10 , 4cC) , gas chromatograph (volatile fatty acid, VFA) .  
 nylon bag(5 x 12 cm, pore size 50 μm) 2mm mesh , nylon bag 5g( ) . 0, 3, 6, 12 24 . tap water 가 nylon bag , 80cC 3 . nylon bag (dry matter, DM) , Orskov

McDonald(1979) 26) , (crude protein, CP),  
 neutral detergent fiber(NDF) (organic matter, OM)  
 (effective degradability, ED) .

period 2  
 ( , , NDF )

2) nylon bag AOAC(1984)  
 GLM27) S- N- K (Steel and Torrie, 1980)28) SAS package .

가 가

: Corridale 8 ( 37.3kg)

:  
 : 8 2  
 ( 4 ) , .

i) (Control);

ii) (SB); 1

(as- fed basis) 50:50

: 6 (42 ) ( 1-2 ) .  
 ( )

1( ) 1- 13 .

: pen  
 6 : 4 ( )

3일간의 사료섭취량을 조사하여 1일 사료 섭취량의 110%를 2회로 분할하여 급여 하였다(09:00h 및 18:00h). 또한 1주 간격으로 증가하는 사료섭취량을 고려하여 사료급여량을 조정하였다. 전체 시험기간에 걸쳐 물과 린칼블록은 자유로이 섭취토록 하였다.

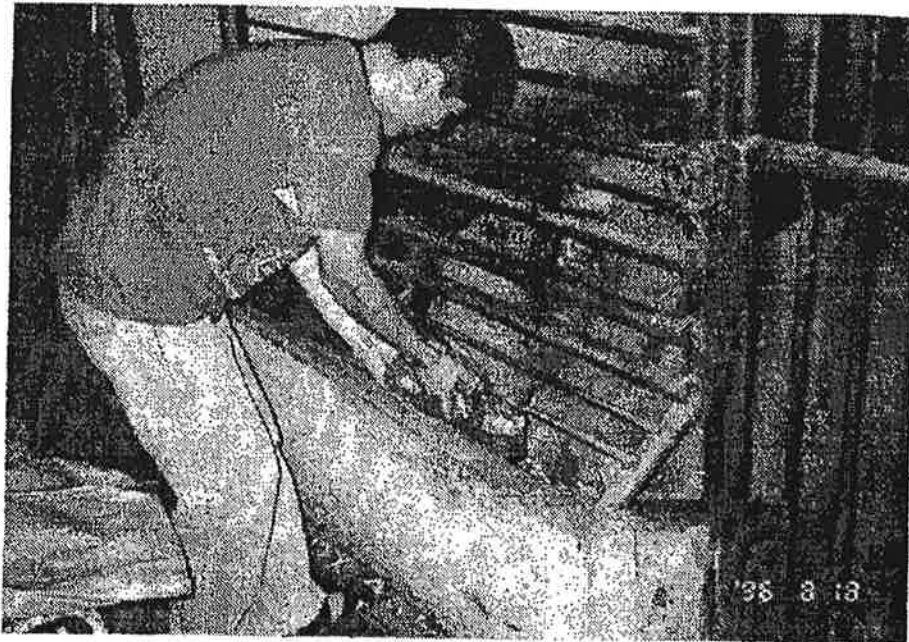


Photo 1-2. Feeding experiment of Sheep.

⑦ 조사항목 및 조사방법:

사료별 사료섭취량은 매일 조사하였으며, 체중은 매주 측정하였다. 시험사료는 개시시와 매 2주 간격, 그리고 종료시에 채취하여 일반성분을 AOAC (1984) 방법<sup>22)</sup>으로 분석하였다. 증체량과 사료섭취량 및 사료효율 등에 관한 성적은 각 사료별로 군사를 시켰기 때문에 산술적인 평균치 만을 비교하였다.

7. 면양용 사양메뉴얼 개발

면양에 급여한 시험사료중 조사료 자원으로는 대조구에서 벧짚만을, 그리고 처리구로서 자기가수분해처리한 폐골목시료의 벧짚 대치수준을 25%와 50%로 하여

(TMR)

60 : 40

1-1

Table 1-1. Formula of experimental total mixed diets<sup>1)</sup>  
(as-fed basis)

Ingredients	Control	SB-25	SB-50
Corn ground	25.5	25.5	25.5
Wheat bran	12.9	12.9	12.9
Soybean meal	9.52	9.52	9.52
Beet pulp	11.0	11.0	11.0
Rice straw	40.0	30.0	20.0
Shiitake bedlog	-	10.0	20.0
Limestone	0.36	0.36	0.36
Salt	0.30	0.30	0.30
Premix	0.42	0.42	0.42
Chemical composition (%):			
Crude protein	13.2	12.9	12.7
Ether extract	3.64	3.62	3.60
Neutral detergent fiber	58.3	57.8	56.4

1) Control, Rice straw as a roughage; SB-25, 75% rice straw+25% wood waste; SB-50, 50% rice straw+50% wood waste.

8.

가

pellet

가가

①

⑤

③

가

가

가

가

3

1. 가

가.

1-2 1-3

가

Table 1-2. Summative analysis of sound oak woods

Components	Contents, %
Extractives	
Cold-water	2.55
Hot-water	5.84
1% NaOH	22.9
Alcohol - benzene	3.04
Holocellulose	76.4
Pentosan	23.7
Lignin	22.4
Acid-soluble	
Lignin	3.33
Ash	0.35

가

가

Table 1-3. Summative analysis of Shiitake bed-logs

Components	Contents, %
Extractives	
Cold-water	8.14
Hot-water	13.4
1% NaOH	47.5
Alcohol - benzene	5.83
Holocellulose	72.1
Pentosan	21.8
Lignin	20.5
Acid-soluble	
Lignin	3.4
Ash	2.25

가  
 1-4 ,  
 가 가  
 가  
 1.20% , NFE(nitrogen free extract) 가 23.2%

Table 1-4. Summative analysis of Shiitake bed-logs

Components	%
Mixture	8.16
Crude protein	1.20
Crude fat	2.57
Crude fiber	44.60
Ash	0.58
NFE	23.21



## 2. 자기가수분해장치의 설계

### 가. 자기가수분해장치의 재원

재 질 : Stainless steel SS316,

반응기 용량 : 3,000 ml

최대 내압력 :  $80\text{kg}/\text{cm}^2$

수증기발생탱크 용량 : 60 liter

최대내압력 :  $80\text{kg}/\text{cm}^2$

수 기 용량 : 50 liter

최대내압력 :  $10\text{kg}/\text{cm}^2$

### 나. 설계도면

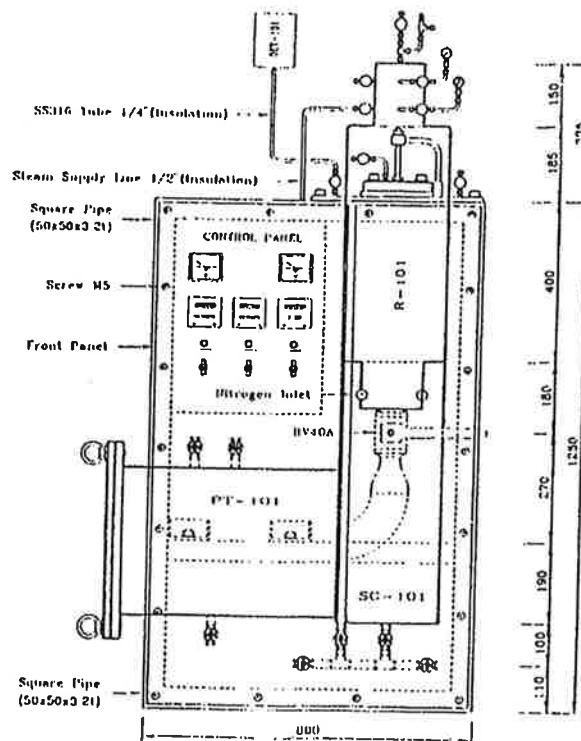


Fig. 1-1. Autohydrolysis Apparatus

R-101 : Reactor, SG-101 : Steam Generator

PT-101 : Products Tank

다. 자기가수분해장치 실물

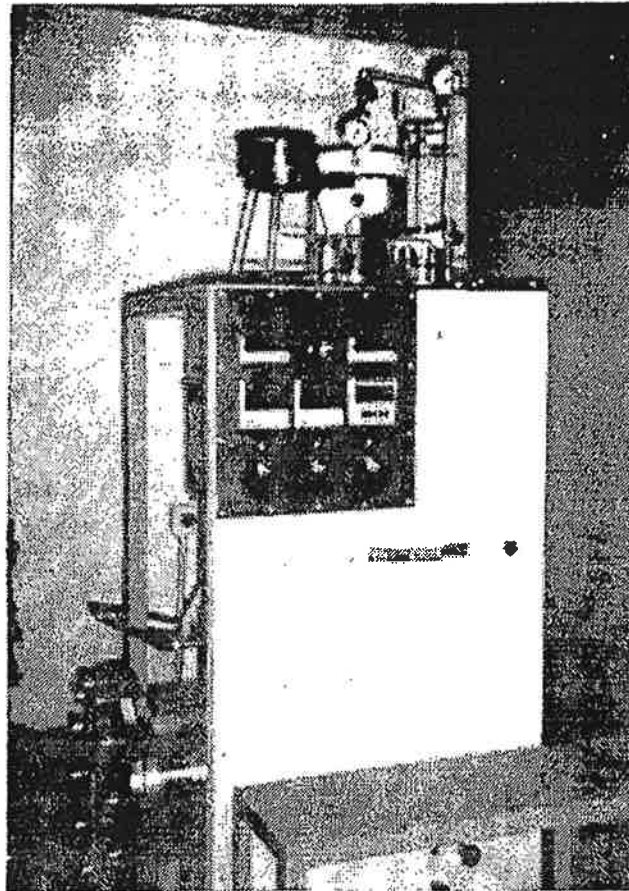


Photo 1-3. Autohydrolysis apparatus.

3. 가

가.

가 45 20 A , 15 liter (20 kg/cm2) 가 .

4 - 7 A 가 .

. .

, , .  
1 - 2 가

40kg/cm2 가 , 40 20kg/cm2 가 ,

.

가 ,

,

.

,

.

4. 가

가 가

가 가

, .

상온.상압하에서의 보통 물분자보다  $10^7$  배나 높아지며, 이러한 상태에서  $H^+$  및  $OH^-$  이온이 증가되어 물분자가 더욱 활성화되는데, 이러한 활성화된 물의 작용으로 목질재료가 단시간에 가수분해된다. 동시에 이러한 상태의 목편을 고압에서 순간적으로 상압의 조건으로 해주면, 목재의 세포벽 및 내강에 도입된 압축되었던 수증기가 대기압상태로 개방됨에 따라 단열팽창이 발생하게 되면서 목재조직이 폭발적으로 분쇄된다. 이와같이 자기가수분해 조건하에서 목재의 파쇄는 화학적요인 및 물리적 요인에 의해 일어나게 된다.

#### 나. 자기가수분해 처리

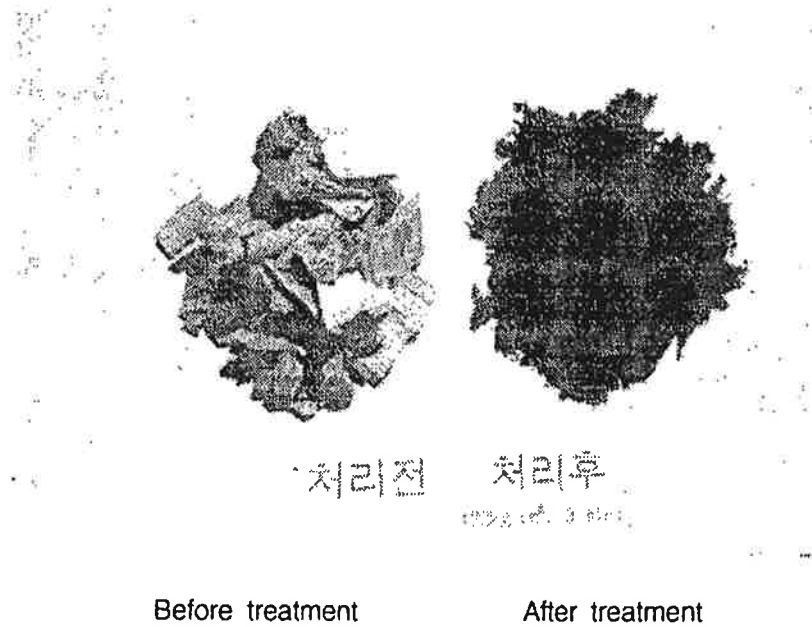


Photo 1-4. Automatic defibration of wood chips by autohydrolysis process.

목재칩 300g(기전 중량)을 반응기에 충전하고,  $18kg/cm^2$ ,  $22kg/cm^2$  및  $24kg/cm^2$  의 수증기 압력하에서 소정시간 처리후, 상압으로 블로한 경우  $18kg/cm^2$ , 6분 및 9분간 처리하더라도 목재칩의 균일한 분쇄가 일어나지 않았으나,  $22kg/cm^2$

가 18kg/cm2 ( 1-2). 가

quinone methide

가 18kg/cm2 6, 9, 12 가

가 1-5 가 가

가 hemicellulose

**Table 1-5. Changes in chemical compositions of autohydrolyzed oak wood**

Autohydrolysis Pressure, kg/cm <sup>2</sup>	Time min.	Yield %	Lignin %
18	6	84.3	25.8
	9	82.6	27.9
	12	79.0	29.1

가

1-2 18kg/cm2 가 가

5 5.2 가 15 10

20 pH 3.2 level-off

가  
가

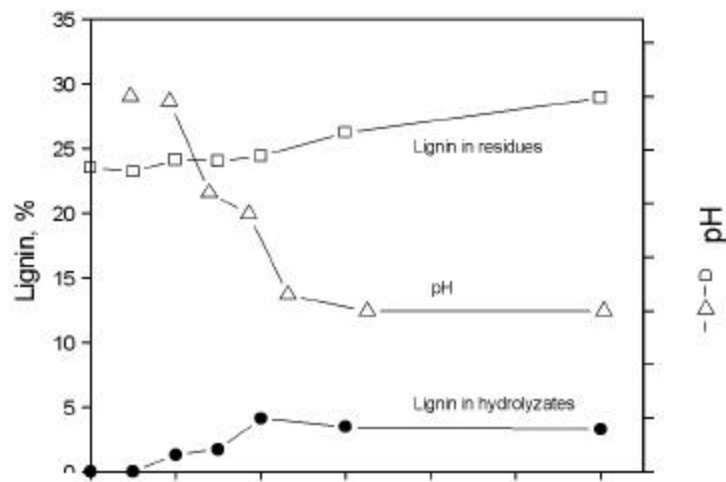


Fig. 1-2. Changes in lignins and pH as a function of autohydrolysis time.

