



( ) 가

Development of Process for Extruded Yukwa  
by Injecting CO<sub>2</sub> Gas

가 “ ( ) ” .

1997. 12. 5.

:  
: ( )  
: ( )

.

( ) 가

.

,

가 가

.

가

가

.

가

가

.

,

가

.

가가

,

.

가

가

.

가

.

1. 가

(1)

1)

2)

3) 가

4)

(2)

1) pH pH

2) BW BW pH

(3)

1)

2)

3)

4) 가

5)

2.

3.

(1)

(2)

1)

2)

(3) CO2

1) CO2

2) CO2

- 3) CO2
- 4) 가 가 CO2

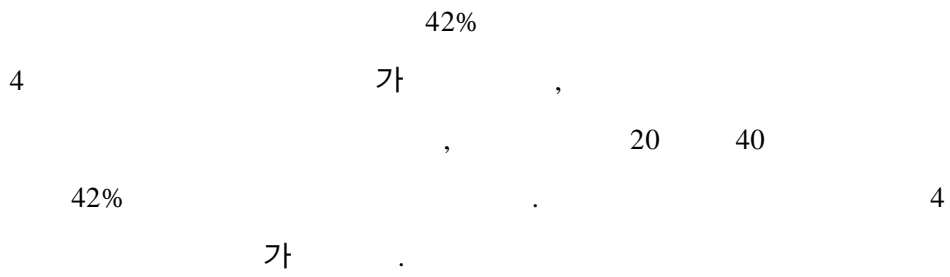
4.

- (1)
- (2) 가

**IV.**

1)

가



annealing

가

6

, ,

.

,

.

pH

, pH

, BW

pH

16 17%가

12

, ,

chain

가

,

.

, 가

가

3

2)

가 가 .

3)

가

31mm, L/D 22, 7.5HP,  
 4mm , , 800psi  
 , , low-shear screw, medium-shear screw  
 high-shear screw , 85 115 ,  
 50 350rpm

4)

105

40%

5)

CO2

CO2

105

CO2

CO2

350rpm

3  
, CO2  
CO2  
가 CO2  
3 가  
. 가  
, 가  
. 가  
6)

16 18% , 60 4  
(CO2 3 ) , 16  
18% 가 가 .  
가 72.6% (RH) desiccator 1  
가  
conditioning 2

, , , 1

105 , 300rpm , 43%





## **I. Subject**

Development of Process for Extruded Yukwa by Injecting CO<sub>2</sub> Gas

## **II. Objective and Results**

Extrusion-cooking and CO<sub>2</sub> gas injection were applied to shorten the process of Korean traditional snack (Yukwa) making. In traditional process, waxy rice pellets were made by several process operations; steeping for 1 week at 15 °C, steaming, mixing with air, moulding (pelleting), and drying. Finally dried pellets are fried at 180 °C. Extrusion-process variables for applying to continuous process for Korean traditional snack making were determined. Steeped waxy rice powder was extruded to gelatinized starch, and mould pellets. Extruded pellets were completely gelatinized above 80 °C at 40% moisture. Air bubbles in pellets were generated by injecting CO<sub>2</sub> gas. Optimum conditions of the puffing and texture for extruded pellets were: steeping time for 7 days at 25 °C; barrel temperature, 105 °C; moisture content, 42%; CO<sub>2</sub> injection pressure, 0.05 MPa.

## **III. Content and Scope of Research**

1. Traditional process for Yukwa making

- (1) Analysis of steeping process
  - (2) Microbial changes during steeping waxy rice
  - (3) Characteristics of Yukwa by process variables
2. Analysis of dough mixing process
3. Development of extruded- Yukwa making by CO<sub>2</sub> gas injection
- (1) Extrusion system
  - (2) Effect of extrusion- process variables on characteristics of Yukwa
  - (3) Effect of CO<sub>2</sub> gas injection on characteristics of Yukwa
4. Post- extrusion of Bandegi
- (1) Drying extruded Bandegi
  - (2) Frying extruded Bandegi

## CONTENTS

I. Introduction	17
1. Scope and objectives of research	17
(1) Background and needs of research	17
2. Review of previous research	19
II. Contents of research	30
1. Schedule of research	30
2. Materials and methods	31
(1) Materials	31
(2) Methods	32
1) Traditional process of Yukwa making	32
2) Methods	32
a. Moisture content	32
b. Expansion	32
c. Density	33
d. Texture	33
e. Cell structure	34
f. Mixing energy input	34
g. Humidity	34
h. Gelatinization degree	34
i. Paste viscosity	34
III. Results and Discussion	35
1. Traditional process of Yukwa	35
(1) Steeping process	35
a. Moisture content for steeping time and temperature	36
b. Protein content and microstructure	39
c. Change in paste viscosity	43
d. Expansion, density and texture	43

(2) Change in microorganism during steeping	49
a. Change in pH	49
(3) Effect of process variables on Yukwa	55
a. Paste viscosity and microstructure	55
b. Moisture effect on Bandegi	59
c. Ingredient effect on Bandegi	62
d. Microstructure of Yukwa	65
2. Mixing process	67
3. Development of extrusion and CO gas injection system	70
(1) Extruder	72
(2) Effect of extrusion variables on Yukwa quality	77
a. Barrel temperature	78
b. Moisture content	83
(3) Extrusion and CO <sub>2</sub> gas injection	87
a. Extrusion temperature	87
b. Screw speed	94
c. Steeping time	99
d. Addition of soy milk	107
(4) Post-extrusion process	111
a. Drying of extruded Bandegi	112
b. Frying of Bandegi	119
VI. Conclusion	122
Reference	125
1	17

1		-----	17
1.		-----	17
2		-----	19
2		-----	30
1		-----	30
2		-----	31
1.		-----	31
2.		-----	32
(1)		-----	32
(2)		-----	32
1)		-----	32
2)		-----	32
3)	Density	-----	33
4)	Texture	-----	33
5)		-----	34
6)		-----	34
7)		-----	34
8)		-----	34
9)	가	-----	34
3		-----	35
1.	가	-----	35
(1)		-----	35
1)	.	-----	36

2)				-----	39	
3)		가		-----	43	
4)			,	-----	43	
(2)				-----	49	
1)		pH		pH	-----	49
2)	BW	BW		pH	-----	50
(3)				-----	55	
1)				-----	55	
2)				-----	59	
3)		가		-----	62	
4)				-----	65	
2.				-----	67	
3.				--	70	
(1)				-----	72	
(2)				-----	77	
1)				---	78	
2)				-----	83	
(3)		CO2		-----	87	
1)			CO2	--	87	
2)			CO2	-----	94	
3)			CO2	---	99	
4)	가	가	CO2	-----	107	
4.				-----	111	
(1)				-----	112	

(2) 가 ----- 119

4 ----- 122

----- 125

**1**

**1**



1.

(1)

가 가  
. , breakfast cereals 가  
. , 가  
가 가  
가 가  
가 , 가  
가 , 가  
가 . 가  
가 .  
가 가 가  
가 ( ) 가 가  
가 .  
가 가  
가 , 가  
가 가  
가 .  
가 .

가

가

( )

가

(2)

가

가

가

syrup

coating

syrup

가

가

가가

가

가

가 .  
가 .

가 .

2

가 .

.4)

가 ,

1)

(菓釘類)

.2)

.1)

(果)

가 .

2)

7 .

( ) 가

,

,

가 , , 가 , 가

,

,

,

,

가

, 가

,

.

.

, 가 ,

,

가 가 ,

(3 14 )

,

가 .4)

,

,

.1)

가 ,  
.11) amylose 가 . 11)  
20%  
, 20%  
. , + (20%)  
가 가  
. , 48% 가 , +  
(20%) 54% 가 .  
amylopectin  
.4) 1)  
가 .  
pH . 2  
pH 6.61 30  
pH 3.71 . 1 3 pH 가  
, (Ca<sup>2+</sup>, Mg<sup>2+</sup>) .  
가  
가 Ca<sup>2+</sup>, Mg<sup>2+</sup>  
가 .  
amylopectin . - amylase  
가 amylopectin

2  $18 \times 10^3 / M\ell$  , 10  
 Lactobacillus spp.  $106 / M\ell$  , Yeast spp.  $70 \times 10^3 / M\ell$

.1,13)

가

, 10 14  
 . 14) 가  
 , 2  $4.97M\ell/M\ell$  15  
 $12.46M\ell/M\ell$  가 .  
 35 3 20 10

가 .4)

3) roller 가 60

mesh, 80 mesh, 100 mesh

. 7)

(ACWS, air classifying wheel speed) 20,000rpm 15,000rpm

ACWS 가

, , 가  
 . 15,000 20,000rpm 15,000rpm

가

(ACWS)

가 .4) 50%

가 .

가 , , , baking powder, , alcohol yeast가 가 , , alcohol .8) 14) 가가 가 7.47M $\mu$ /M $\mu$  (P < 0.001), - amylase (2- amylase)가 . 100% 5 20%, 5 10%, 5 8%, baking powder 3%, 3 5%, yeast 5%, 0.5% . 가 ( ) 가 가 , 가 .4) 64.5 67 95 , 95 15 amylopectin .9) 가 가 가 가 가 가 가 가 가

가 13 30

.3)

( )

가

colloid

.4)

가

,

.

,

가

.3) 14)

,

160

가

가

80

160

,

,

160

가

. 4)

60 80

200g

60 가

.

texture

,

. ,

.

4)

.

3(가 )×5( )×

0.5( ) . ,

.



가 amylopectin  
가 (flexibility)  
3), 50%  
가  
가  
가 ,  
.4)  
“  
” , “ 95  
. ” , “ ” ,  
“ rack 30 ” 4), “  
. ” 14) . 6) oven 4  
5 5 , 23 15  
45 5 5  
가 texturometer 가  
가  
가 ,  
가 가 ,  
(15 20 )  
fan(ventilator)  
가 가

plastic bag 7 8  
 20% 가 가 ,  
 15% 가 가 .  
 가  
 가  
 , , amylopectin (solidification)  
 , ,  
 가 가 .4) 6) 14  
 1 120 2 19  
 0 2 가 가  
 .  
 1 110 120 가  
 1.5 2 , 170 180  
 2  
 . 2 1 2  
 가 2 가  
 . heater 가  
 1 2 . 1  
 2  
 chain conveyer system , 1  
 가 stainless steel  
 가 .

가

,

.

가

,

가( 30% )

가

.4) 12)

brittleness

가 254.4 centistrokes

가 70

18.8centistrokes

83.2,

1,450

.

.4)

, ,

.