가

1-6 가 18kg/cm<sup>2</sup> 가

1-6 1-2

가

가

가

가

가

가

가 30

가

**Table 1-6. Lignin contents of hydrolyzates and autohydrolyzed residues**

	Autohydrolysis time , min.						
	0	5	10	15	20	30	60
<b>Hydrolyzates</b>							
Sol. lignin, %	-	0.03	1.32	1.73	4.12	3.47	3.29
Final pH		6.9	5.2	4.8	3.3	3.0	3.0
<b>Residues</b>							
Klason lignin, %	23.5	23.2	24.1	24.0	24.4	26.2	28.9

5. 가

가 , , , NFE(Nitrogen free extract), NDF(Neutral detergent fiber), ADF(Acid detergent fiber), , 1-7 .

가 20kg/cm<sup>2</sup> 22kg/cm<sup>2</sup> 가 가

, 가 가 .

가 가 가 가

. 가 20kg/cm<sup>2</sup>, 6 22kg/cm<sup>2</sup>, 3 가 .

Table 1-7. Chemical components of autohydrolyzed shiitake bed log

Pressure (kg/cm <sup>2</sup> ) Steaming time(min.) Constituents(%)	20			24		
	2	4	8	2	4	8
Moisture	8.51	9.66	10.1	8.71	10.0	11.1
Crude protein	0.85	0.85	0.89	0.63	0.81	0.79
Crude fat	0.88	1.25	1.88	1.36	1.95	2.11
NFE	44.1	47.8	46.5	45.2	51.2	52.2
Crude fiber	47.1	48.5	47.5	43.8	43.6	44.0
Ash	0.30	0.34	0.36	0.42	0.49	0.48
NDF	62.8	59.2	58.6	58.6	58.8	57.6
ADF	57.5	57.1	56.9	55.0	55.3	57.1
Hemicellulose	3.54	2.82	2.31	3.76	2.56	1.12
Cellulose	48.7	47.5	47.6	46.5	45.4	47.2
Lignin(Klason)	23.4	24.6	27.7	24.5	28.6	27.2
Silica	0.03	0.02	0.03	0.03	0.03	0.03

Table 1-8. Nutritive values of defibrated and autohydrolyzed shiitake bedlogs

Components	Untreated sawdust*	Steaming defibrated*	Autohydrolyzed
Moisture	8.75	24.6	76.4
Crude fiber	61.2	60.7	46.4
Crude protein	0.65	0.71	0.81
Lignin(Klason)	23.2	26.5	32.6
Ash	0.29	0.25	0.34
Digestibility 1)	4.5	46.5	56.7
Digestibility 2), 24hr	10.0	32.5	62.3
48hr	9.1	85.0	88.7

\* sound oak wood

1) Enzymatic hydrolysis

2) *in sacco*

1-8 가

가



40.5%, 23% 가 , 56.7%

가 in vitro 가 (digestable dry matter, DDM) , 1-9 NDF , ADF . Acid detergent lignin 14.6 % 3 . 가 21.6 % .

**Table 1-9. Chemical composition and *in vitro* digestible dry matter**

L/I	Autohydrolyzed bed-log	Rice straw	Hay
<b>Proximate analysis, %</b>			
Crude protein	0.8		14.5
Ether extracts	0.5		3.2
Crude fiber	43.8		32.9
Crude ash	0.4		8.5
NFE	45.2		40.9
<b>Cellwall constituents, %</b>			
NDF	58.6	72.0	68.9
ADF	55.0	60.1	36.5
Hemicellulose	27.7	32.4	32.4
Cellulose	42.5	30.0	30.0
Acid detergent lignin	14.6	4.3	4.3
<b>In vitro DDN, %</b>	<b>21.6</b>		

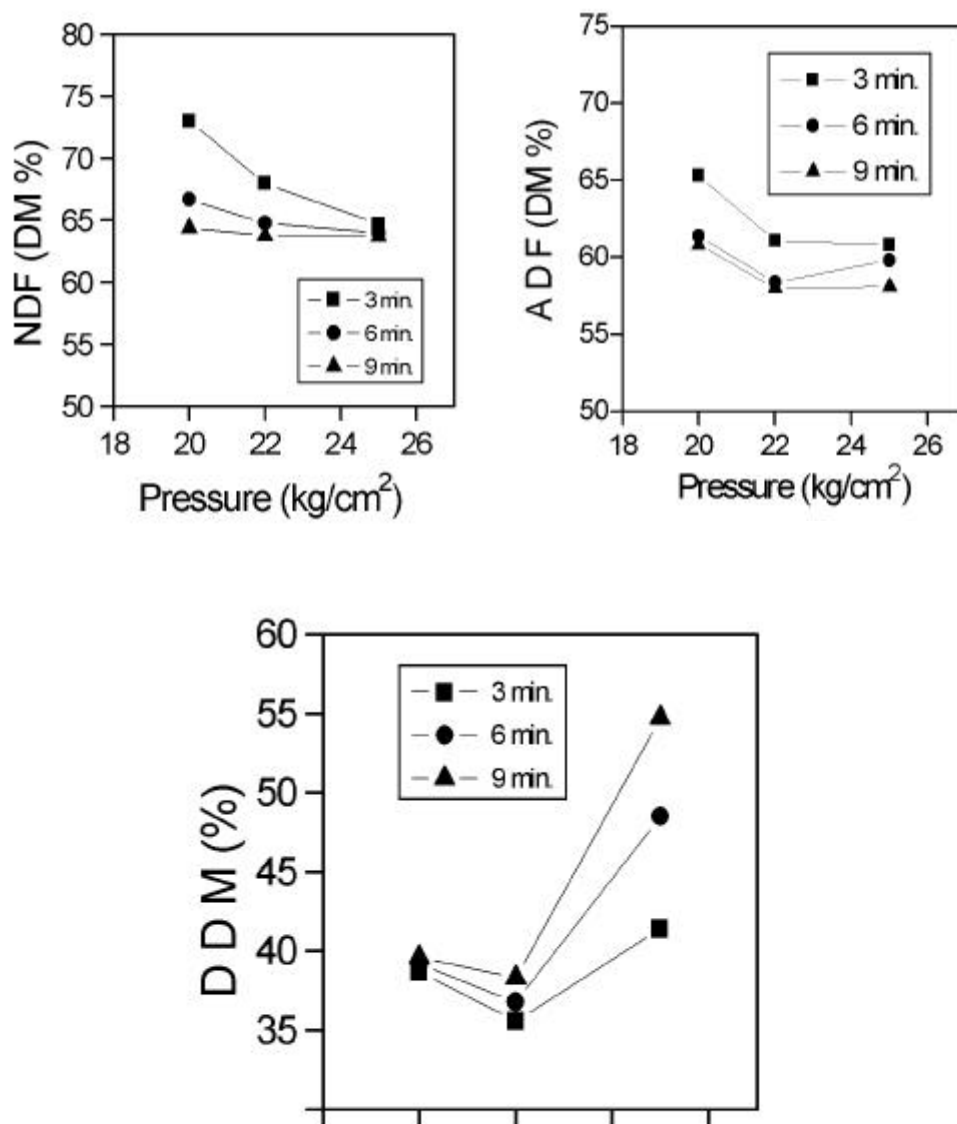


Fig. 1-3. Effect of autohydrolysis of on NDF, ADF, and DDM.

가  
 NDF, ADF DDM  
 가 NDF ADF , DDM 가  
 . 3, 6, 9 , 9  
 NDF ADF 가 , DDM  
 가 35.2% 가 . DDM 21.6%

7.  
 가.

10mesh 10kg 1kg  
 , 80 liter 가 1 3 3 . 1- 10  
 , NFE(nitrogen free extract) 가 23.2% .  
 Ca(OH)2 3 , NFE 35.4%  
 65.3 % 가 .

**Table 1-10. Summative analysis of Shiitake bed-logs**

Components	Shiitake bed-log	
	Control	Ca(OH)2 treated
	%	%
Moisture	8.16	7.62
Crude protein	1.20	1.22
Crude fat	2.57	1.88
Crude fiber	44.60	44.32
Ash	0.58	8.52
NFE	23.21	35.43

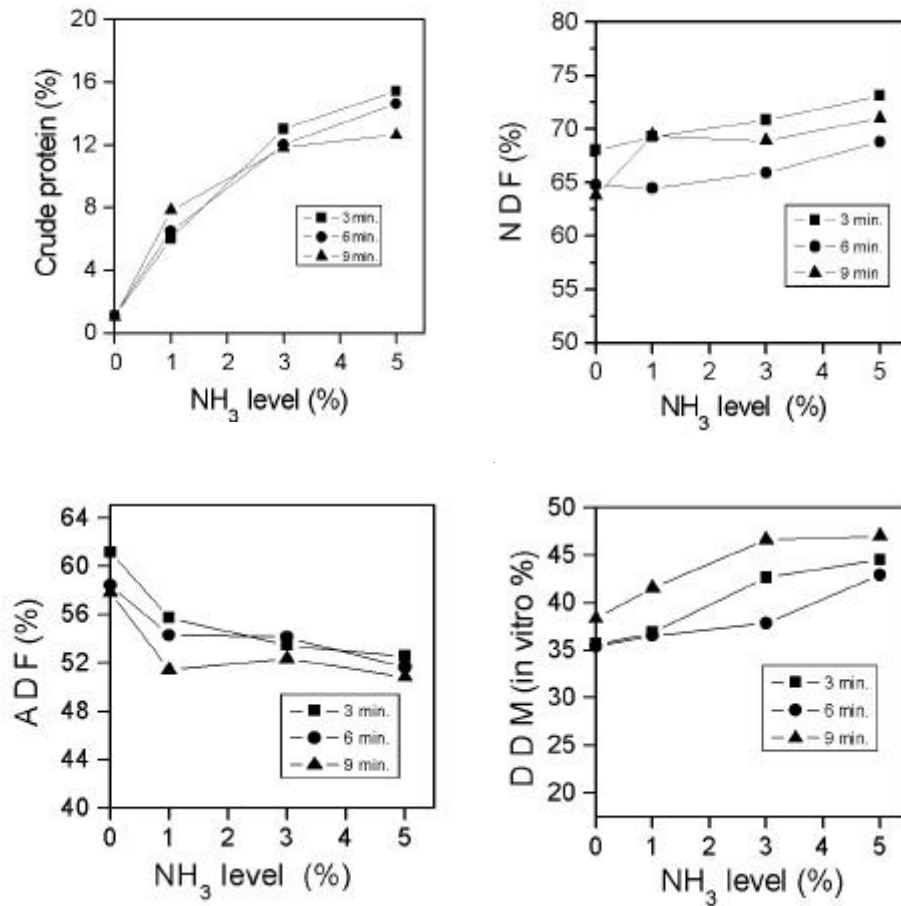


Fig. 1-4. Effect of ammonia treatment of autohydrolyzed Shiitake bedlog on protein content, NDF, ADF, and in vitro DDM.

가 1-4 , 3% , 12% ,  
 5% , 15% 가 ,  
 NDF 10% 가 , ADF 50  
 , DDM 35% 42 - 47%  
 가

8.

가. Cellulase

5 - 10mesh 1kg 0.3%  
 가 가 0.1 M sodium acetate 40 72  
 , 1- 11  
 2 가 , , NFE  
 가 .

Table 1-11. Sumnative analysis of Shiitake bedlogs

Components	Shiitake bedlog	
	Control %	Cellulase treated %
Moisture	8.16	9.69
Crude protein	1.20	2.84
Crude fat	2.57	2.01
Crude fiber	44.60	40.85
Ash	0.58	1.52
NFE	23.21	28.21

5 , 1- 12  
*Trametes versicolor* 가 5 13.06%  
 , *Phanerochaete chrysosporium* 8.92%  
 . 가 .

Table 1-12. Crude protein of Shiidake bed-log treated by white-rot fungi

Strain Treating time(non)	<i>Hleurotus ostreatus</i>	<i>Ganderna lucidum</i>	<i>Tranetes versicolor</i>	<i>Fhanerochaete chrysosporium</i>	<i>Aerocvbe cylindracea</i>
0	2.14	2.14	2.14	2.14	2.14
1	3.80	4.11	4.58	4.61	3.25
3	4.05	4.97	7.30	7.68	4.02
5	4.25	5.88	13.06	8.92	4.77

9. 가

가

가

가

(Mellenberger, 1971)8, (Dinius, 1970)4, (Millet, 1970) (Baker23, 1973; Enzmann 19, 1968)

가

(, 1990)29)

가

(, 1992)30)

가 가

(1990)31)

(chip)

가

*in vitro*

bed-logs, SB) 150,000m3 (, 1995)33, (Shiitake

가

(1995)33)

(*Lentinula edodes*)

가

가

2.26%

23.2%

가

가

( , 1990)29)

가 가 가 .

가 가

가 .

가 가

fistulaga Corridale 3 ( 48kg) ,

1- 13 24

1- 14

(dry matter) (organic matter)

NDF

**Table 1-13. Chemical composition of experimental concentrate and roughages(% , DM basis)**

Items	Concentrate	Roughages	
		Rice straw	Shiitake bedlog
Dry matter	14.1	10.5	14.1
Crude protein	17.0	5.2	1.1
Ether extract	6.8	0.5	-
Neutral detergent fiber	46.2	80.9	63.1
Crude ash	7.2	12.7	1.0

**Table 1-14. Degradation of rice straw and Shiitake bedlog in the rumen of sheep after 24h incubation**

Roughages	Dry matter	Crude protein	NDF	Organic matter
Rice straw	23.8	51.9	31.3	27.1
Bedlog	33.7	-	38.6	36.3

1,100g( ) 가  
 , 가  
 NDF  
 가 ( 1-15).

**Table 1-15. Daily intakes(g) by sheep as influenced by replacment of rice straw with autohydrolyzed Shiitake bed-logs**

Diets <sup>2)</sup>	DM	CP	EE	NDF	OM
Control	960.7	116.9	40.5	580.5	869.9
SB-25	956.8	112.8	40.0	560.5	877.6
SB-50	952.8	107.3	39.5	540.5	885.1

- 1) DM, dry matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fiber; OM, organic matter
- 2) Control, fed rice straw only as a roughage; SB-25, fed rice straw 75% and Shiitake bed-logs 25% as roughages; SB-50, fed rice straw and Shiitake bed-logs in an equal portion. Amount of concentrate fed was same among treatments.

**Table 1-16. pH of the ruminal fluid in sheep as influenced by Shiitake bedlog(SB) intake**

Sampling time <sup>1)</sup>	Diets <sup>2)</sup>			SEM <sup>3)</sup>	Pr>F <sup>4)</sup>
	Control	SB-25	SB-50		
09:30	6.78	6.76	6.72	0.072	0.809
11:00	6.66	6.61	6.59	0.077	0.790
14:00	6.68	6.63	6.70	0.057	0.677
17:00	6.76	6.81	6.79	0.047	0.750

- 1) Ruminal fluid was taken at indicated times after morning feeding(09:00).
- 2) Control, fed rice straw as a roughage; SB-25, fed rice straw 75% and wood waste 25% as roughages; SB-50, fed rice straw and wood waste in an equal portion. Concentrate fed to sheep was same among treatments.
- 3) Standard error of the means.
- 4) Significance level.



pH  
가  
( 1-16). 30 가  
control  
가 가  
가 ( 1-16). 1 4 pH  
(Shiitake bedlog,  
SB) ( 1-16).  
( 1-17)  
가 가 .  
30

**Table 1-17. Ammonia concentration (ng/100nl) of the ruminal fluid in sheep as influenced by Shiitake bedlog (SB) intake**

Sampling time)	Diets <sup>2)</sup>			SEM <sup>3)</sup>	Pr>F
	Control	SB-25	SB-50		
09:30	10.39	8.51	9.33	1.824	0.775
11:00	8.56	9.47	7.82	2.352	0.886
14:00	5.25	4.20	5.45	1.940	0.890
17:00	5.75	7.28	5.00	1.827	0.685

1), 2), 3) and 4) Referred to Table 1-16.

VFA (Total VFA)  
(SB-50) , 50%  
25%  
(SB-25) ( 1-18).

Table 1-18. Molar percent(moles/100moles) of volatile fatty acids (VFA) and total VFA concentration(moles) in rumen fluid of sheep by sampling time as influenced by Shiitake bedlog intake

Diets <sup>1)</sup>	VFA <sup>2)</sup>						Total	C <sub>2</sub> /C <sub>3</sub>
	C <sub>2</sub>	C <sub>3</sub>	iC <sub>4</sub>	C <sub>4</sub>	iC <sub>5</sub>	C <sub>5</sub>		
- 0.5h -								
Control	65.6	20.4	1.0a	10.4	1.6	0.9	46.9	3.22
SB-25	63.7	20.4	0.9ab	11.0	3.1	0.9	51.4	3.13
SB-50	65.5	20.4	0.8b	11.3	1.2	0.9	49.6	3.24
SEM <sup>3)</sup>	0.925	0.996	0.049	0.649	1.030	0.028	4.717	0.138
Pr>F <sup>4)</sup>	0.325	0.648	0.049	0.626	0.429	0.056	0.804	0.833
-2h-								
Control	65.5	19.8	1.09a	10.7	1.5a	1.4	50.8	3.3
SB-25	64.2	20.4	1.01a	11.7	1.3ab	1.4	53.5	3.2
SB-50	63.4	19.4	0.86b	11.8	1.1b	3.5	49.8	3.3
SEM <sup>3)</sup>	1.218	0.632	0.034	0.663	0.083	1.249	3.207	0.146
Pr>F <sup>4)</sup>	0.519	0.544	0.008	0.509	0.055	0.451	0.714	0.753
-5h-								
Control	67.1	18.6	0.9	11.5	1.0	0.9	41.5	3.61
SB-25	65.5	19.1	0.9	12.7	0.9	1.0	46.4	3.44
SB-50	66.4	18.5	0.8	12.6	0.8	0.9	42.3	3.61
SEM <sup>3)</sup>	0.765	0.746	0.052	1.024	0.080	0.073	3.169	0.140
Pr>F <sup>4)</sup>	0.382	0.822	0.204	0.680	0.293	0.635	0.546	0.632
-8h-								
Control	67.1a	18.2	0.9	11.8	1.1	0.8	35.4	3.70
SB-25	66.1ab	18.6	0.9	12.6	0.8	0.8	39.8	3.55
SB-50	65.4b	18.7	0.8	13.4	1.0	0.8	40.9	3.57
SEM <sup>3)</sup>	0.314	1.143	0.067	1.148	0.087	0.020	3.029	0.223
Pr>F <sup>4)</sup>	0.023	0.956	0.485	0.626	0.113	0.199	0.444	0.876

1), 3) and 4) Referred to Table 1-16.

2) C<sub>2</sub>, acetic acid; C<sub>3</sub>, propionic acid; iC<sub>4</sub>, isobutyric acid;  
C<sub>4</sub>, butyric acid; iC<sub>5</sub>, isovaleric acid and C<sub>5</sub>, valeric acid.

8  
acetic acid (P<0.023)

가 가  
acetic acid

가 butyric acid  
propionic acid, iso butyric acid, isovaleric acid  
가  
valeric acid . acetic acid/propionic acid  
가

Nylon bag 24  
(dry matter), (crude protein), neutral  
detergent fiber(NDF) (organic acid)

1- 19 1- 22 .

( 1- 19) NDF( 1- 20) ( 1- 22) ,  
(control) (SB- 25

SB- 50)

(Table 1- 20).

**Table 1-19. Dry matter degradation(%) of experimental diets in the rumen of sheep by incubation time as influenced by Shiitake bedlog intake**

Incubation time(h)	Diets <sup>1)</sup>			SEM <sup>2)</sup>	Pr>F <sup>3)</sup>
	Control	SB- 25	SB- 50		
0	29. 8	31. 4	30. 1	1. 340	0. 703
2	37. 2	36. 9	35. 9	0. 711	0. 466
5	40. 9	39. 9	43. 4	2. 269	0. 572
12	49. 6	50. 4	49. 3	1. 671	0. 887
24	57. 7	60. 3	61. 1	2. 178	0. 548

1), 2) and 3) Referred to Table 1-16.

**Table 1-20. Crude protein degradation(%) of experimental diets in the rumen of sheep by incubation time as influenced by Shiitake bedlog intake**

Incubation time(h)	Diets <sup>1)</sup>			SEM <sup>2)</sup>	Pr>F <sup>3)</sup>
	Control	SB-25	SB-50		
0	54.4	54.5	55.7	1.272	0.728
2	63.9	63.6	62.1	1.252	0.586
5	66.3	64.6	67.3	2.818	0.799
12	74.1	71.9	73.0	2.837	0.862
24	78.8	78.6	81.2	2.425	0.718

1), 2) and 3) Referred to Table 1-15.

**Table 1-21. Neutral detergent fiber(NDF) degradation(%) of experimental diets in the rumen of sheep by incubation time as influenced by Shiitake bedlog intake**

Incubation time(h)	Diets <sup>1)</sup>			SEM <sup>2)</sup>	Pr>F <sup>3)</sup>
	Control	SB-25	SB-50		
0	11.9	6.2	12.1	2.319	0.202
2	18.0	13.7	15.0	1.115	0.080
5	21.6	16.9	24.5	2.848	0.243
12	31.8	28.8	30.8	2.377	0.611
24	41.7	41.9	44.7	2.714	0.699

1), 2) and 3) Referred to Table 1-16.

**Table 1-22. Organic matter degradation(%) of experimental diets in the rumen of sheep by incubation time as influenced by Shiitake bedlog intake**

Incubation time(h)	Diets <sup>1)</sup>			SEM <sup>2)</sup>	Pr>F <sup>3)</sup>
	Control	SB-25	SB-50		
0	37.1	38.3	38.4	1.213	0.718
2	43.7	44.3	42.6	0.768	0.331
5	47.0	47.1	49.4	1.985	0.646
12	55.1	56.2	54.6	1.528	0.745
24	62.5	65.5	65.3	1.975	0.509

1), 2) and 3) Referred to Table 1-16.

Tables 1-19 ~ 1-22  
 (expected degradability)  
 (EDCP) (EDDM), NDF(EDNDF) (EDOM)  
 가 ( 1-23).

**Table 1-23. Expected ruminal degradabilities(%) of dry matter(EDDM), crude protein(EDCP), neutral detergent fiber(EDNDF) and organic matter(EDOM) in the experimental diets as influenced by Shiitake bedlog intake**

Items	Diets <sup>1)</sup>			SEM <sup>2)</sup>	Pr>F <sup>3)</sup>
	Control	SB-25	SB-50		
EDDM	50.0	51.8	52.6	1.876	0.636
EDCP	73.0	72.3	73.8	2.060	0.869
EDNDF	32.3	30.8	37.1	3.089	0.385
EDOM	55.4	57.6	57.2	1.783	0.670

1), 2) and 3) Referred to Table 1-16.

( 1-24). ,  
 (CP) (DM), (ether extract, EE),  
 NDF (OM)

**Table 1-24. Whole tract digestibilities(%) of dry matter(DM), crude protein(CP), ether extract(EE), neutral detergent fiber(NDF) and organic matter(OM) in the experimental diets as influenced by Shiitake bedlog intake**

Items	Diets <sup>1)</sup>			SEM <sup>2)</sup>	Pr>F <sup>3)</sup>
	Control	SB-25	SB-50		
DM	60.9	64.5	64.1	2.853	0.654
CP	70.4	71.0	72.1	2.392	0.872
EE	65.8	66.3	69.1	3.907	0.821
NDF	60.5	65.4	67.6	2.943	0.296
OM	71.1	73.7	73.7	1.922	0.641

1), 2) and 3) Referred to Table 1-16.

1  
(Control) 60% 40% ( )  
( ) 25% (SB- 25) 50% (SB- 50)  
pH,  
( 가 )  
가  
가 60% 40%  
( )  
50%  
NDF  
가  
가  
Corridale 8 ( 37.3kg)  
가 8 2 가  
37kg ,  
(rice straw) 60 : 40  
50% (wood waste)  
6  
1- 25

Table 1-25. Intakes, body weight gain and feed efficiency of sheep as influenced by autohydrolyzed Shiitake bedlogs(SB feedings as roughage source<sup>1)</sup>)

Items	Diet <sup>2)</sup>	
	Control	SB-50
Initial body weight (kg)	37.1	36.6
Intakes (g/day) :		
Dry matter (DM)	1081.0	1064.9
Crude protein	137.4	132.7
Neutral detergent fiber	635.9	617.6
Organic matter	981.8	979.3
Final body weight (kg)	44.0	42.3
Daily body gain (g)	141.0	135.0
Feed efficiency (body gain / DM intake)	0.13	0.12

1) Rice straw vs Shiitake bed-logs. Statistical comparison was not made between two diets because data obtained were simple mean values as the sheep fed in group.

2) Referred to Table 1-16.

가 ,  
141 135g 가 . 0.13  
50%

가 .

10.

가 . -

가

(chip) , 가 . (1995)

radical  
 quinone methide  
 가  
 fistula가  
 Corridale  
 가  
 25% 50% (TMR)  
 60 : 40  
 NDF  
 가  
 24  
 , 1-26  
 (organic matter) NDF  
 (1989)<sup>32</sup>  
*in vitro* (1990)<sup>31</sup>  
 36.8 77.5%  
 가  
 12.8 54.7%  
 (Baker, 1973)<sup>23</sup>,  
 가  
 가  
 가  
 ( , 1995)<sup>33</sup>



Table 1-26. Degradation of rice straw and Shiitake bedlog in the rumen of sheep after 24h incubation

Roughages	Dry matter	Crude protein	NDF	Organic matter
Rice straw	23.8	51.9	31.3	27.1
Shiitake bedlog	33.7	-	38.6	36.3

가  
(VFA)  
4 , 25% 가  
가 50%  
VFA

Table 1-27. Whole tract digestibilities(%) of dry matter(DM), crude protein(CP), ether extract(EE), neutral detergent fiber(NDF) and organic matter(OM) in the experimental diets as influenced by Shiitake bedlog intake

Items	Diets <sup>1)</sup>			SEM <sup>2)</sup>	Pr>F <sup>3)</sup>
	Control	SB-25	SB-50		
DM	60.9	64.5	64.1	2.853	0.654
CP	70.4	71.0	72.1	2.392	0.872
EE	65.8	66.3	69.1	3.907	0.821
NDF	60.5	65.4	67.6	2.943	0.296
OM	71.1	73.7	73.7	1.922	0.641

, NDF  
25%  
( 1-27 )  
50%  
가  
가

가 , 가 , 가  
 , 50% 가  
 1-25 가 ,  
 가 50% 가  
 가 ( ) 가  
 가 ( ) 가  
 가 pellet  
 가가  
 (manual)

① : NRC  
 ②  
 ③ ( : )  
 ④ 가

②



①

; 10 30kg

; 30 60kg

⑤ (pellet) Formula : 1-28

**Table 1-28. Formulae and chemical composition of total mixed diets for pelleting (DM basis)**

Ingredients	Growth stage (%)	
	Early-growing (10-30kg)	Late-growing (30-60kg)
Corn, ground	30.6	34.5
Wheat bran	12.9	13.5
Soybean meal	17.5	11.0
Beet pulp	5.0	6.5
Shiitake bed-logs	20.0	30.0
Molasses	3.0	3.5
Limestone	0.40	0.35
Salts	0.20	0.30
Vit. -min mix	0.40	0.35
<b>Chemical composition (%) :</b>		
Crude protein	16.6	14.1
Crude fat	3.82	3.67
Neutral detergent fiber	47.5	56.3
TDN*	67.5	70.1
Ca	0.52	0.48
P	0.41	0.40

\* Calculated values

③ ( )