30

4

9

가

.10)

,

(PE - 20 1

) ,

가,

N2 gas CO2

가

가

, 가

가

1992

snack

, (70-90 )

vitamin

가

, 가 snack flat bread

snack

가

가

가

가

configuration

data

가

,

.

2

1

1.

1995. 12 - 1997. 11

2.

(1) 1

	12	1	2	3	4	5	6	7	8	9	10	11	12
가 가	--	-											
		--	--	--	--	--							
						--	--	--	--	--			
								--	--	--	--	--	--

(2) 2

	1	2	3	4	5	6	7	8	9	10	11	12
(post-extrusion)	가											
	_____											
					_____							
	_____											
						_____						

2

1.

1996 가 가  
 ( ) . 가  
 ,

2.

(1)

가 , roller  
 2 가 ( , )  
 50% 가  
 가 90 95 가  
 40  
 12 12

15 19% 가

1 2

120

2

180

2

(2)

1)

150 /35min

setting

8 10g

2)

sample 3

가

Mℓ

, 70Mℓ



3) Density

particle density . 3

4) Texture

SUN RHEO

METER(Compac - 100, mode 20)

. Texture

analyzer 3 ,

bending strength

rupture strength, hardness ,

$$\text{Bending strength} = (dF/dl)(64d^3/48 D^4)$$

(dF/dl) slope , d

, D .

$$\text{Rupture strength} = N/m^2$$

N , m<sup>2</sup>

. hardness rheometer data

Test type	
Measure type	Press
Max	10kg
Table speed	100mm/m
Bending strength	slope
Rupture strength	force

5)

( )

slid glass sample (Olympus, Tokyo, C  
- 35) × 50, × 100 .

6)

가 53%  
mixer(Sinmag Corporation-  
SM200, Bowl(A200- 12)) mixer speed 2 (207rpm)  
Power meter(Clip- on AC Power meter)  
. 5, 10, 15, 20

7)

가 Digital  
Thermo- Hygrometer(Model, P570) .

8)

가 differential scanning calorimeter(DSC)

9) 가

Rapid Visco Analyzer(RVA) , 18 .

4 가 , 4 , 4

.  
**3**

1.

가

(1)

가

.

,  
가

가

가

가

40%

15

1

40%

,

4

가

.

가

가

가

가

6

6

,

가

가

가

가

1)

가

1

가

3.8%

, 4

(Fig. 1).

43%

40

가

3

45%

43%

4

, 40

2

43%

가

(Fig. 2).

가

amylose

amylopectine

42- 43%

가

preconditioner

가

50%

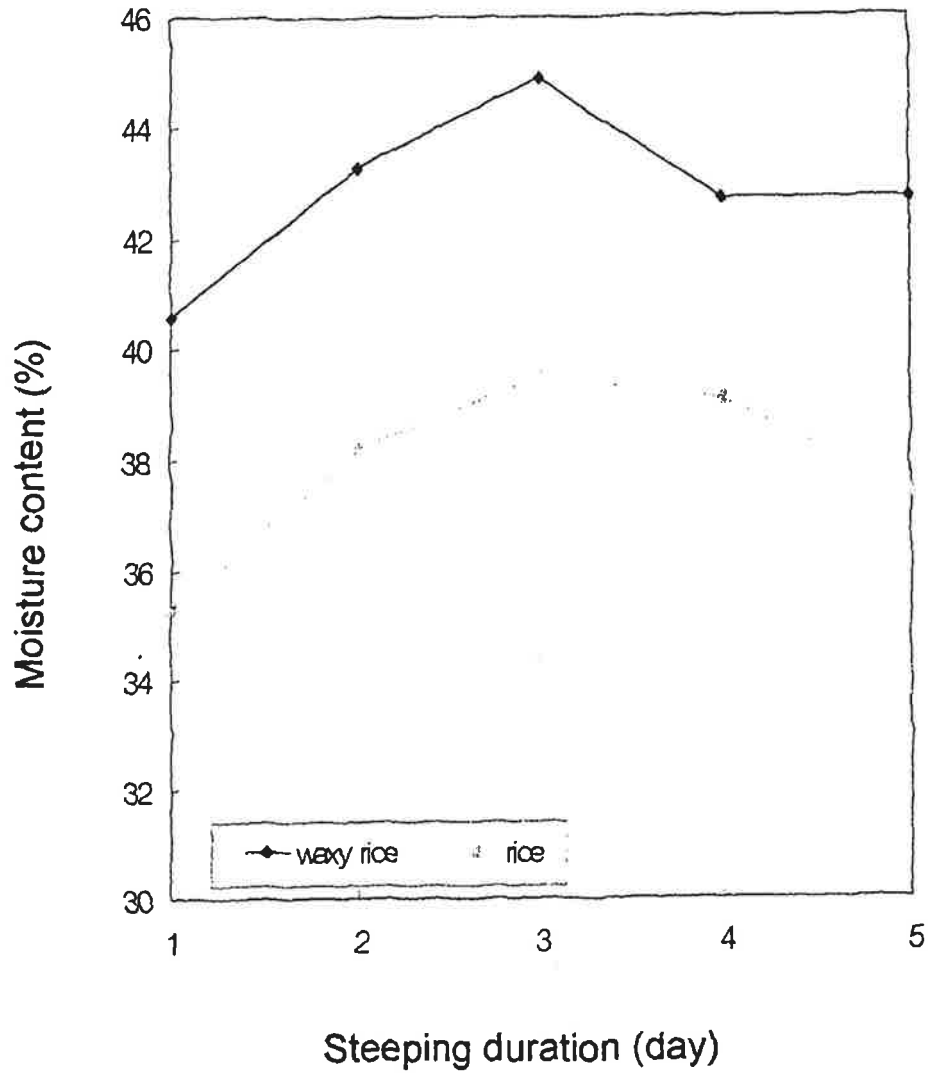


Fig. 1. Effect of steeping time on moisture content of waxy rice and rice

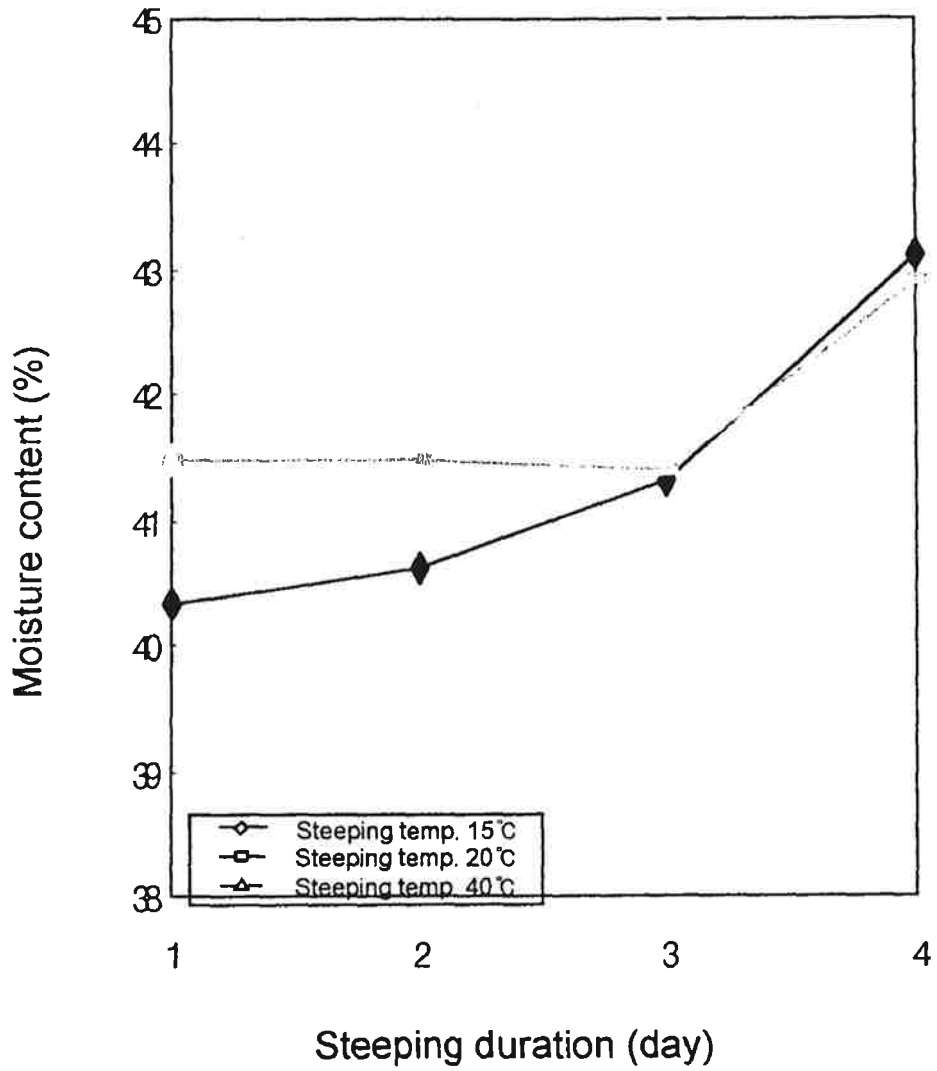


Fig. 2. Effect of steeping time on moisture content of waxy rice

Table 1

가

500

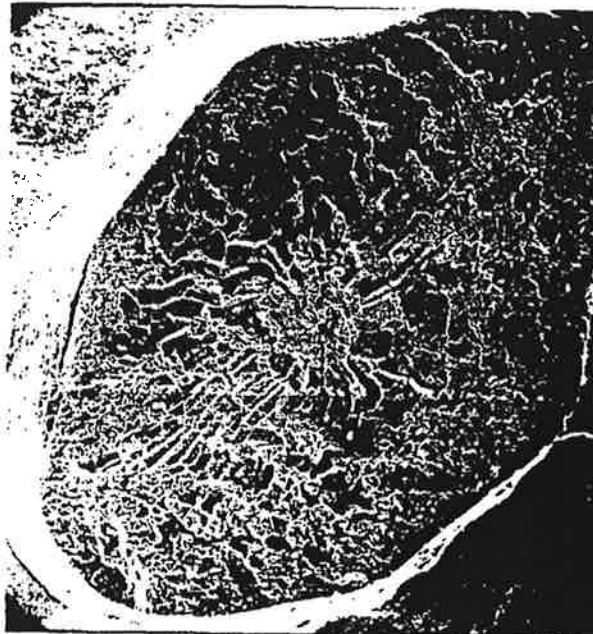
(Fig. 3- 1,2).

Fig. 4 가

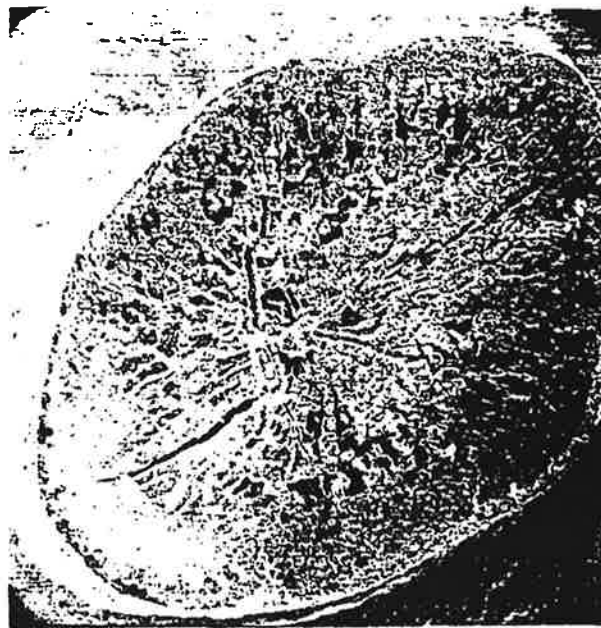
- amylase

Table 1. Change in chemical compositions by steeping

Steeping Time (day)	Moisture (%)	Protein (%)	Ash (%)
0 (Raw rice)	14.3	8.05	0.44
2	4.4	8.68	0.23
7	4.3	7.30	0.22
10	4.1	5.73	0.20



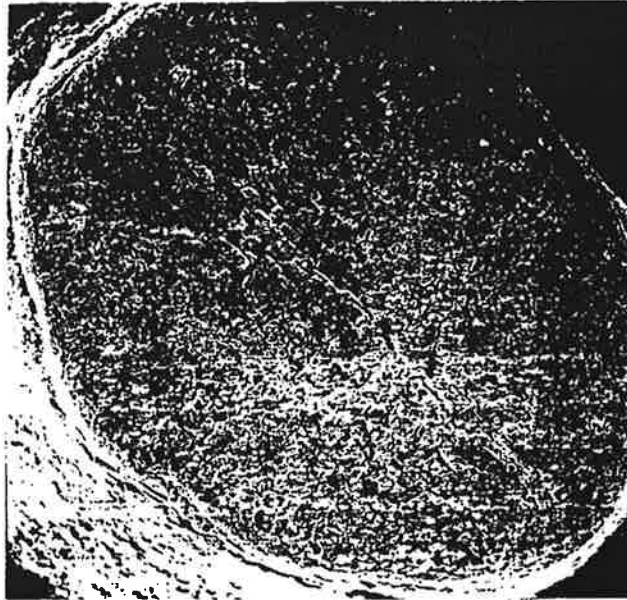
(a) Raw waxy rice



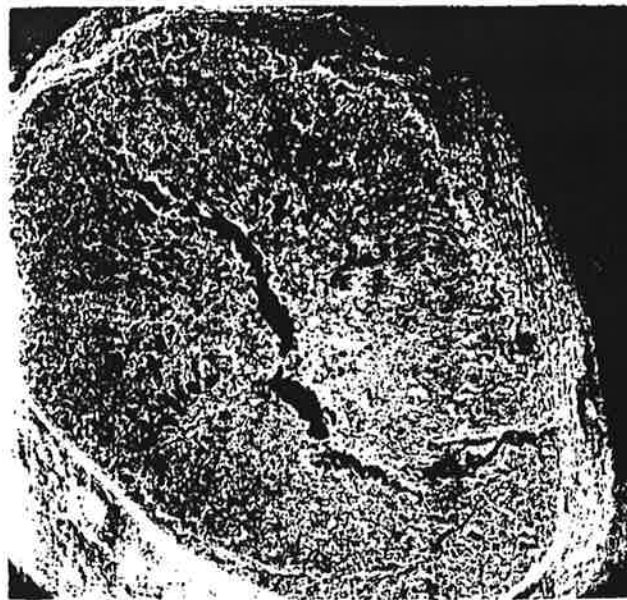
(b) Steeping for 2 days

Fig. 3-1. Scanning electron microphotographs of the pericarp of waxy rice during steeping.



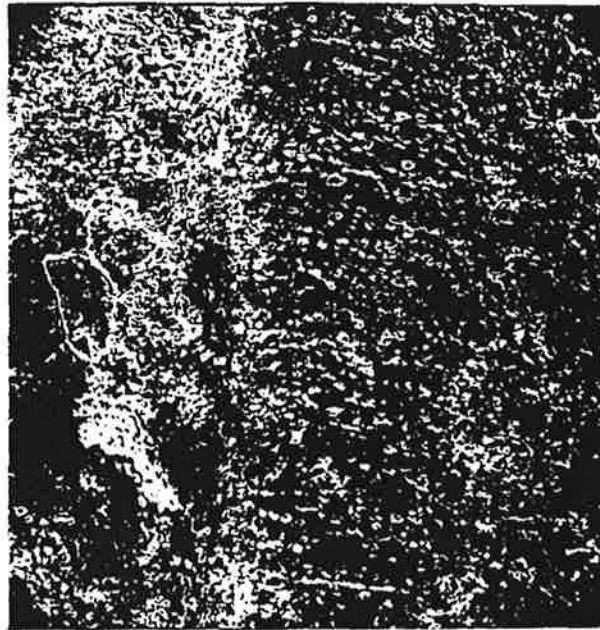


(c) Steeping for 7 days

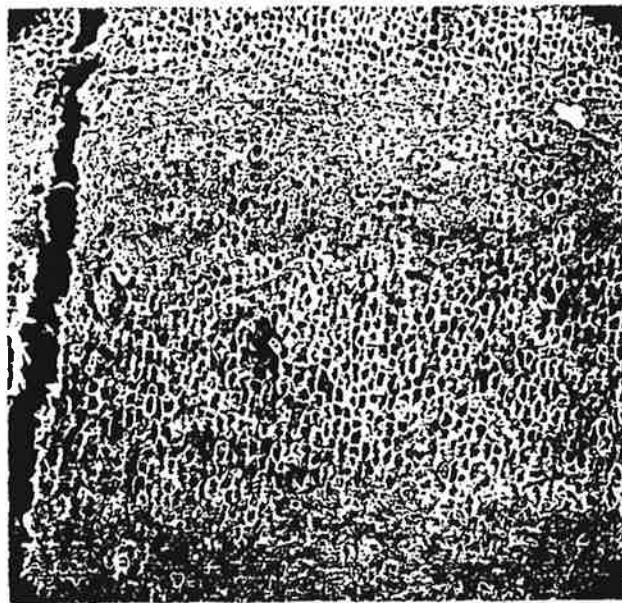


(d) Steeping for 10 days

Fig. 3-2. Scanning electron microphotographs of the pericarp of waxy rice during steeping.



(a) Raw waxy rice starch



(b) Waxy rice starch steeped for 2 days

Fig. 1. Scanning electron microphotographs of cross section of raw and steeped waxy rice ( $\times 8,000$ )

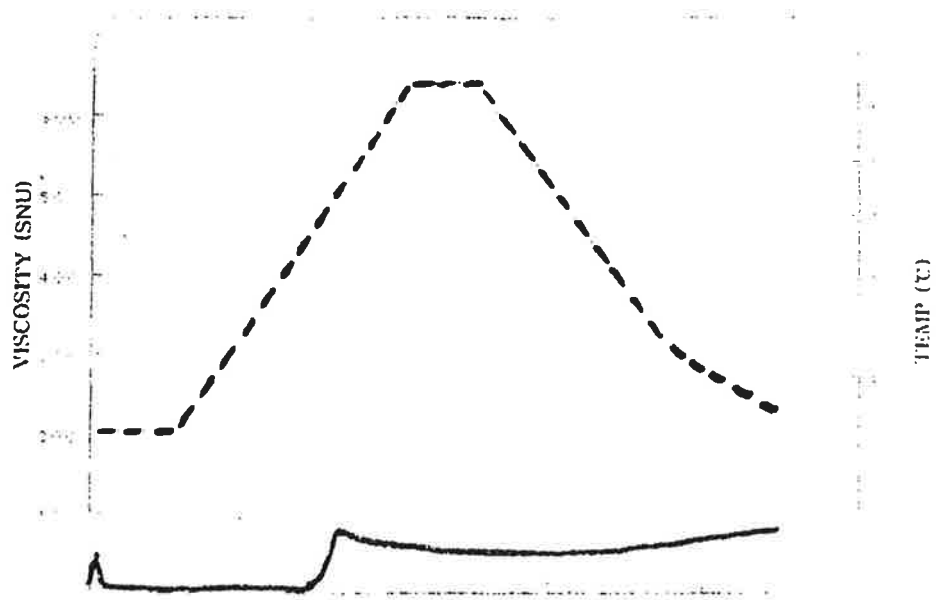
(RVA) 가 Rapid visco-analyzer  
 . 가 6 75  
 100 SNU , 2 가  
 350 SNU , 7 가 400  
 SNU 가 . 10 가 350  
 SNU (Fig. 5- 1,2).  
 가 .  
 가 가  
 가 .  
 가  
 chain annealing  
 가 .

4)

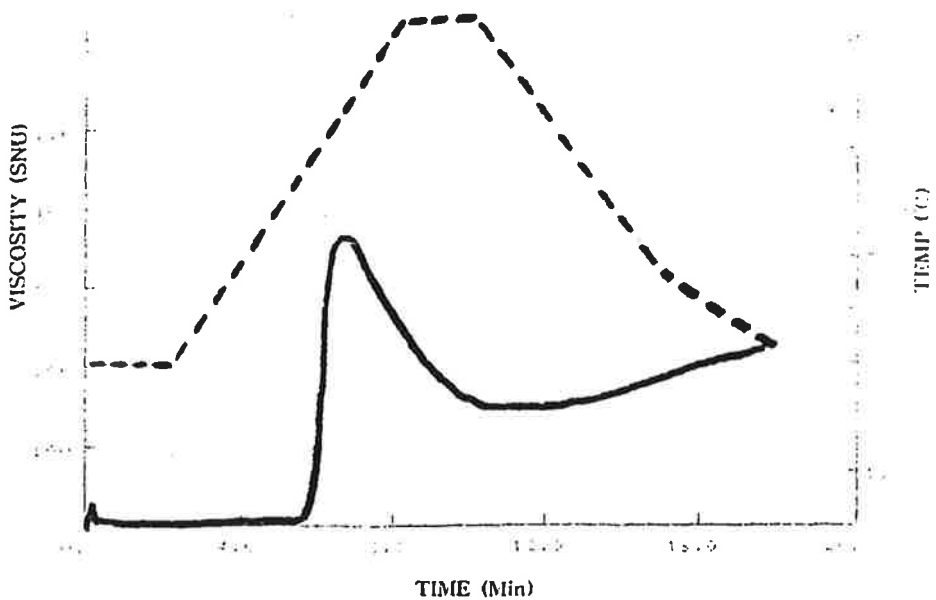
Fig. 6 15 1 , 3 , 6 , 13

(1 , 2.83 ; 3 , 3.67 ; 6 , 5 ; 13 , 6.22).