**Table 1-29. Expected Intakes of major nutrients by sheep from diet containing autohydrolyzed Shiitake bed-logs as roughage source**

Body weight (kg)	DM (kg)	TDN (g)	CP (g)	Ca (g)	P (g)
10	0.7	473	115	3.64	2.87
20	1.0	675	164	5.20	4.10
30	1.3	878	213	6.76	5.33
40	1.5	1052	212	7.20	6.00
50	1.6	1122	225	7.68	6.40
60	1.7	1192	240	8.16	6.80

\* (Conditioned that sheep may consume rice straw in case they need more roughage)

11. ( )

가. ( )

가 . 가 TMR  
 가 ,  
 ,  
 pellet  
 . Pellet  
 pellet . 가

가 가  
 3 - 5% 가  
 pellet , 가  
 가

1) :

①

②

③ 가

2) :

①

: 1-30

1 (Energy) :

$$1\text{kg TDN} = 4.4 \text{ Mcal DE} = 3.62 \text{ Mcal ME}$$

$$(\text{ME} = 0.82 \text{ DE})$$

1 (Crude protein) :

$$\text{g/day} = \frac{\text{PD} + \text{MFP} + \text{EUP} + \text{DL} + \text{Wool}}{\text{NPV}}$$

PD, ; MFP, ; EUP, ; DL, ;  
 NPV, : NRC (1985)

⑤ ( : )  
 - 가 (1.1%) 5%

가

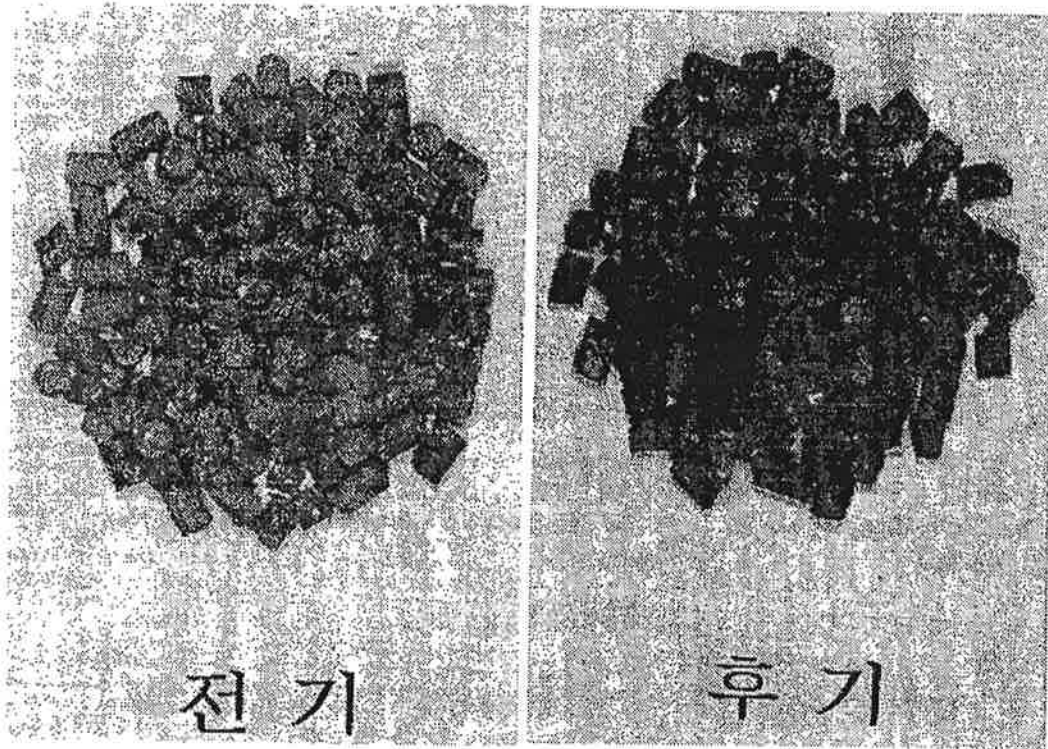
Table 1-30. Daily nutrient requirements for the development of feeding manual of sheep

BW (kg)	D. gain (g)	D. intake (kg)	Intake (% of BW)	TDN (kg)	CP (g)	Ca (g)	P (g)
10	150	0.7	7.0	0.40	127	4.0	1.9
20	190	1.0	5.0	0.80	167	5.4	2.5
30	225	1.3	4.3	1.00	191	6.7	3.2
40	260	1.5	3.8	1.16	202	7.7	3.9
50	225	1.6	3.2	1.16	181	7.0	3.8
60	210	1.7	2.8	1.20	185	7.0	3.8

\* Daily gain was adjusted to 75% of NRC(1985) requirements

- ③ 가 가  
 - (pellet) ( 가  
 ) 가 pellet 가 70 : 30  
 - pellet 가 ,  
 4% 가 가
- ④ 가 가 ( )  
 ( ) 60-70%

나. 펠릿형태의 목질 배합사료 (사진 1-5)



Early-growing stage

Late-growing stage

Photo 1-5. Photos of pelleted total mixed diets for the sheep.

사진 1-5에서 보는 바와 같이 시험제조한 면양 육성용 펠릿사료(직경 0.8cm)는 에너지 보충제 겸 결합제로 사용한 당밀의 첨가로 매우 이상적인 펠릿 형태를 보였다. 사실, 최적 결합도를 찾기 위해 수차에 걸친 시험제조를 실시하였다. 그러나 자기가수분해 처리된 폐골목 첨가량이 20%에서 30%로 증가됨에 따라 펠릿의 색(color) 역시 점차 진하게 나타났다. 이는 자기가수분해 처리된 폐골목 자체가 매우 진한 갈색을 띄기 때문인 것으로 보인다. 이렇게 제조된 펠릿사료의 경우 자기가수분해 처리로 인한 폐골목 고유의 자극성 냄새는 거의 감소되어 면양이 섭취하는데에는 전혀 문제가 없었다.

3

1.

가

2.

, NFE(nitrogen free extract) 가 23.2% 1.20%  
Ca(OH)<sub>2</sub>

3.

18kg/cm<sup>2</sup>, 22kg/cm<sup>2</sup> 24kg/cm<sup>2</sup>  
, 18kg/cm<sup>2</sup>, 6 9  
가 , 22kg/cm<sup>2</sup>  
가 가 18kg/cm<sup>2</sup>

4.

quinone methide

5.

가 , 가 가  
, 가 가 가  
가 가 가  
가 가 30 가 가

6.

pH,  
( 가 )  
NDF



7. 가 가  
 ,  
 가 가 ,  
 가 . 50% 가  
 .
8. 가  
 , ( 0.8cm)  
 가 가 20% 30% 가 가  
 , 가 가 (color)  
 가 .

< >

- 1) Nam - Seok Cho, On the manufacturing of soil conditioner and fodder from waste wooden materials. Forest Res. Inst. (1974)
- 2) . 9(1):1- 9(1990)
- 3) . *Trichoderma viride* (1983)
- 4) , , . 1990  
KOSEF87- 0510 (1990)
- 5) . (1990)
- 6) Anthony, W.B. & J.P. Cunningham, Jr., J. Anim. Sci., 27:1159 (1968)
- 7) Drevjany, L.A., G.S. Hooper & W.V. Candler. Can. J. Anim. Sci. 64:1035- 1044(1984)
- 8) Mellenberger, R.W., L.D. Satter, M.A. Millet and A.J. Baker. Digestion of Aspen, alkali-treated Aspen and Aspen bark by goats. J. Anim. Sci. 32:756 (1971)
- 9) Welton, R.F. & B.R. Baumgardt. J. Dairy Sci. 53:1171 (1970)
- 10) Anthony, W.B., J.P. Cunningham & R.R. Harris, Advances in Chem. Sec., 95:279. Amer. Chem. Soc., Washington, D.C. (1969)
- 11) Cody, R.E.Jr., J.L. Morrill & C.M. Hibbs. J. Dairy Sci. 51:952 (1968)
- 12) Dinius, D.A., L.D. Satter & D.L. Kern. J. Anim. Sci. 35:228 (1972)
- 13) Kinsman, D.M., D.A. Grant, A.R. Cobb & L.A. Peterson. J. Anim. Sci. 28:875 (1969)
- 14) Dinius, D.A., A.D. Peterson, T.A. Long and B.R. Bumgardt. Intake and digestability by sheep of rations containing various roughage substitutes. J. Anim. Sci. 30:309 (1970)
- 15) Lawton, E.J., W.D. Bellamy, R.E. Hungate, M.P. Bryant & E. Hall. Science 113:380(1951)
- 16) Mater, J., Forest Prod. J. 7:208 (1957)
- 17) Millet, M.A., A.J. Baker, W.C. Feist, R.W. Melklenberger and L.D. Satter. Modifying wood to increase it in vitro digestibility. J. Anim. Sci. 31:781(1970)
- 18) Baker, A.J., A.A. Mohaupt & D.F. Spino. J. Anim. Sci. 37:179 (1973)

- 19) Enzmann, J.W., R.D. Goodrich and J.C. Meiske. Chemical composition and nutritive value of Poplar bark. *J. Anim. Sci.* 29:653 (1968)
- 20) . . . . . 6. . . . . , 1983
- 21) Anthony, W.B. and J.P. Cunningham, Jr.. Hardwood sawdust in all concentrations for cattle. *J. Anim. Sci.* 27:1159 (abstracts) (1968)
- 22) AOAC. Official Methods of Analysis(14th ed.). Association of Official Analytical Chemists, Washington, D.C. (1984)
- 23) Baker, A.J. Effect of lignin on the *in vitro* digestibility of wood pulp, *J. Anim. Sci.* 36:768 (1973)
- 24) Fawcett, J.K. and J.E. Scott. A rapid and precise method for the determination of urea. *J. Clin. Pathol.* 13:156 (1960)
- 25) Goering, H.K. and P.J. Van Soest. Forage fiber analysis (apparatus, reagents, and some applications). *Agric. Handbook 379*, ARS, USDA, Washington, D.C. (1970)
- 26) Orskov, E.R. and I. McDonald. The estimation of Protein degradability in the rumen from incubation measurements weighted according to rate of passage. *J. Agric. Sci. (Camb.)* 92:499 (1979)
- 27) SAS. SAS User's Guide. Statistical Analysis Systems Institute, Inc., Cary, N.C. (1985)
- 28) Steel, R.G.D. and J.H. Torrie. Principles and Procedures of Statistics. McGraw Hill Book Co., N.Y. (1980)
- 29) . . . . . II. . . . . . 32:37 (1990)
- 30) . . . . . IV. 가 . . . . . 34:41 (1992)
- 31) , , , . . . . . (1990)
- 32) . . . . . (1989)
- 33) , , , . 가 . . . . . (1995)

2

1

가

가

,

가

가

가

가

가

,

가

가

가

1987

1000 m<sup>3</sup>

30% 300 m<sup>3</sup>

1) , 가

가

,

,

가

2),

3 - ㉔)

(C/N )

4)

㉕)

가

,

,

,

,

,

.

pH, C/N 가 , 가 ,  
가 1 , 가  
) , ( ,  
1950 , 가 1960 ,  
1974  
17) 가 , 1985  
가  
1977 ( )  
1983  
( ) , 가 ,  
18) 가  
8 - 11) 가 1950 Dunn  
, Wisconsin Davey 12, 13)  
Sugar maple ,  
1970 18 ,  
가 가  
14) , Bark dust, Fertile mulch Forest gold , Forest  
humus, Ivory orchid bark, Oregon black gold, Silvacon ,  
1956 Shimamoto15) 가 가  
가 , Ootaki16) 가

목재산업 협동조합등이 중심이되어 1968년부터 본격적인 목질계 퇴비의 기업화를 추진하였으며, 근년에 와서 약 80개 공장에서 년생산량이 약 40만톤에 달하고 있다.

## 제 2 절 재료 및 실험방법

### 1. 공시 톱밥의 제조

표고폐골목 및 지조목.임지폐재(충북 제천시 봉양읍 명암리 산 34-1 에서 벌채한 지조목)등을 공시재료로 하여 톱밥 제조기 (경운기부착용, 15마력(삼진기업사 제작, 모델 S79215)를 사용하여 사진에서 보는바와 같이 톱밥을 조제하여 제조공정을 산출하였다.



Photo. 2-1. Sawdust making machine



Photo. 2-2. Milling of Shiitake bedlogs.

## 2. 발효상 설계 및 축조

한개 발효상의 크기는 가로 1.5m, 세로 1.5m, 높이 2m 로서, 시멘트블록을 이용하였다. 이러한 발효상을 사진 2-3 에서 보는 바와같이 연속하여 4개 축조하므로써 발효과정이 진행됨에 따라 뒤집기를 하면서 비어있는 다음 발효상으로 이적할 수 있도록 설계되었다.



Photo. 2-3. Composting house.

### 3. 원재료의 배합 및 퇴적

톱밥을 부숙시킴에 있어서 가장 중요한 사항은 목질계 폐재가 일반적으로 C/N율이 매우 높을뿐만 아니라 미생물에 의해 분해되기 어려운 리그닌 성분을 많이 함유하고 있으므로, 자연 분해시키기가 다른 유기재료에 비하여 매우 어렵다.

표 2-1 은 본 실험에서 사용한 원료의 배합비율을 나타낸 것으로서 원료 및 첨가 부원료의 배합조합은 부숙과정 및 제품의 경제성에 크게 영향하므로 신중하게 검토되어야 한다. 사진 2-4 에서와 같이 잘 배합하여 발효를 개시하였다.



Table 2-1. Mixing of raw materials for composting

Raw materials	Japan		This Exp.
	A	B	
Shiitake bedlog	1,000 Kg	1,000 Kg	1,000 Kg
Urea	10 Kg		12 Kg
Chicken shit	50 Kg		50 Kg
Man excretion	-	650 l	-
Fermentation aids	little	little	4 kg
Lime	-	10 Kg	20 Kg
Rice brane	-	-	5 kg
M. C. (%)	50-60	50-60	60



Photo. 2-4. Mixing stuffs and its composting.

가 가 .  
가 가 ,  
1.5m 2.0m  
가 60% 가

4.

가.