(1 , 0.43 ; 3 , 0.40 ; 6 , 0.2 ; 13 , 0.17 g/M $\theta$ ).

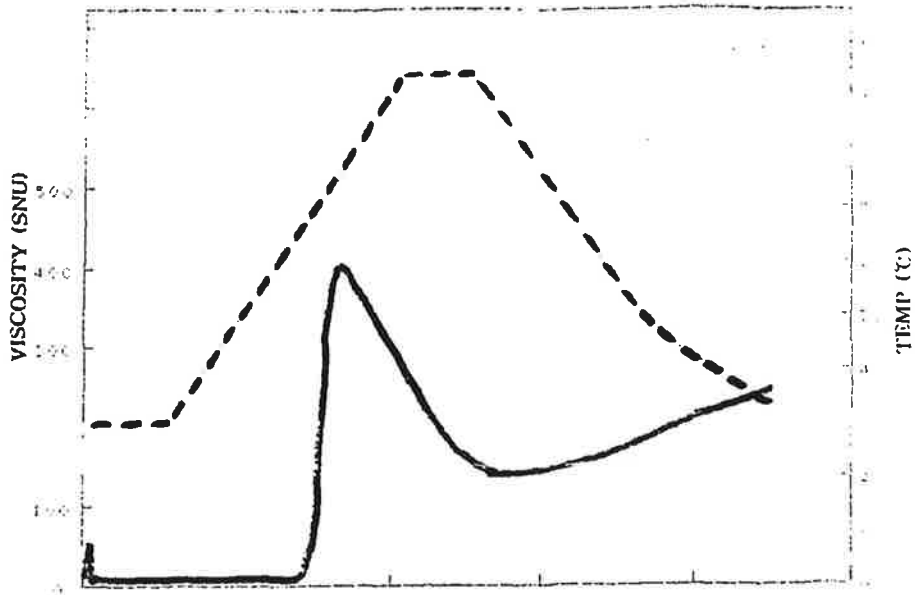


(a) raw waxy rice

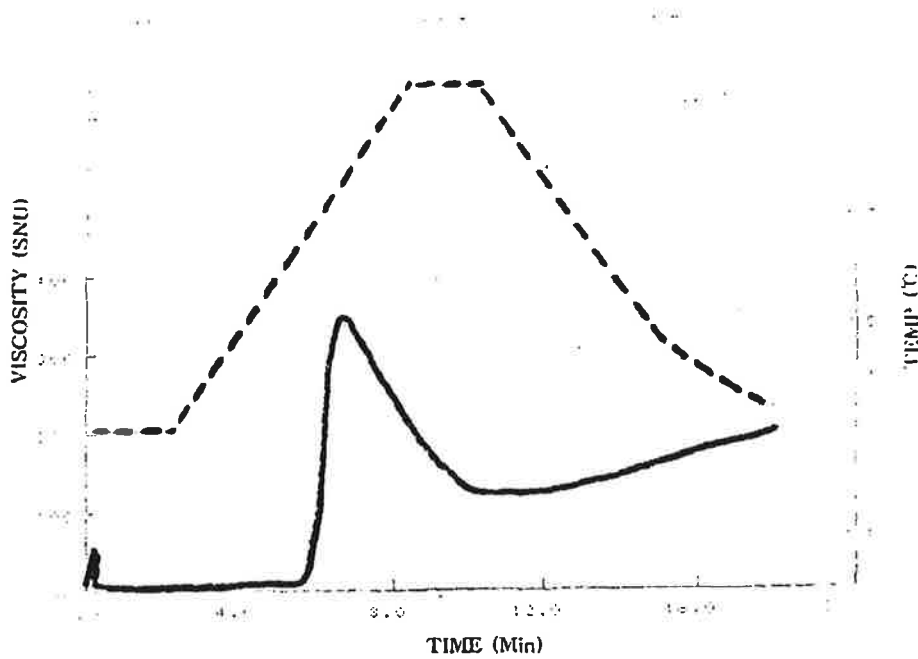


(b) steeping for 2 days

Fig. 5-1. Effect of steeping time on paste viscosity of waxy rice.



(c) steeping for 7 days



(d) steeping for 10days

Fig. 5-2. Effect of steeping time on paste viscosity of waxy rice.

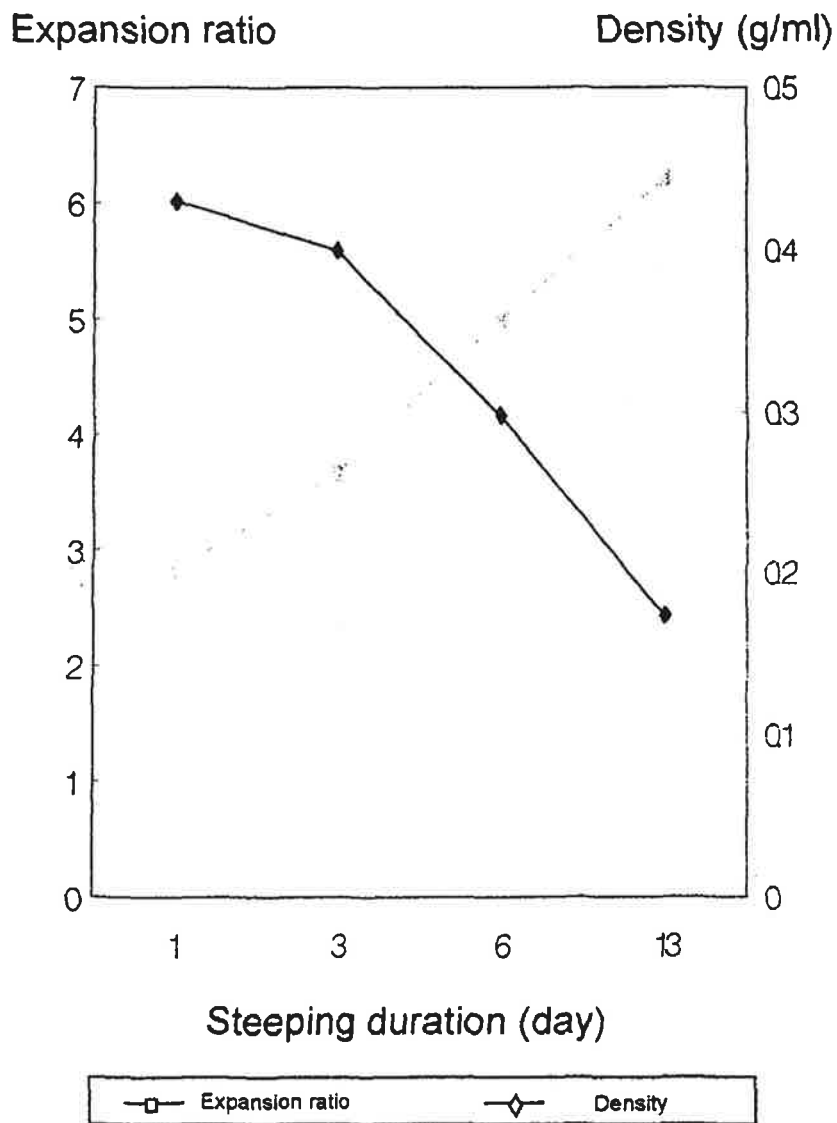


Fig. 6. Effect of steeping time on expansion ratio and density of Yukwa

가 . 13  
 가 가 , 가 6  
 가 가 .  
 Rheometer (Sun, Compac-100) -  
 , breaking strength hardness . 가  
 breaking strength hardness 6  
 (Fig. 7).  
 가 .  
 14 , 7

frying

Breaking strength (g)    Hardness (10dyne/cm<sup>2</sup> )

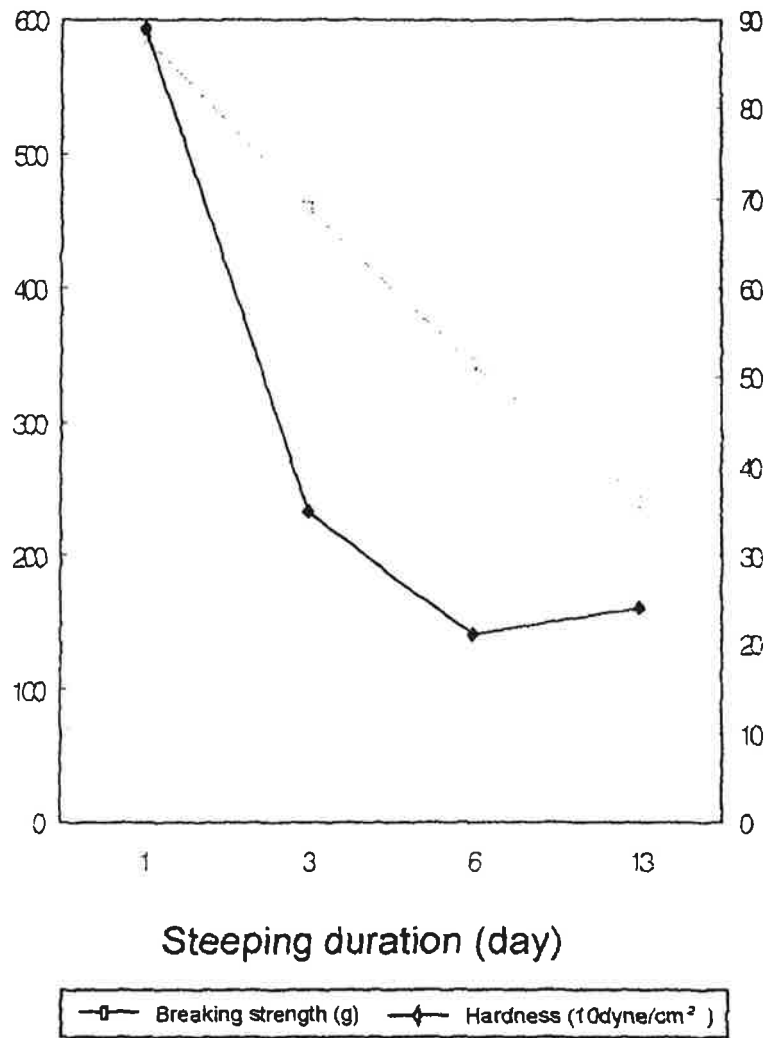


Fig. 7. Effect of steeping time on breaking strength and hardness of Yukwa.



“ ”, “ ”, “ ”, “ ” 가 ” .  
7 , 14

3  
6

pH pH

1) pH pH

가 가  
가

pH가

, pH

pH가

(11 5

pH

: , 5.4; , 5.8;  
, 6.7). pH가

pH

(Fig. 8).

2) BW

BW

pH

pH

가

pH

( colony  
yellow), W(white),

BW(big white)

DY(dark yellow), LY(light

BW

가 pH

(Fig. 9). BW

pH

pH 5

(Fig. 10).

BW

pH

BW

(ultrasonic homogenation)

가 pH가

BW 가

pH가

(Table 2).

BW 가

pH

가

가

가 pH

가

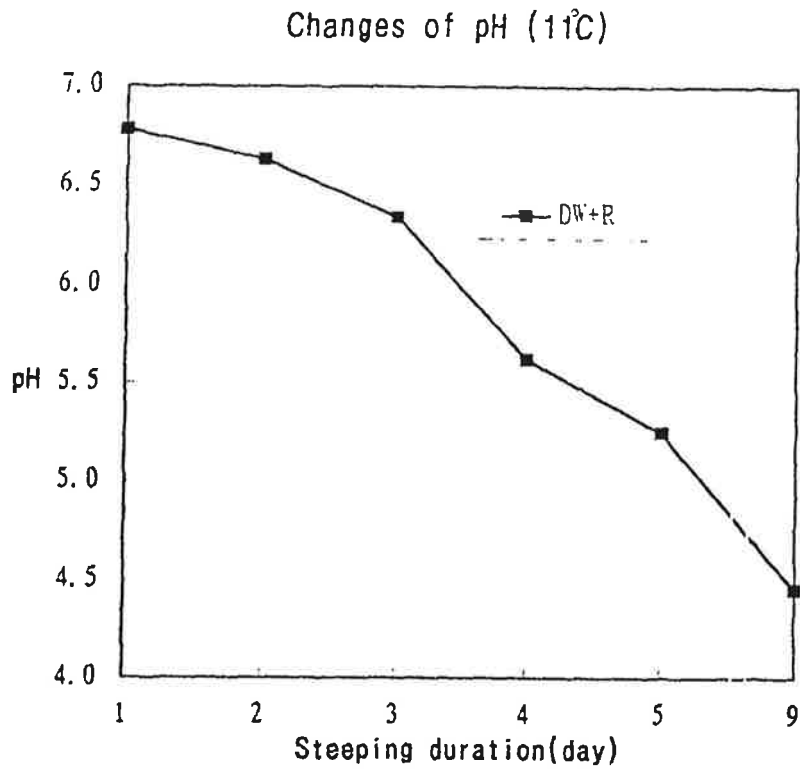


Fig. 8. Decrease in pH for steeping waxy rice.

가 20 가 가 ,  
 20 가 15)  
 - amylase가 가 1)  
 가 . ,  
 .

Table 2. Changes of pH by addition of BW cell extract (25 )

Incubation Period (hrs)	Addition of cell extract (ml)					
	0	0.5	1	2	4	8
0	6.95	-	-	-	-	-
1	6.80	6.49	6.24	6.09	5.88	5.64
2	6.75	6.20	5.86	5.56	5.40	5.26
3	6.65	5.94	5.63	5.39	5.31	5.14
4	6.63	5.87	5.48	5.26	5.20	5.04

Effect of bacterial strains  
on pH changes(33C)

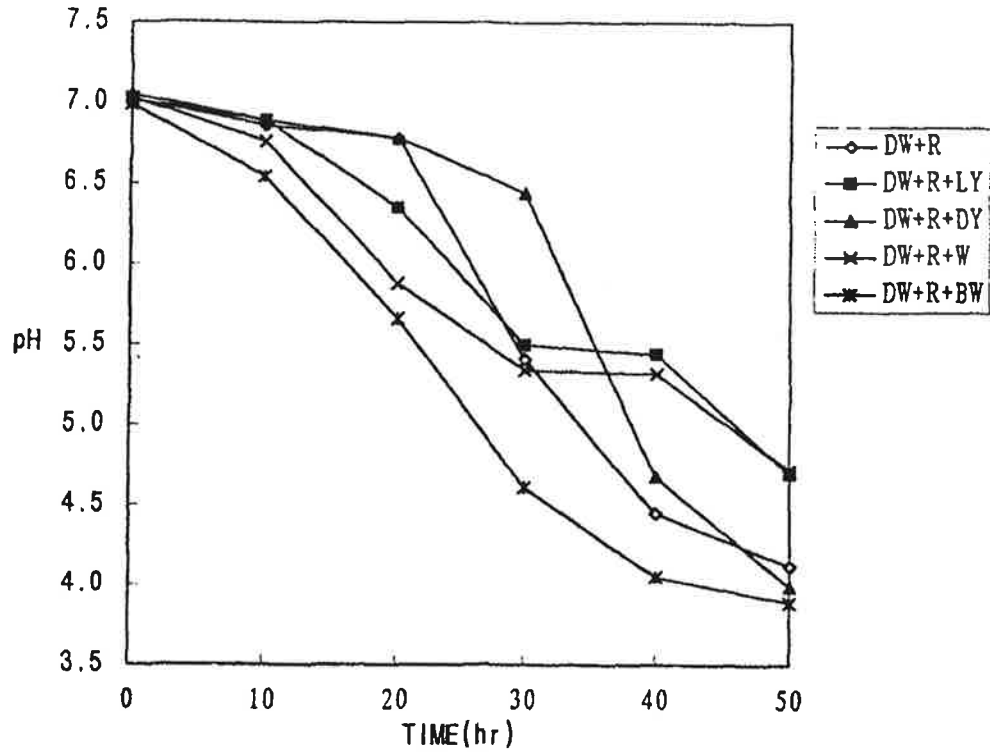


Fig. 9. Decrease of pH by addition of 4 bacterial strains into steeping solution.

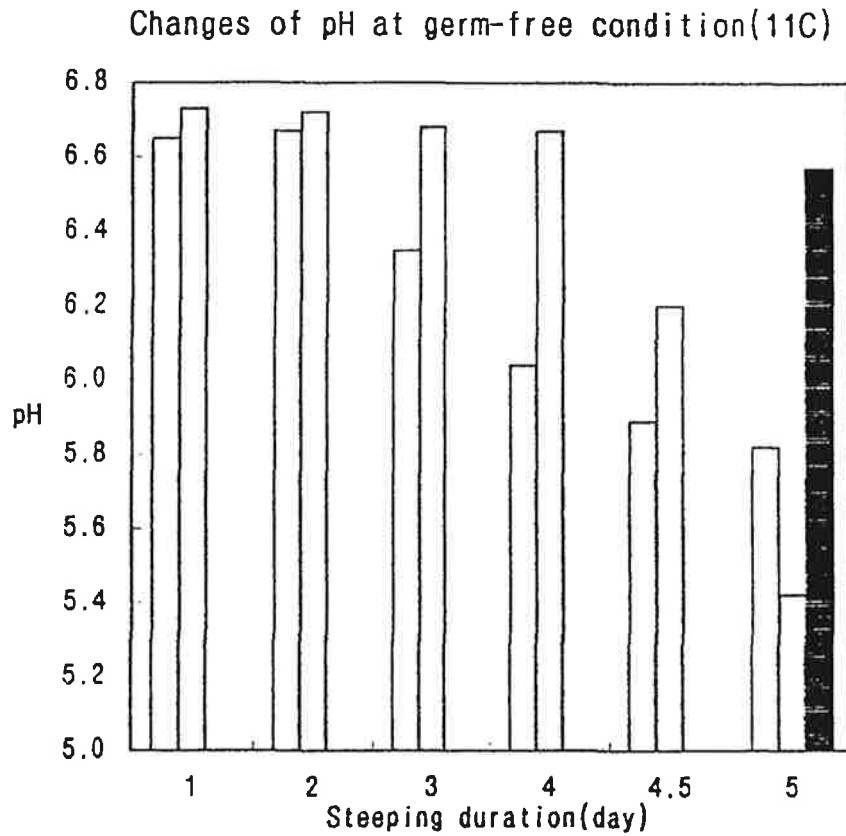


Fig. 10. Influence of germ-free condition on the pH decrease during steeping rice.

R + DW (No sterile).

Sterilized rice and DW, incubated at non germ-free condition.

Sterilized rice and DW, incubated at germ-free condition.

가 , 14 17% 가

2 300SNU ,  
가 .

conditioning

가

가

가 ,

가 .

1)

1 .