, , ,

2 1 0%, 50% 100%

, 2 ( , ) 30cm, 가 30cm (30, 50, 70%) ,  
2 ( , ) 2 ( , ) 5

18:00 3 8:00, 14:00

5.

가 ,

가.

( , , , , ) 100kg, 30kg, 3  
( ) 1kg  
.  
.

1) : 9 , (*Magnolia sieboldii*), (*Phellodendron amurense*), (*Prunus padus*), (*Acer buergerianum*), 가 (*Juglans mandshurica*), (*Acer mono*), (*Acer palatum*), (*Platycarya strobilacea*), (*Ligustrum obtusifolium*) 9 , 90 , 27 .

2) 1m<sup>2</sup> x 1 x 3 m<sup>2</sup> 90 , 90m<sup>2</sup> 10 x 9 x 3 x 3 .

3

1.

가.

(15 , , S79215,  
 2.5m3 ) . 1  
 ( 2 . 1 ) 1.2 m3 145 kg(666 liter)  
 . 1 m3 121kg (555 liter) ,  
 10 1,452 kg (300 , 6,660 liter) .

1 ( 2 . 1 ) 1 m3  
 98 kg(441 liter) . 10  
 980 kg (300 , 4,410 liter) .

2. ( )

1 , , 2-1  
 , 1 10 ( 60 )  
 , 10 가 가 .  
 가

55% 가  
 , 4-5 27-30 가  
 가 55-57  
 . 60 2 , 50 ,

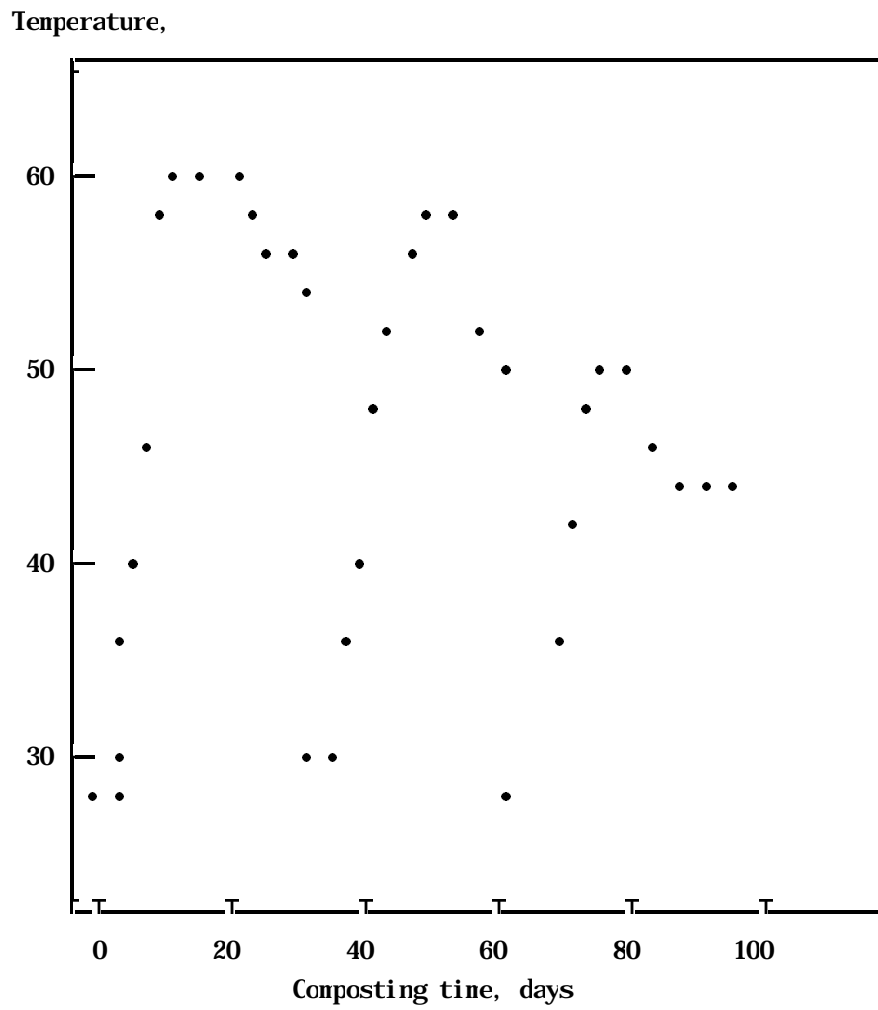


Fig. 2-1. Changes in temperature during composting process. (Shiitake bedlog)

60 3  
phenolic acids, tannic acids , C/N

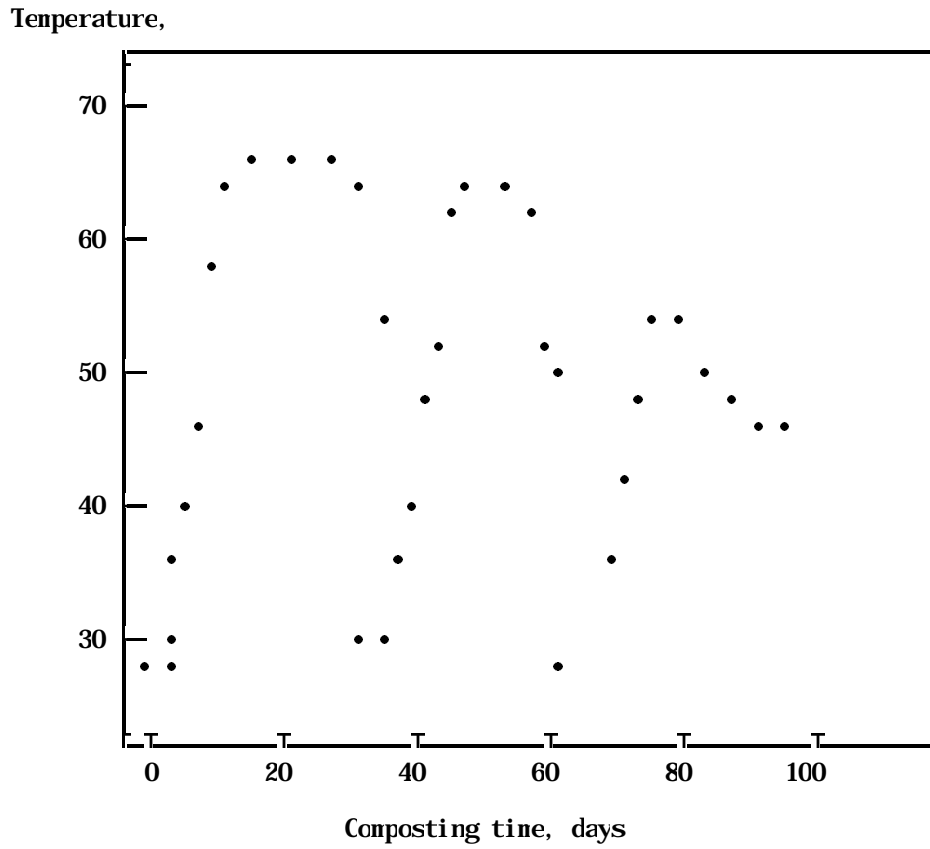


Fig. 2-2. Changes in temperature during composting process. (Fresh twig)

2-2  
 1 , 2  
 20 ( 66 )  
 10 가 .  
 가 .  
 가 66  
 15 , 가 가 .  
 가 64 ,

3.

가.

2-2

가

**Table 2-2. Chemical components of composts**

L/I	Bedlog compost	Fresh twig compost	Garbage compost
P <sub>2</sub> O <sub>5</sub> , %	0.57	1.02	0.85
Total N, %	0.48	0.31	0.58
K <sub>2</sub> O, %	0.38	0.33	1.46
CaO, %	3.01	2.82	0.16
MgO, %	0.22	0.19	0.13
Organic matter, %	7.77	10.68	58.63

**Table 2-3. The effect of organic wood composts on growth of radish**

Organic composts	Days after seeding	Mixing ratio with sand, %		
		0	50	100
Shiitake bedlog(B-1)	5	9.5/2.5	11.5/3.5	14.5/5.0
	10	11.0/3.5	14.5/3.8	15.8/7.5
Fresh twig(B-2)	5	8.0/2.1	11.0/3.5	13.5/4.2
	10	11.5/3.0	12.5/3.0	14.5/8.0

\* All values are top/root length(unit : cm) of radish.

유기질비료와 모래에 유기질비료를 0%, 50% 혼합한 것과 유기질비료 100% 혼합한 포트에 생육저해 물질에 가장 민감한 것으로 알려진 무우종자를 파종하고 2일마다 1회 관수하면서 그 생육상황을 관찰하였다. 모든 처리에서 무우종자가 발아되었으며, 모래만의 대조구에 비해 유기질비료의 혼합량이 많아질수록 무우의 생장이 우수한 것으로 나타났다(표 2-3, 사진 2-5 및 사진 2-6 참조).

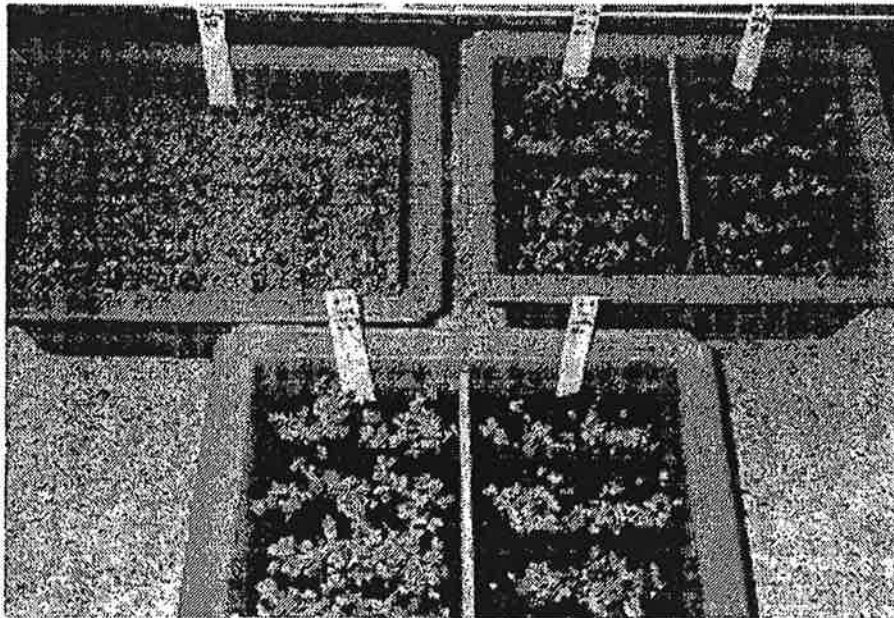


Photo 2-5. Growth of radish on 3 days after seeding.



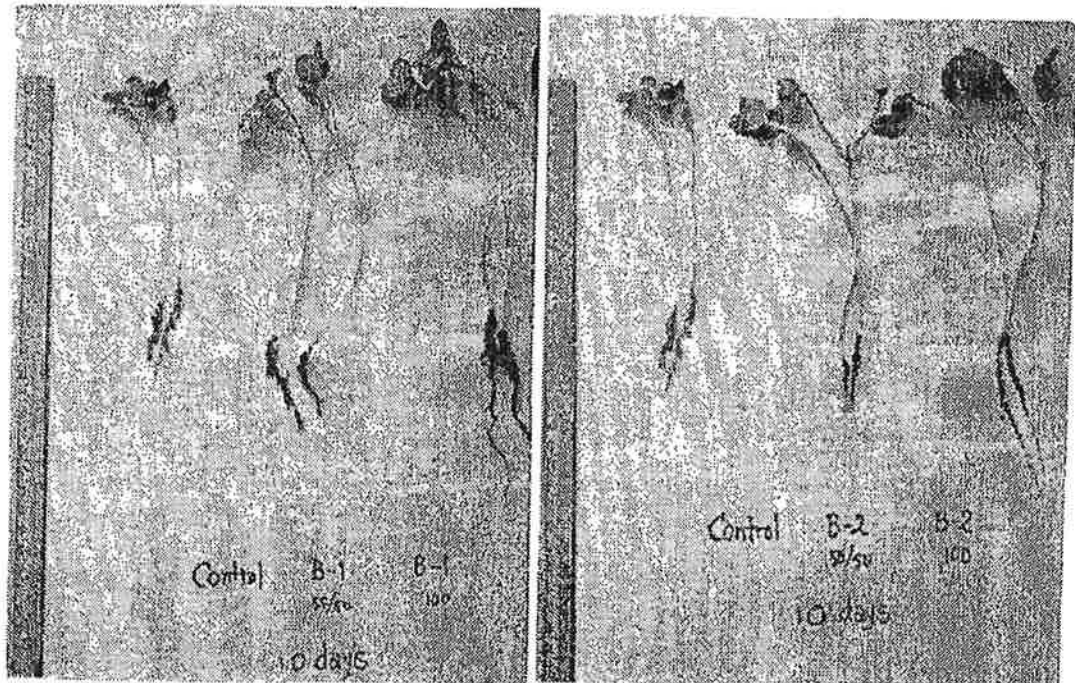


Photo 2-6. Growth of radish on 10 days after seeding.

모래와 유기질비료를 여러가지의 혼합비 (0, 30, 50, 80, 100%) 로 섞고, 이를 직경 20cm, 높이 30cm 의 화분에 넣은 다음, 식물생육검정 재료로서 많이 사용되는 무우종자를 파종하고, 2일 1회 관수하면서 그 생육상황을 관찰하였다.

무우종자를 파종하여 4 - 5일이 지나면서 모두 발아하였으며 모래로만 이루어진 100:0 구가 1일 늦게 발아하였다. 그리고 파종하여 10 일이 경과한 무우의 지상부 및 지하부 생육상황을 관찰한 결과, 그림 2-3 에서 보는 바와같이

가 100:0  
 , 가  
 , 50% 가 가  
 80% 가 .