Fig. 11

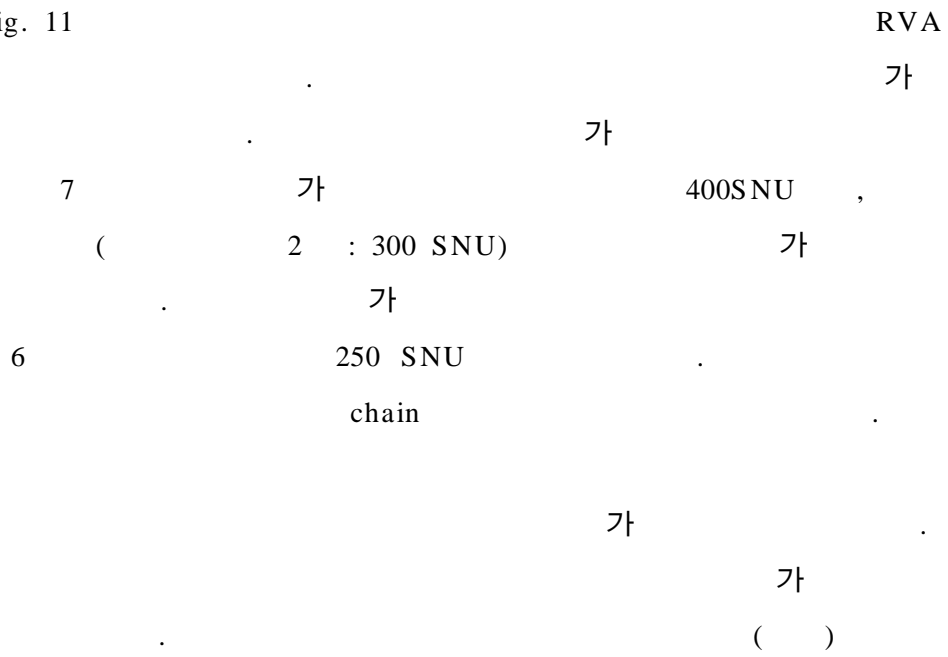
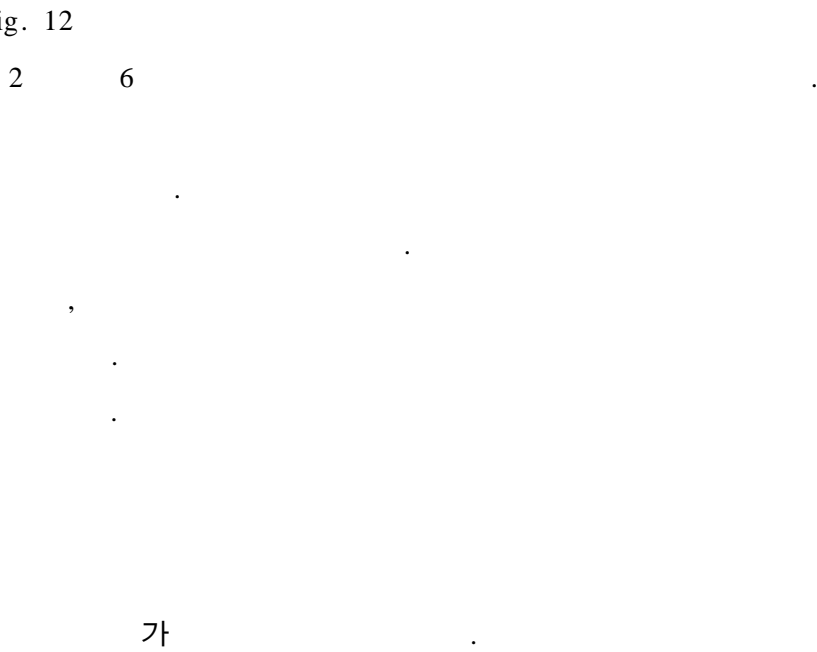
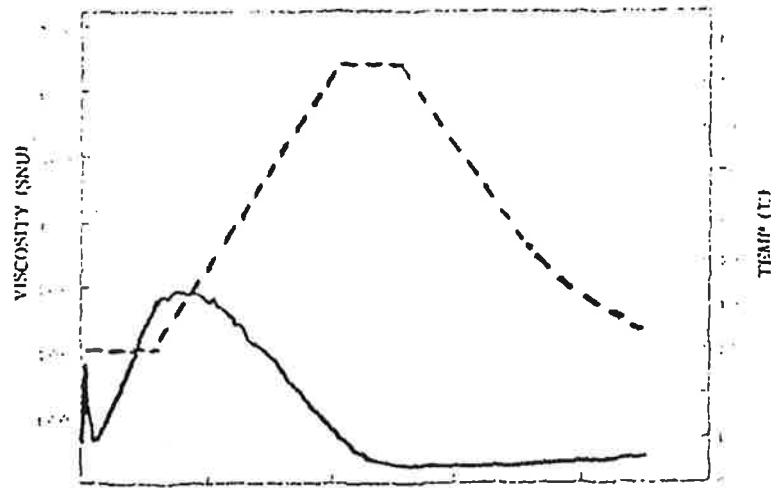


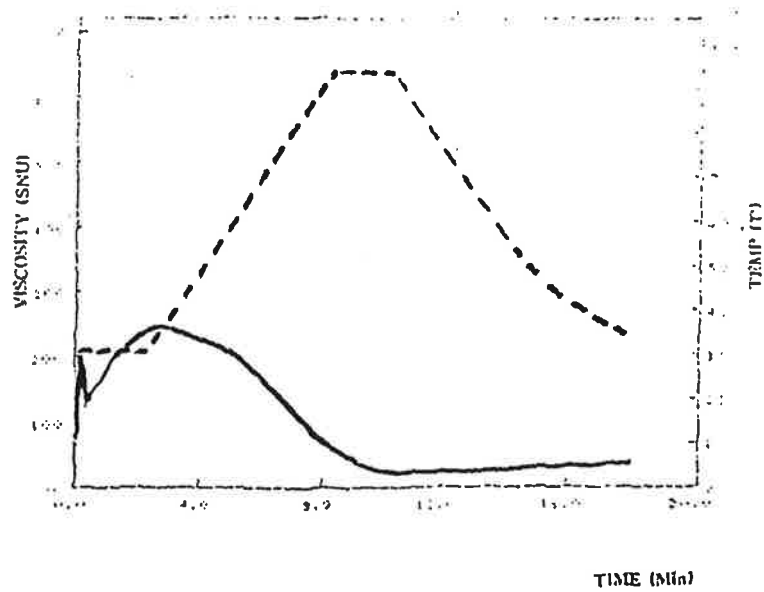
Fig. 12





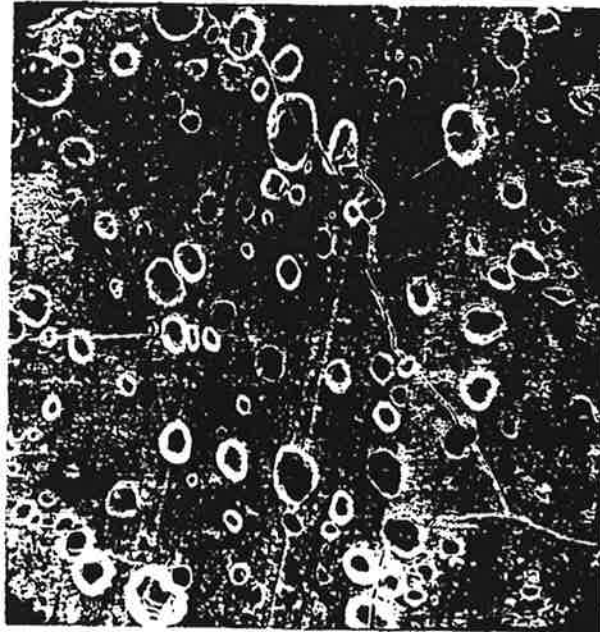


(a) Aging for 2 days

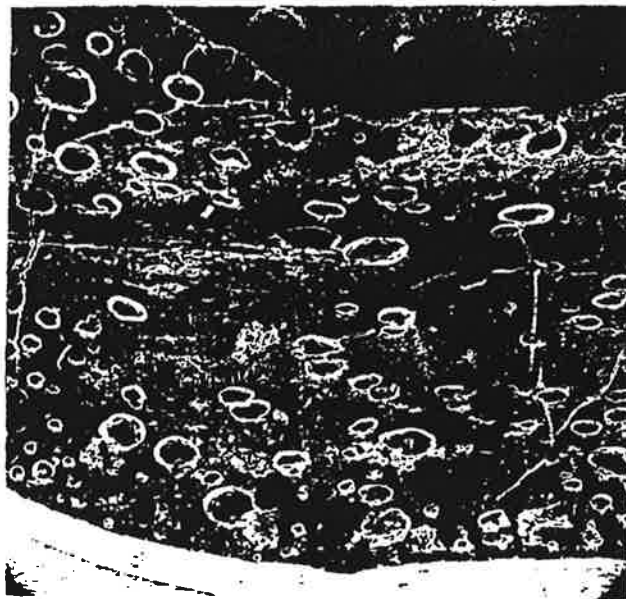


(b) Aging for 6 days

Fig. 11. Effect of aging time on pasting properties of Yukwa plate



(a) Aging for 2 days



(b) Aging for 6 days

Fig. 12. Scanning electron microphotographs of cross-section for aged Yukwa plate. (x 30).

2)

Fig. 13

10%, 12%, 14%, 17%,  
19%

10% 17% 가 2.64  
가 가 19% 가 2.44  
17% 가 0.21 g/M $\emptyset$  가  
19% 0.22 g/M $\emptyset$  가

17%

19% 가 가

13% 가

가 가

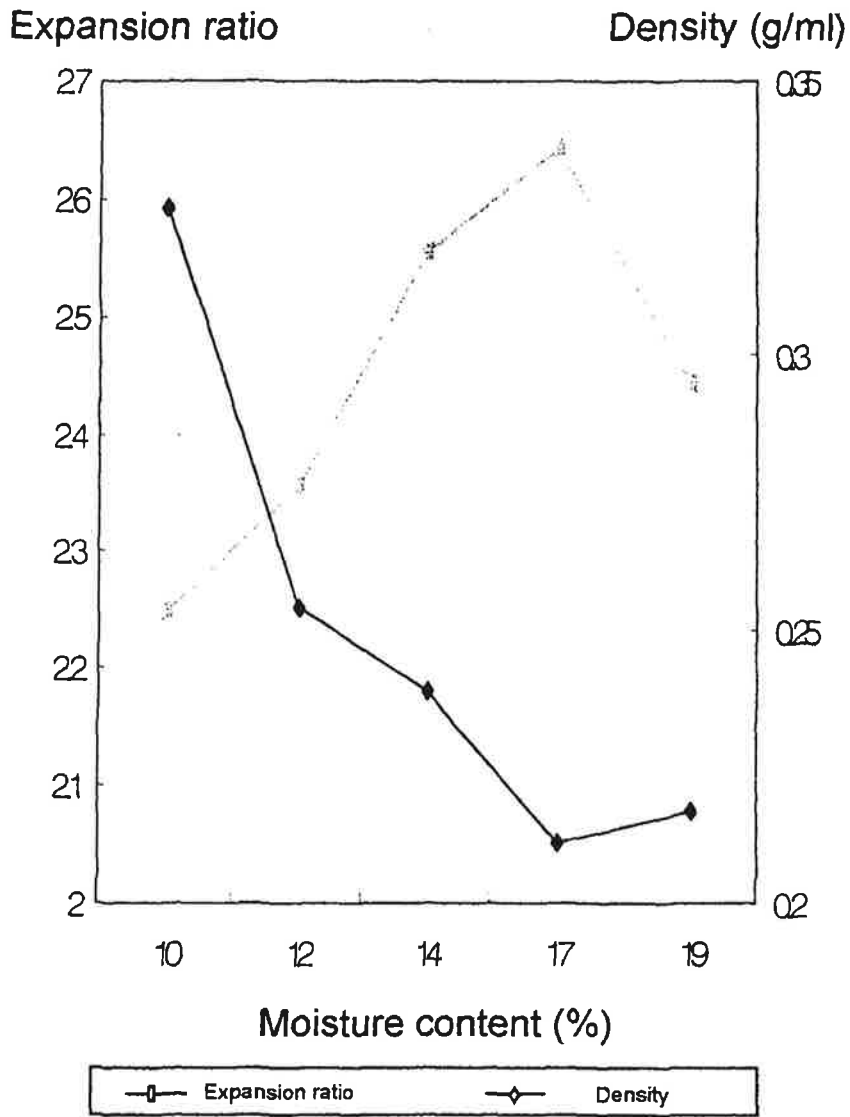


Fig. 13. Effect of moisture content on expansion ratio and density of Yukwa plate.