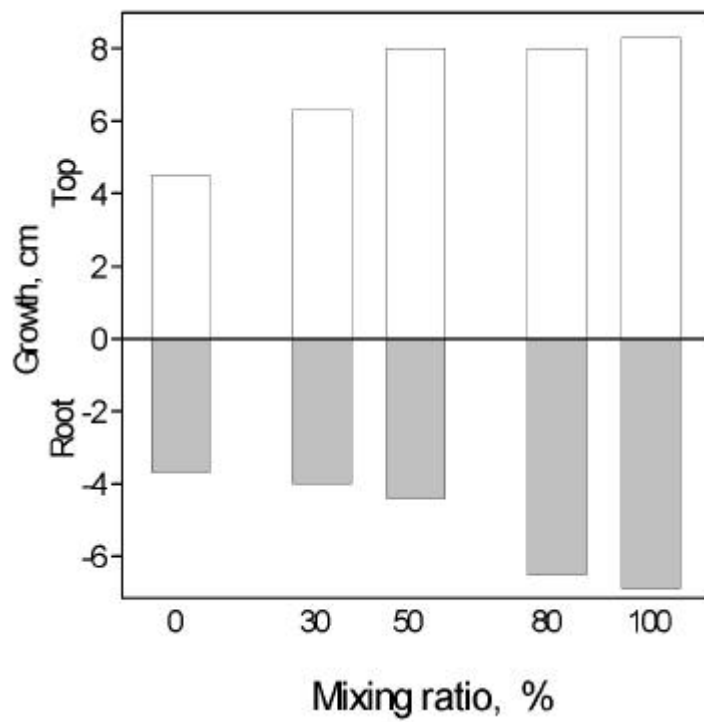


Fig. 2-3. The effect of bedlog compost on growth of radish (10 days after seeding).

15 2-4 100:0  
 , 가  
 10 . 25 2-5 가  
 가 , 가 2

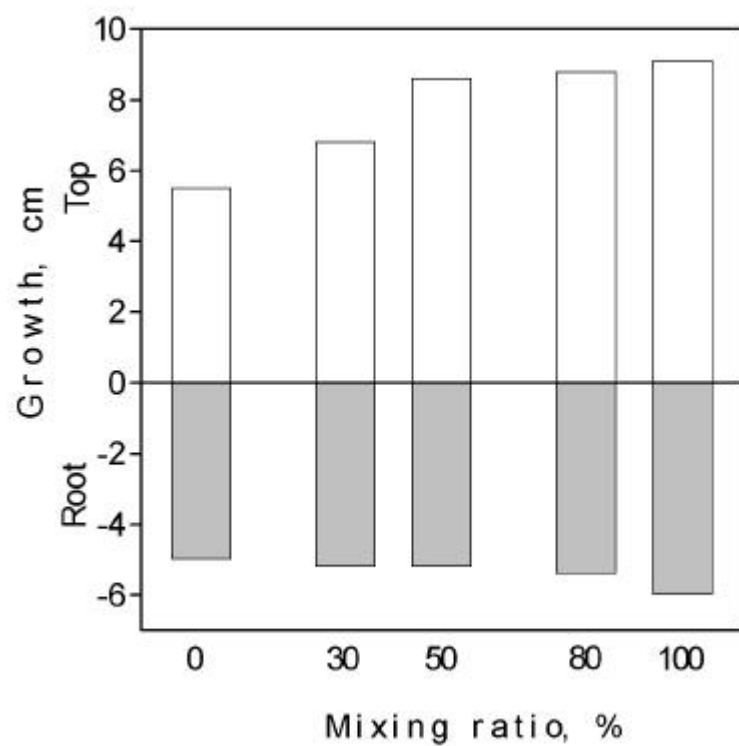


Fig. 2-4. The effect of bedlog compost on growth of radish (15 days after seeding).

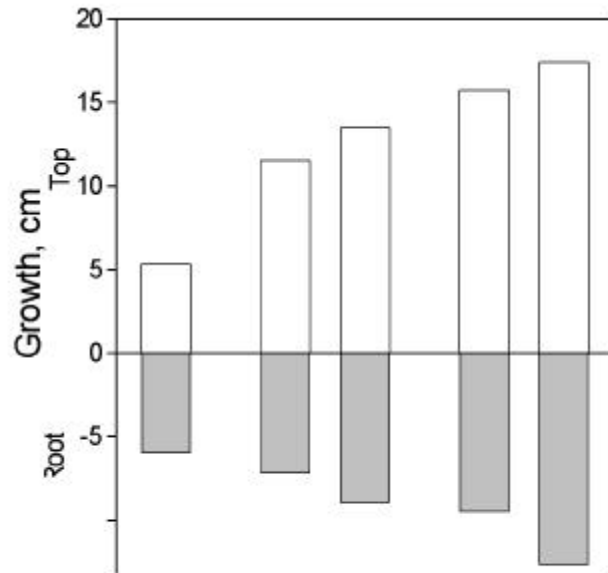


Fig. 2-5. The effect of bedlog compost on growth of radish (25 days after seeding).

4.

가 (30, 50, 70%)  
 , 30cm, 30cm  
 , 2 ( , ) 5  
 , 100% , 120  
 가 .

5.

가 . 2-6 가 8:00  
 , 가 가 ,  
 5 15 , 가

25

가

가

가 가

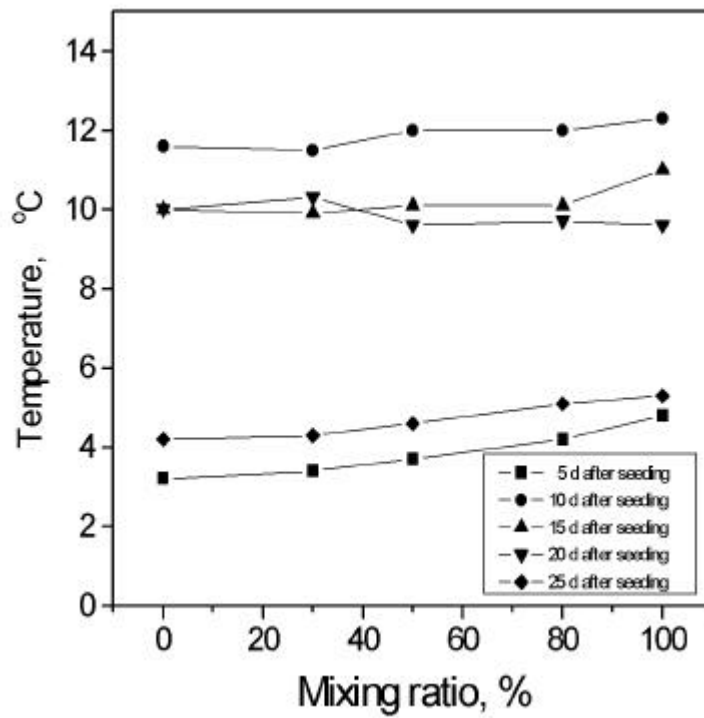


Fig. 2-6. The effect of bedlog compost on soil temperature of radish pot at 8:00.

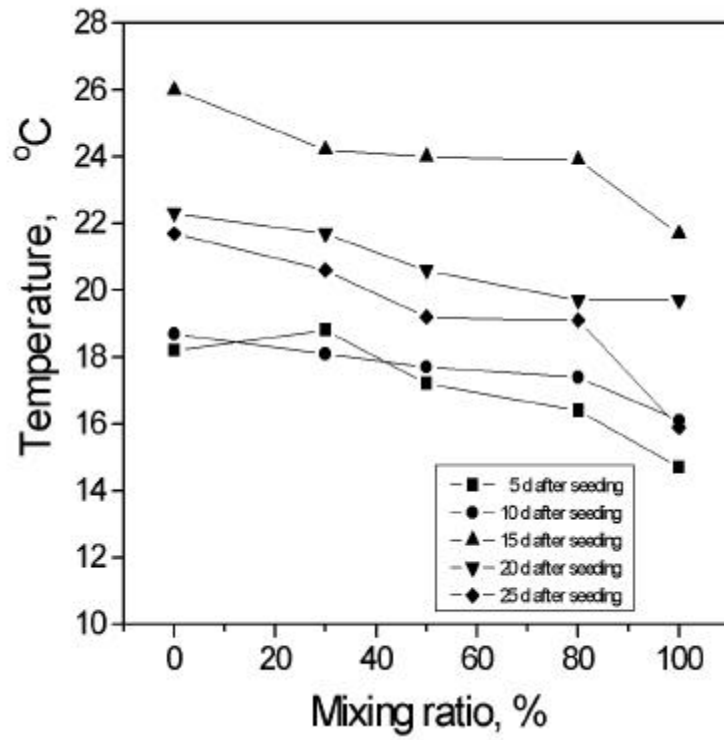


Fig. 2-7. The effect of bedlog compost on soil temperature of radish pot at 14:00.

2-7 2:00 , 가  
 가 4 - 5 , 가  
 가 가 ,  
 (18:00) 가 2-8 가  
 , 가  
 가 가  
 가 가  
 가 가

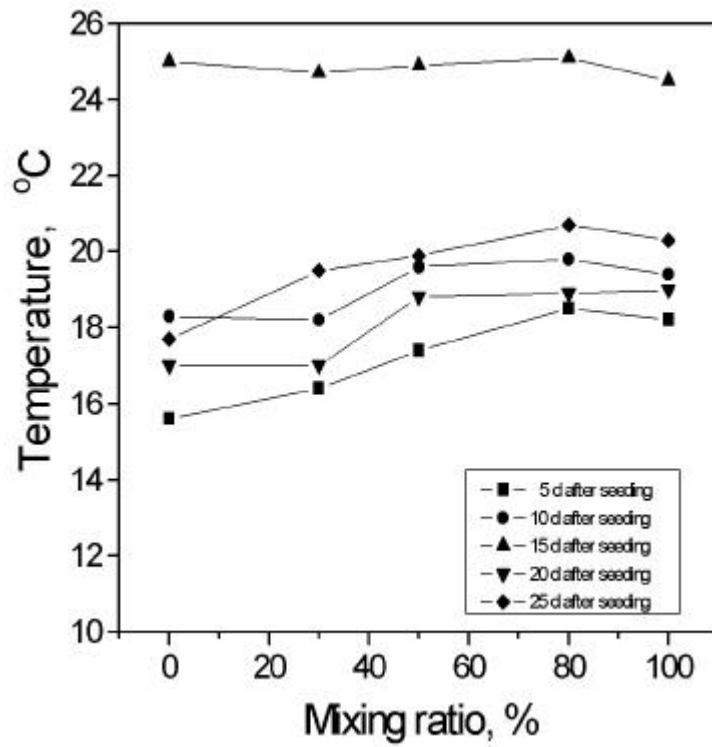


Fig. 2-8. The effect of bedlog compost on soil temperature of radish pot at 18:00.

2-9 , 08:00 8.5 5 20 ,  
 1 , 15 ,  
 ( 가 )가 .  
 ,  
 가 가 (14:00) ,  
 가 가 가 (18:00)

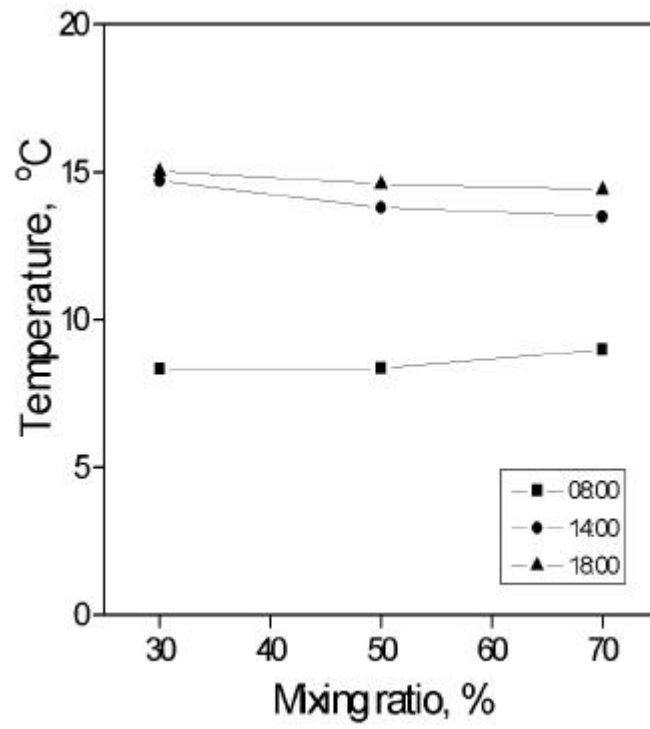


Fig. 2-9. The effect of bedlog compost on soil temperature of tree planting field.

, 80%

가  
가

6.

3



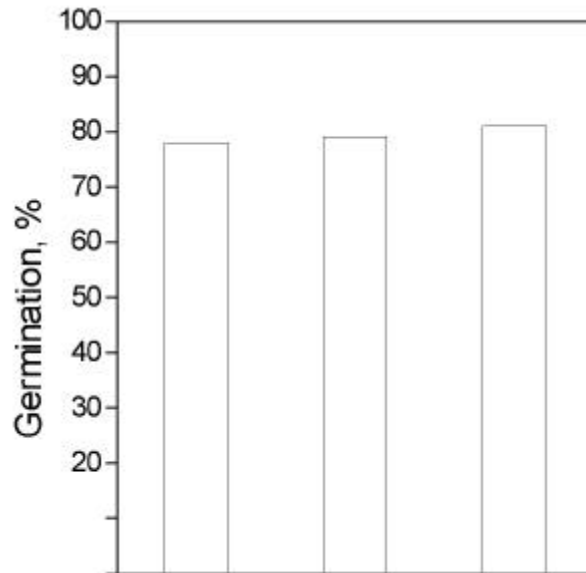


Fig. 2-10. The effect of organic composts on germination of tree seed.

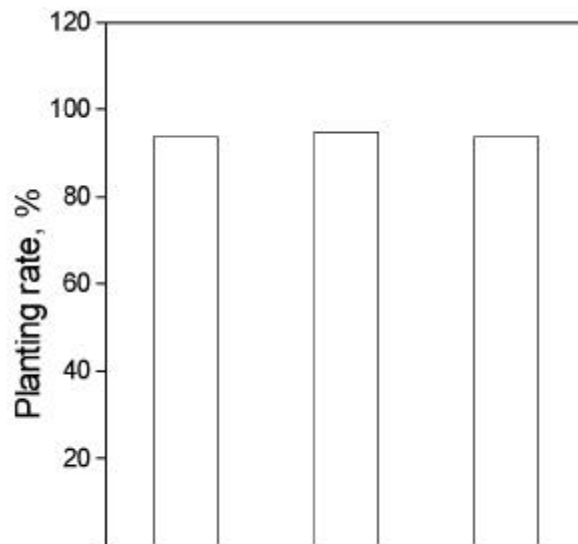


Fig. 2-11. The effect of organic composts on planting of trees.