Breaking strength (g)    Hardness (10dyne/cm<sup>2</sup> )

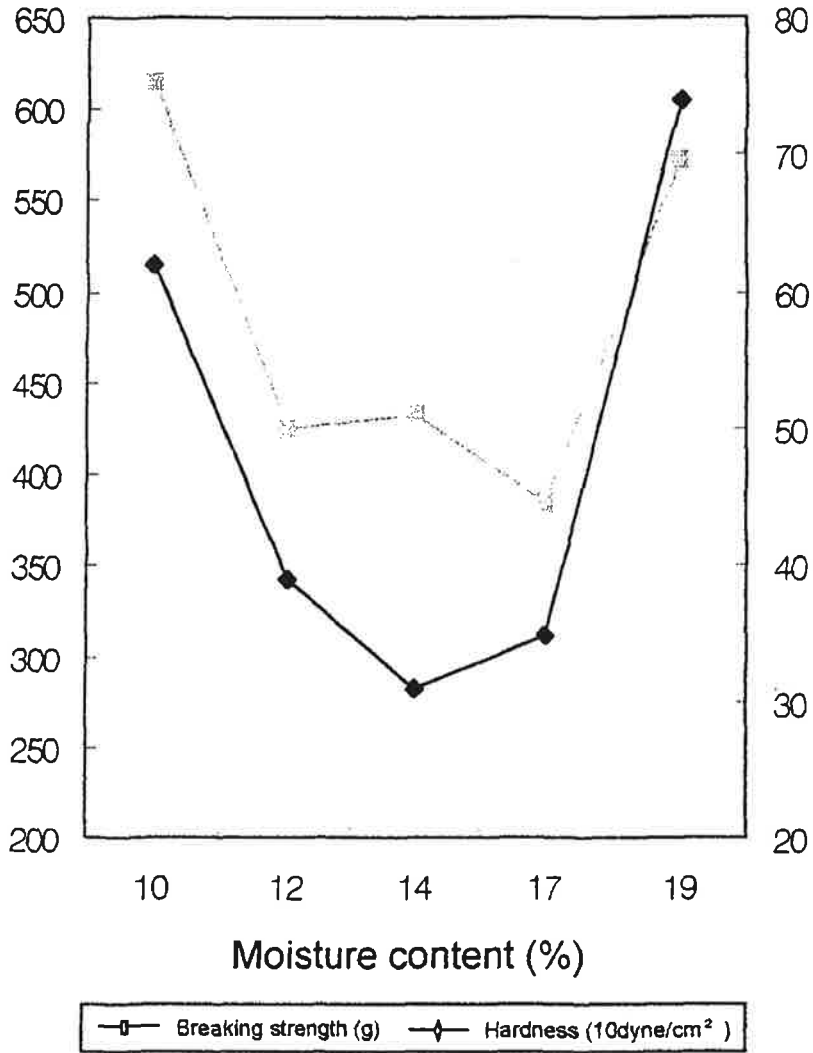


Fig. 14. Effect of moisture content on breaking strength and hardness of Yukwa plate.

Fig. 14는 10%와 19%의 반데기의 수분함량 변화에 따른 조직감의 지표로서 breaking strength와 hardness를 나타낸 것으로 수분함량 14%에서 hardness가 가장 낮았으며, breaking strength는 수분함량 12%에서 가장 낮았다.

이상의 결과를 분석해 보면 건조 후의 숙성시킨 반데기의 최적 수분함량은 14~17%로 건조시켜야 유과의 밀도와 팽화도 및 조직감이 우수함을 알 수 있었다. 압출성형 공정에 의해 제조된 반데기의 수분함량은 14~17% 범위를 기준으로 하여 재래식 유과반데기와 압출성형 유과반데기의 차이점을 관찰하는데 지표가 될 수 있을 것이다.

### 3) 부재료의 첨가에 따른 유과의 변화

전통적인 유과제조에서 부원료로 첨가되는 것은 주류와 대두즙이다. 참쌀의 수침 중에는 막걸리를 첨가하여 미생물의 발효를 도왔으며, 반죽 시에는 소주와 대두즙을 첨가하여 유과의 팽화와 조직감을 높였다고 한다.

이 실험은 부재료가 유과제품의 성질에 미치는 영향을 검토하기 위하여 반죽의 원료 배합비를 각각 대두즙 5% (대두 1: 물 4) 를 첨가한 유과, 대두즙 5% (대두 3: 물 1)+ 소주 7%를 첨가한 유과, 소주 7%를 첨가한 유과, 물10%로 첨가한 유과의 성질을 측정하였다.

Fig. 15는 부재료 첨가가 유과의 팽화율 및 밀도에 미치는 영향을 나타낸 것이다. 소주를 첨가한 유과가 팽화도 11.0으로 가장 높았다. 또한 다른 부재료의 첨가와 팽화율을 보면 대두즙 5%는 3.8, 대두즙5%와 소주 7%는 5.17, 물 10%는 6.0을 각각 나타내었다. 유과의 밀도는 소주 7%를 첨가했을 때 0.073 g/ml로 가장 낮았으며, 대두즙 5 %를 첨가한 유과의 밀도가 0.231 g/ml로 가장 높음을 알 수 있었다.

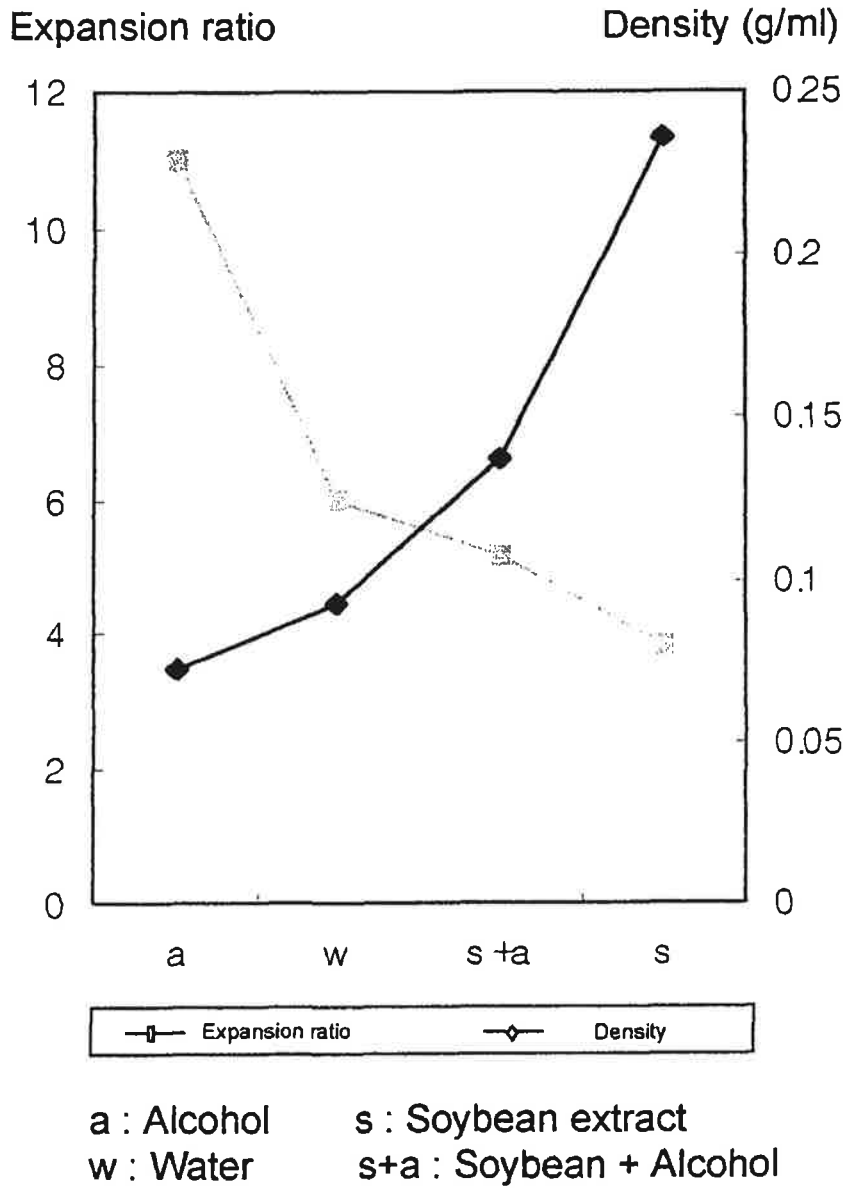
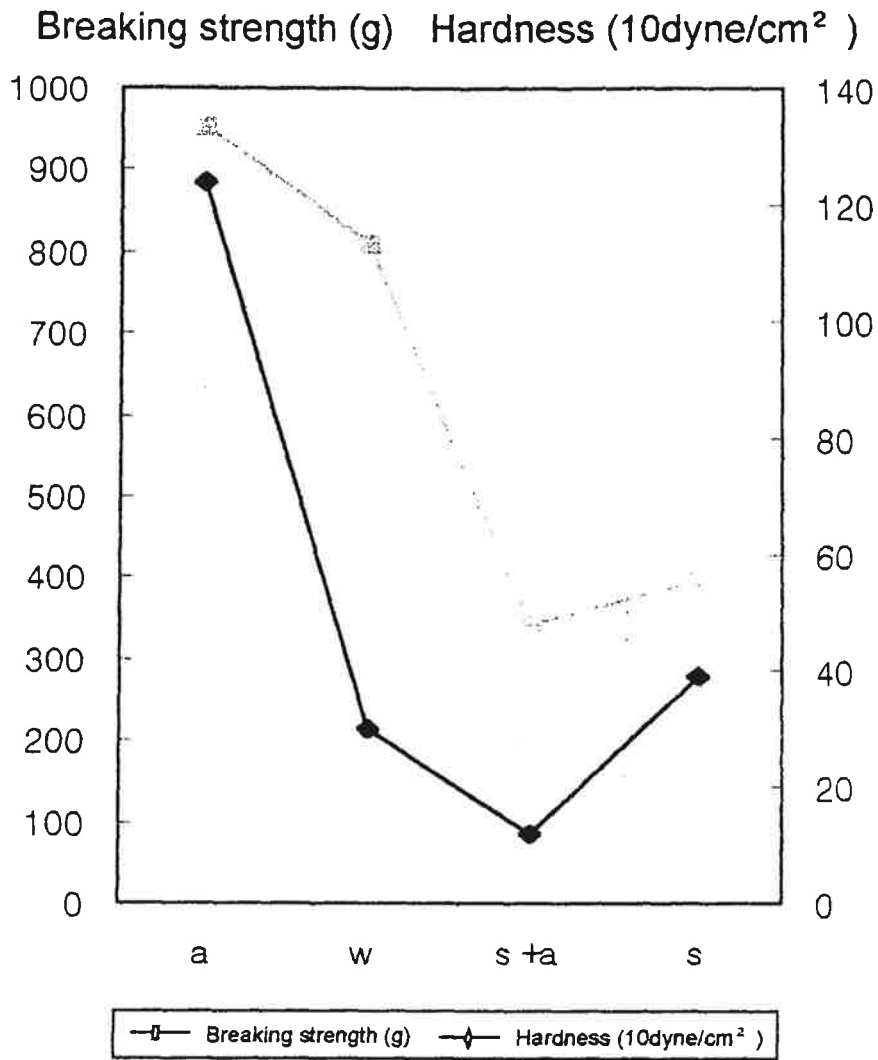