2-10  
 80% 가  
 2-11 9  
 가 94%  
 81% 가  
 2-4  
 가  
 가 220 - 250%  
 가 , 11 - 22%  
 730% 가  
 602% , 가 , 117 -  
 120% , , 52 - 78%

Table 2-4. The effect of organic composts on growth of trees

Organic composts Species	Garbage		Fed-log		Fresh twig	
	Stump cm	Height cm	Stump cm	Height cm	Stump cm	Height cm
<i>Magnolia sieboldii</i>	1.08	62.0	1.15	69.8	1.18	71.7
<i>Helleboron aureuse</i>	1.36	111.6	1.43	116.1	1.12	85.4
<i>Ficus pacis</i>	0.60	46.8	0.71	56.6	0.65	52.6
<i>Acer buergerianum</i>	1.53	182.8	1.72	190.7	1.38	162.6
<i>Juglans nanshurica</i>	1.85	99.2	2.02	72.0	2.02	76.3
<i>Acer natio</i>	0.94	96.2	0.90	77.3	1.06	122.8
<i>Acer palatum</i>	0.54	50.3	0.60	60.5	0.50	48.9
<i>Hatycaya strdbilacea</i>	1.04	49.2	1.22	45.4	1.14	52.6
<i>Ligustrum obtusifolium</i>	0.94	90.8	1.08	81.6	0.98	102.1
Average	1.04	84.1	1.14	82.3	1.06	82.5

가 , 가 ,

귀퉁나무가 우수하였고, 가래나무, 적단풍, 함박꽃나무 등이 불량하였다. 신선 지조목의 경우도 중국단풍과 귀퉁나무가 우수한 성장을 보였고, 가래나무, 함박꽃나무, 적단풍 등이 불량한 근원경 성장을 나타냈다.

그림 2-12 는 3종의 유기질비료의 근원경생장에 미치는 효과를 종합한 것으로서 음식쓰레기의 성장율에 미치는 효과가 가장 컸으며, 표고버섯폐골목 및 신선지조목 비료의 효과는 유사하게 나타났다.

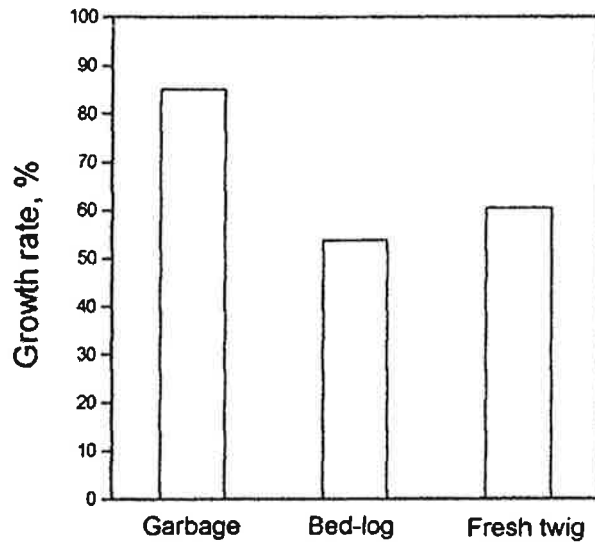
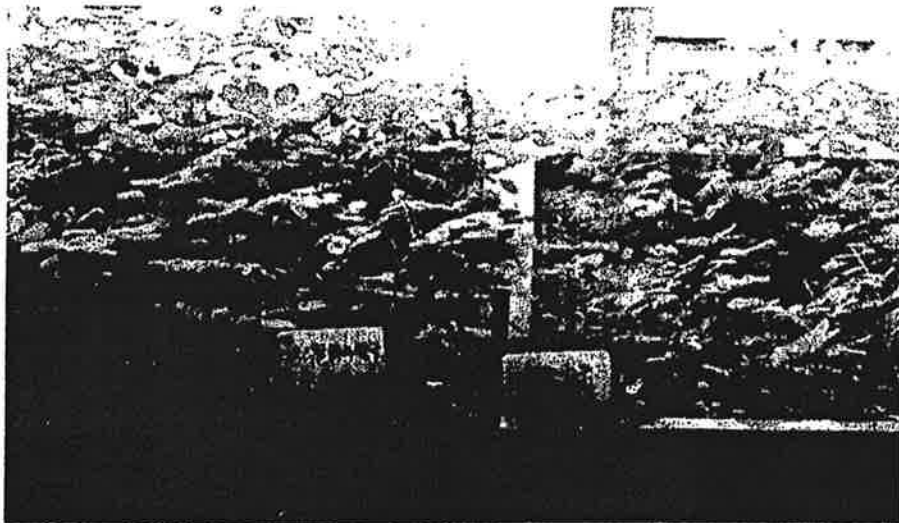


Fig. 2-12. The effect of organic composts on growth rate of stump diameters.

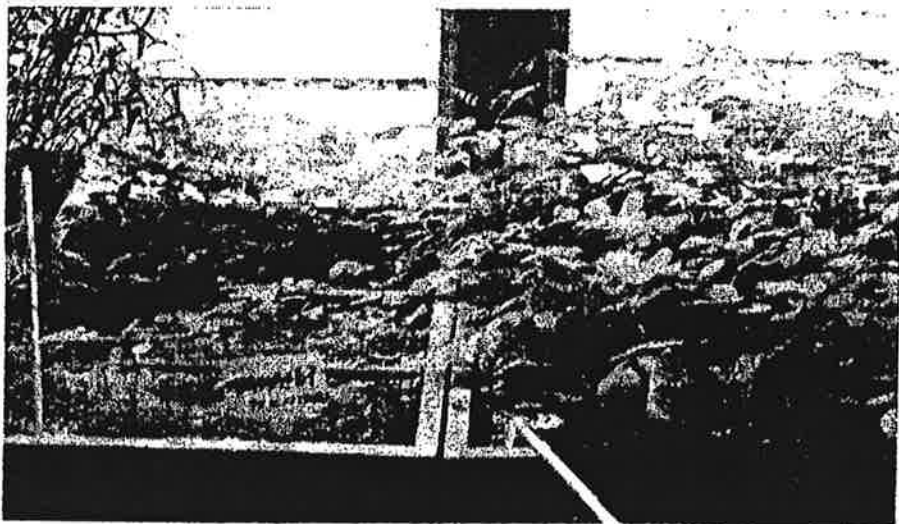
그림 2-13 은 유기질비료가 높이생장에 미치는 효과를 종합적으로 나타낸 것으로서 근원경에서와 마찬가지로 음식물쓰레기가 232%의 가장 높은 성장률을 나타냈으며, 그 다음이 224%의 표고폐골목비료로서 음식물쓰레기 비료와 거의 유사한 결과를 보였다. 이에 대하여 신선지조목비료는 187%의 가장 낮은 성장율을 기록하였다. 수종별로 살펴보면 음식물쓰레기의 경우 중국단풍이 730.9%, 적단풍 602.5% 로서 높은 성장율을 기록하였고, 산목련이 200% 를 초과하는 성장량을, 황벽나무는 52.5%, 귀퉁나무 78%, 고로쇠나무가 72.8%로서 매우 낮은 수고성장율을 나타냈다. 표고재배 폐골목비료는 중국단풍, 적단풍, 귀퉁나무등이 우수하였고,





Garbage

Control



Fresh twig

Shiitake bedlog

Photo 2-7. Growth of red acacia on organic composts.

4

1. S79215) , 15 ( , 2.5m3 .
2. liter) , 1 ( 2 . 1 ) 1m3 121kg (555 145 kg(666 liter) . 1.2m3, 1 ( 2 . 1 ) 1m3 98kg(441 liter) 980kg (300 , 4,410 liter) 10 .
3. 1.5m x 1.5m x 2m , 가 가 , 가 60% 가 . 1 10 ( 60 ) , 10 가 .
4. 가 66 15 , 가 가 . 64 , 가 .
5. , 가 가 가 , 가 가 가 .
6. , 가 , 가 , .



- 10) Wolf, S.P.Jr. & S. Dunn, Sawdust composts in soil improvement. - Studies on aeration, acid hydrolysis, manure, and waste materials as composting aid. *Plant & Soil* 4:223-234(1953)
- 11) Baker, J.R. & S. Dunn, sawdust composts in soil improvement. - Pot studies with composts from out-door pits, wooden bins with high moisture, and other mixtures. *Plant & Soil* 6: 113-128(1955)
- 12) Davey, C., Sawdust composts: their preparation and effect on plant growth. *Soil Sci. Soc. Am. Proc.* 17:59-60(1953)
- 13) -----, transformation of sawdust in the course of its decomposition under the influence *Coprinus ephenerus*. *Soil Sci. Soc. Am. Proc.* 19 : 376-377(1955)
- 14) Sales, R.L., Using and marketing bark residues. *For. Proc. J.* 23(8) : 10-14(1973)
- 15) 島本賞也, 最近 微生物農法, 酵素 世界社 (1956)
- 16) 十河村男, 樹皮lignin 及び 樹皮 phenol に 關する 研究, 香川大學 農學部 紀要 25: 1-76 (1971)
- 17) Nam - Seok Cho, On the manufacturing of soil conditioner and fodder from waste wooden materials. *Forest Res. Inst.* (1974)
- 18) . ,  
9(1): 1-9(1990)



3

1

가 , , 가 .

가 , 가 , 가 , 가 , 가 , 가 , 가 , 가 .

U.R. 가 , , 가 .

植材 , hardening , .

가 .

가 가 .

가 , , 가 .

가 , , 가 .

“ ” , 1 - 8, 14)가 .

, 가 . 가

2

1.

( )

2.

(polymerization) (foaming)

가  
( 3-1 )

Table 3-1. Preparation of wood polyol

Woodneal (#20-80)	50 g
PEG (#400)	150 g
Sulfuric acid	4.5 g
Reaction temperature	150
Reaction time	60 min.

40% : , diphenylmethanediisocyanate (MDI),  
(triethylenediamine, TEDA), ( )  
, , ,  
:  
가 . MDI 가  
가 가 .

3-2 .

**Table 3-2. Composition of polyurethane foams**

Wood polyol	20 g
48% NaOHaq.	0.7 ml
TEDA	0.1-0.3 ml
Anti foamer	0.3-0.4 ml
MDI	18 g

0.3g/cm<sup>3</sup> , : 3-2 가  
 가 , 가  
 : 가  
 , 가  
 , 가  
 , 3-3 .

**Table 3-3. Residues during preparation of wood polyol (%)**

(PEG: Gly: Wood)	( )	(%)	(hr)		
			1	1.5	2
6 : 4 : 5	150	3	5.8	9.0	6.0
	150	5	40.5	77.0	78.8
	165	3	6.5	10.7	11.3
	165	5			
	180	3	6.5		83.0
	180	5			
6 : 4 : 3.3	150	3	4.5	3.0	3.8
	150	5	6.5	6.5	8.3
	165	3	4.5	6.7	4.7
	165	5			
	180	3			
	180	5			

3-3

(polyethyleneglycol, PEG)

(PEG:Gly:Wood = 6:4:5)

가 ( )  
가

: 3-4  
( MDI 가 가 )

Table 3-4. Mixing ratio of polyol and isocyanate

Polyol, %	100
MDI, %	138

: 3-4  
가 가

3

가 , isocyanate (-N=C=O) 가 (-OH) 가  
 polyurethane . isocyanate  
 가 polyurethane  
 가 polyurethane isocyanate  
 가 .

1.

가. 20-80 ,  
 ( 가 ) , 1,  
 2 3 .

(MDI) , diphenylmethanediisocyanate ,

2.

가. 100ml 가 ,  
 Oil bath , 100rpm  
 .  
 , 1,4- dioxane 150ml  
 ,  
 105 4 , .

3.

가. OH NCO NCO index , ,  
 MDI .

가 6,000rpm 1 pH , , MDI  
 가 , 6,000rpm 10 NCO index

4

1.

가.

PEG 400  
 / ( ) 1/1 1/4 가  
 3-1

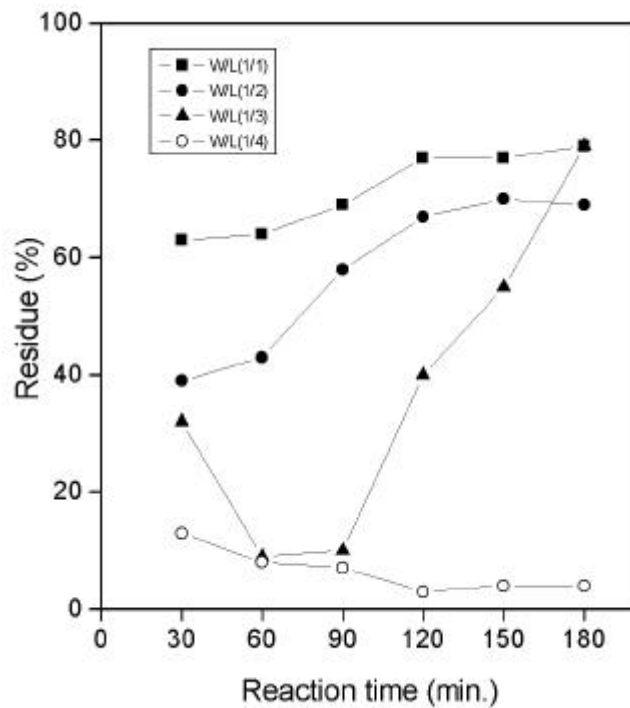


Fig. 3-1. The effect of wood/solvent ratio on the liquefaction.

1/3 30 3% , 150  
 , 60 90  
 가  
 1/3  
 , 가 1/4

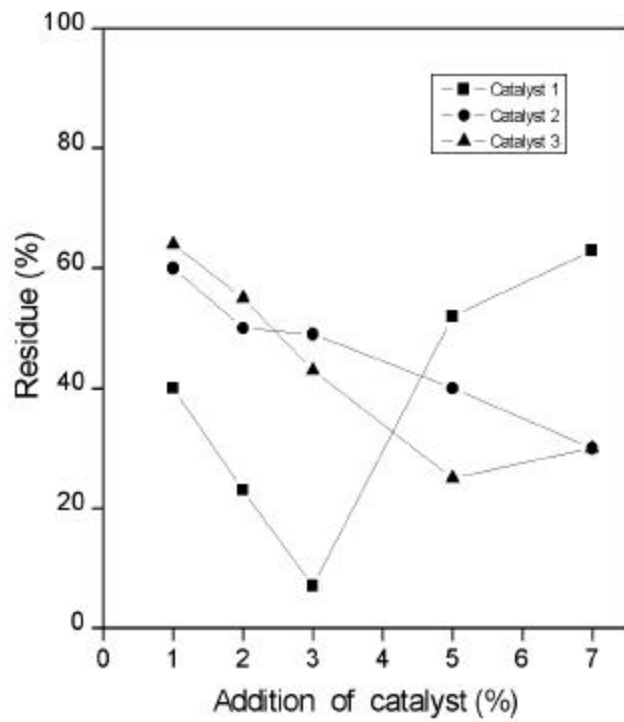


Fig. 3-2. The effect of acid catalysts addition on the liquefaction.

3-2 1 가  
2 3

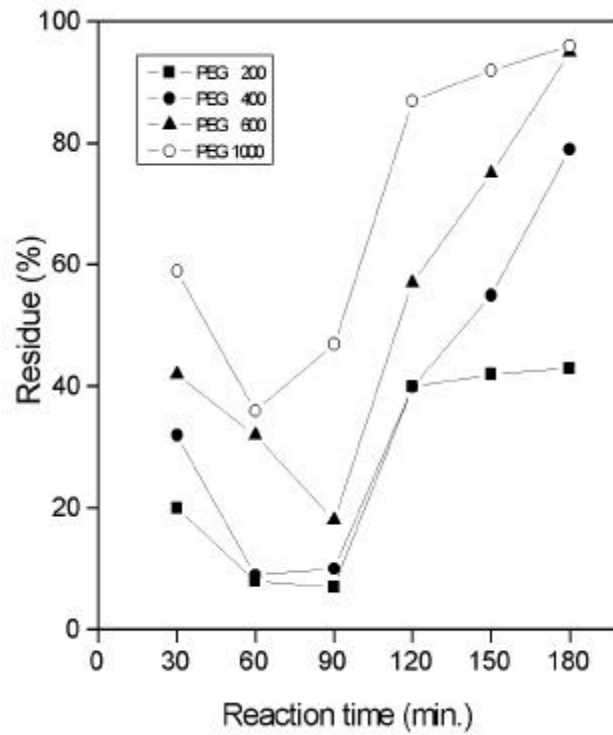


Fig. 3-3. The effect of molecular weight of liquefying solvent on the liquefaction.

PEG 200 - 1,000  
PEG  
150 3-3 가 60 90  
가 ,



가

, 20%  
400

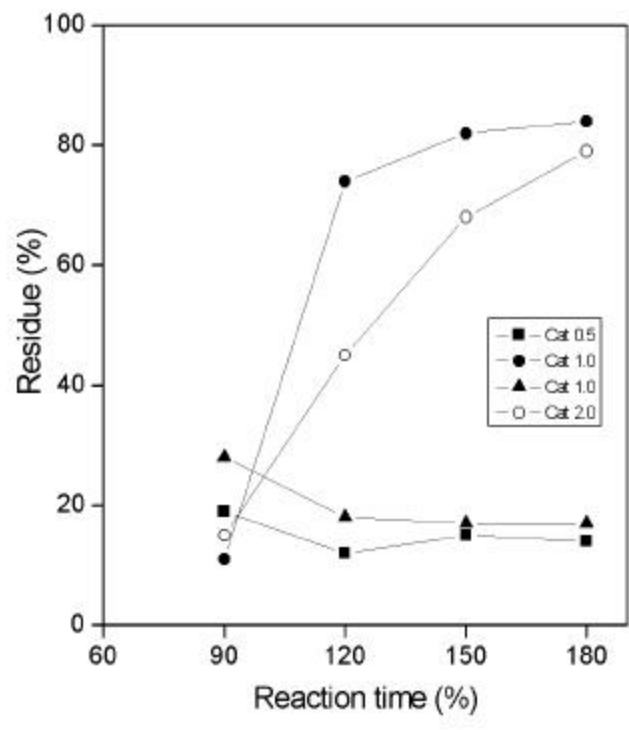


Fig. 3-4. The effect of catalyst and reaction temperature on the liquefaction.

180 , 180 , 150 , 150

3-4

가 1% 0.5% 가 , 1%  
150 180 80% 가 가

가  
 , 가  
 40% 90% 가 3-5 50% 가 가

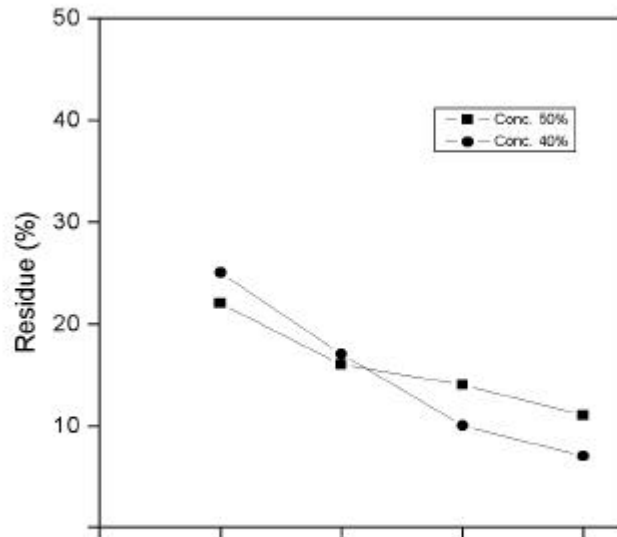


Fig. 3-5. The effect of starch addition on the liquefaction.

2.

isocyanate urethane furon IC-12)가 isocyanate 가

isocyanate 가 , 가  
 가 urea , 가 가  
 (H<sub>2</sub>O) 가 (CO<sub>2</sub>) isocyanate -NCO  
 가 .

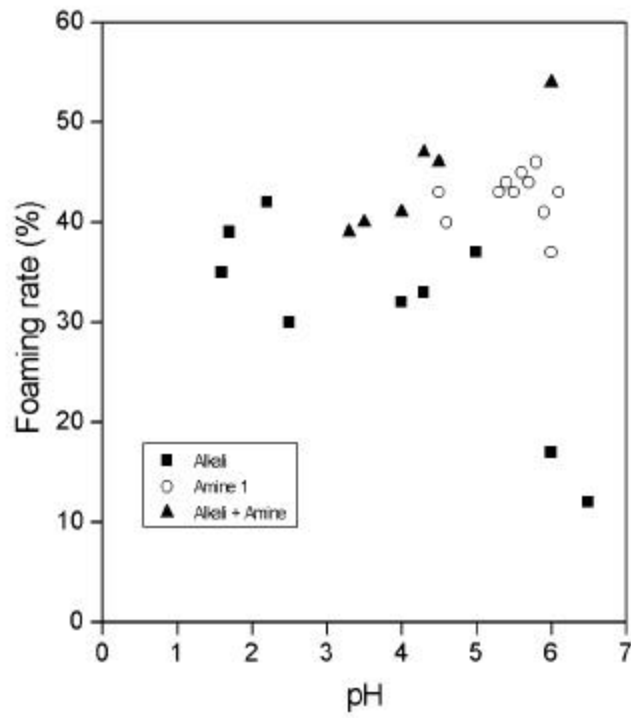


Fig. 3-6. The effect of neutralization of liquefied materials on the liquefaction.

pH , 가 .  
 pH  
 , pH 가 , pH  
 3-6 . pH

40 - 50% , amine 1 pH 5 - 6  
 pH 5 - 6 가 가 amine  
 NaOH 50%  
 가 pH 가 5  
 가 , , .  
 .  
 3 - 20% . 가 ,  
 (foaming rate) , .  
 가  
 0.6% 5 , 5% 가  
 30 ( 3-7 ).  
 가 ,  
 3-8 3% 가 45kg/cm<sup>3</sup> , 7  
 - 9% 가 38kg/cm<sup>3</sup> 가 ,  
 가 가 가 가  
 가 .

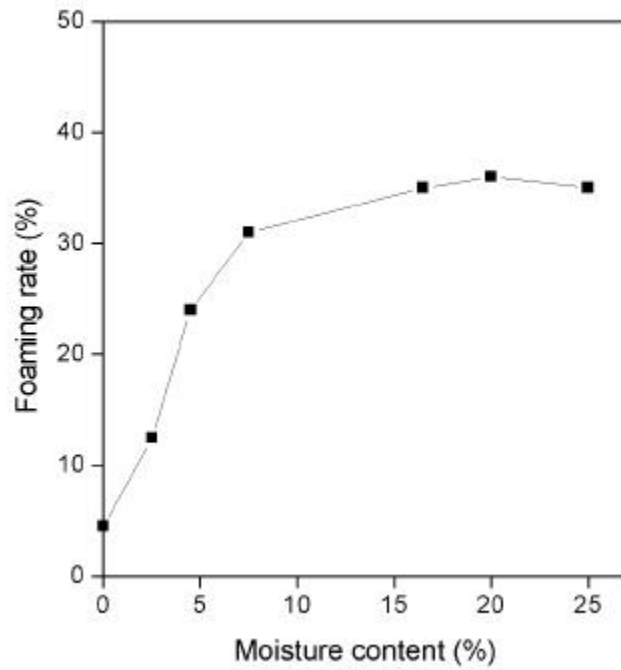


Fig. 3-7. Moisture content and foaming rate.

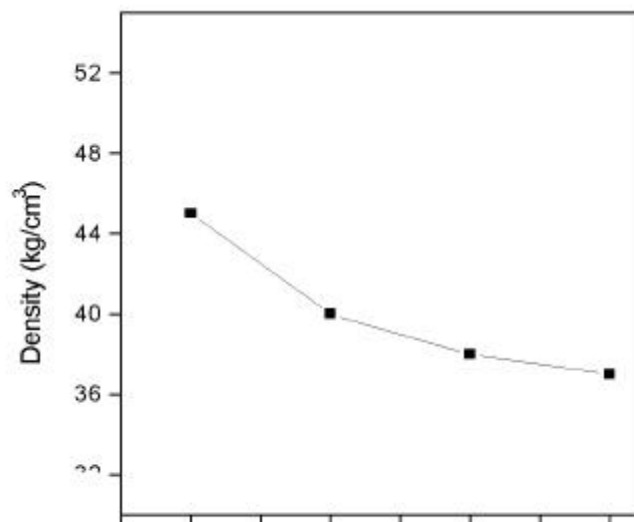


Fig. 3-8. The effect of moisture content on density of urethane foam.

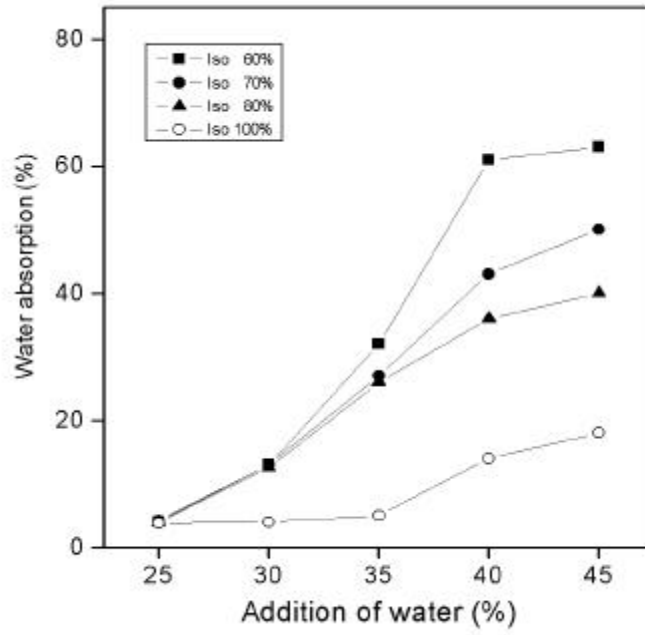


Fig. 3-9. The effect of water on the water absorption of foam.

isocyanate 25% 3-9 isocyanate  
 ,  
 25- 45% isocyanate 60- 100%  
 3-9 isocyanate  
 ,  
 가 isocyanate 60% 가 가 , 45%  
 가 20- 60 가

5

가 가 isocyanate (-N=C=O) 가 , polyurethane isocyanate 가 .

가 가 , .

MDI 1) OH NCO NCO index , , 가 , .

1/3 2) PEG 200 - 1,000 , 400 가 . PEG 400 , ( ) .

3) 가 가 . 가 1% 0.5% 가, 1% 150 180 80% 가 40% 가 90% 가 .

4) 0.6% 5 , 5% 가 30 가 , 3% 가 45kg/cm<sup>3</sup>, 7 - 9% 가 38kg/cm<sup>3</sup> 가 .

5) 25- 45% isocyanate 60- 100% isocyanate 60% 가 가 , 45% 가 .





- 10) Ge, J. J. and K. Sakai. Synthesis of biodegradable polyurethane foams from the bark, *Acacia nearnsii*. *Nokuzai Gakkaiishi* 42(1): 87-94 (1996)
- 11) Ge, J. J. and K. Sakai. Phenylurethane formation from (+)-catechin as a model reaction for polyurethane synthesis from condensed tannins. *Nokuzai Gakkaiishi* 42(4): 417-427 (1996)
- 12) Ge, J. J. and K. Sakai. Decomposition of polyurethane foams derived from condensed tannin I. *Nokuzai Gakkaiishi* 42(8): 776-781 (1996)
- 13) Yoji Nakashina, Ge, J. J. and K. Sakai. Preparation and characteristics low-density polyurethane foams from the barks of *Acacia nearnsii* and *Cryptomeria japonica*. *Nokuzai Gakkaiishi* 42(11) 1105-1112 (1996)
- 14) Sakai, K., J. J. Ge, and Yoji Nakashina. Synthesis and properties of biodegradable polyurethanes from tree bark tannins. Proc. '97 International Syn. Wood Sci. Technol., Seoul Korea, Oct. 23-24, 1997. pp. 81-98(1997)

1.	.
2.	.
3. 가	.