Fig. 15. Effect of additives on expansion ratio and density of Yukwa



a : Alcohol                      s : Soybean extract  
 w : Water                        s+a : Soybean + Alcohol

Fig. 16. Effect of additives on breaking strength and hardness of Yukwa.



hardness breaking strength hardness 7%  
가 가 가 , 5%+ 7% 가 가 breaking  
strength hardness가 가 .

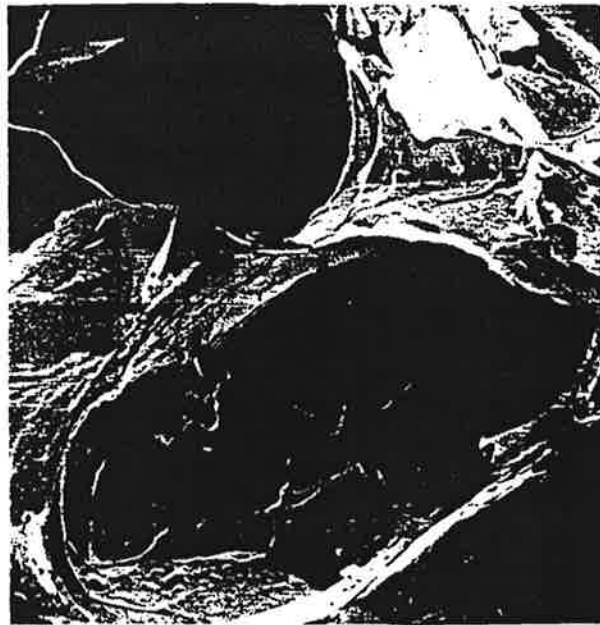
, ,  
+ 가

가 ,

4)

. Fig. 17

3



(a) Center of Yukwa



(b) Edge of Yukwa

Fig. 17. Scanning electron microphotographs for the cross-section of Yukwa.(x20)

가

( )

가

Fig. 18

1, 3, 6

(kJ/kg)

가

가

가

Fig. 19

가

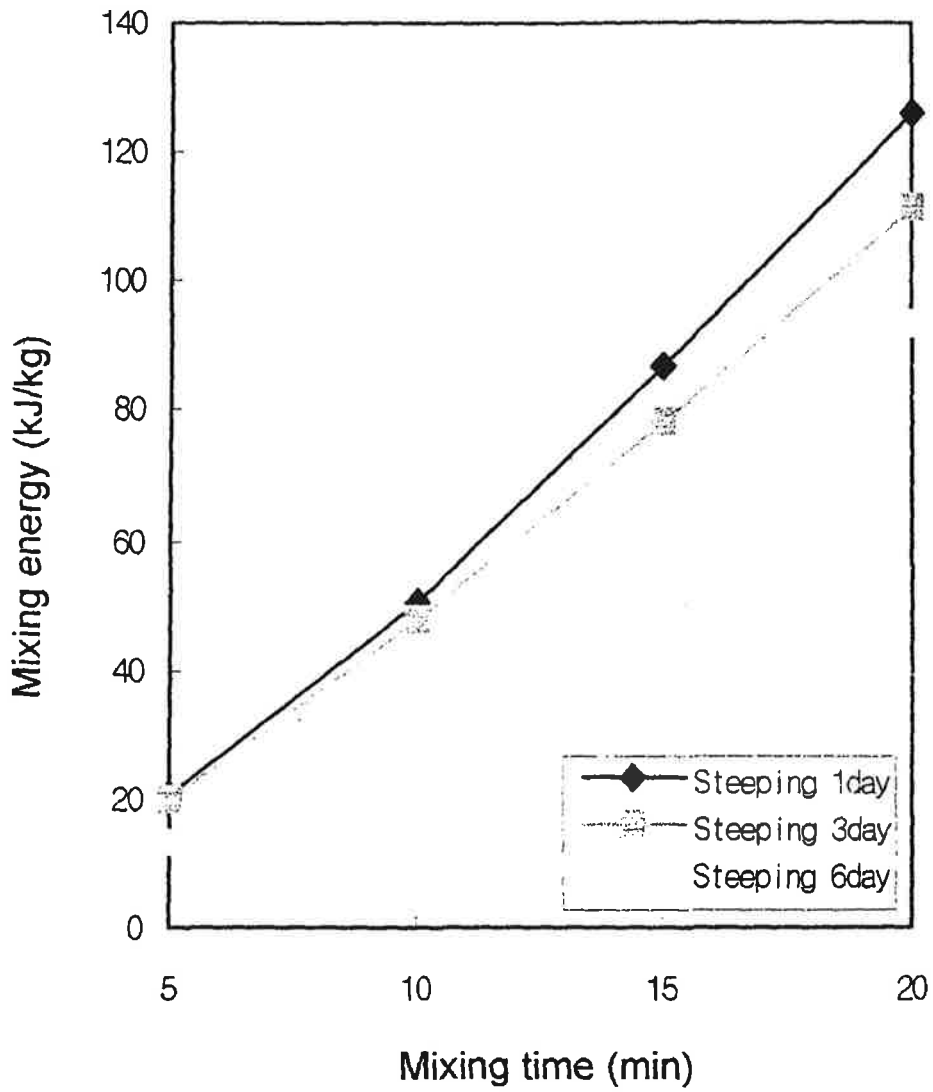
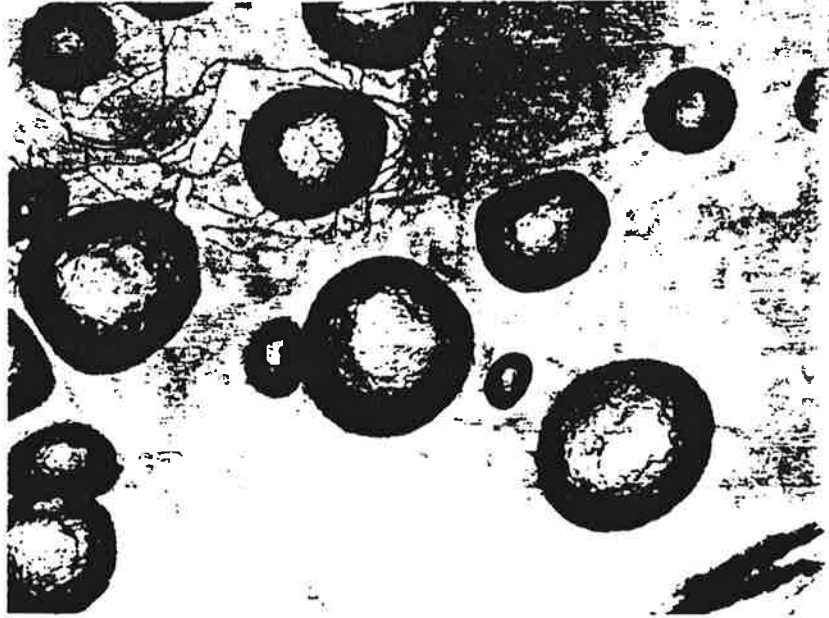
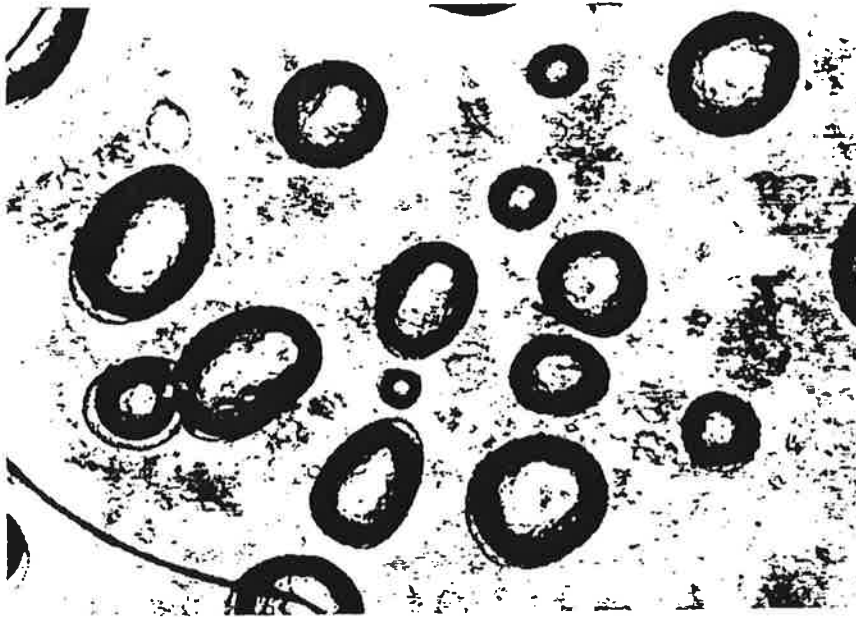


Fig. 18. Effect of steeping time on specific kneading energy input for Bandegi dough making.



(a) 1 day steeping, 21kJ/kg kneading energy input



(b) 6 day steeping, 16kJ/kg kneading energy input

Fig. 19. Effects of steeping time and kneading energy input on the size and distribution of air bubbles in Bandegi.

가

가

3.

가

가

가

가 가

3

screw, medium-shear screw    high-shear screw    low-shear reverse screw

가

4mm

conditioning,

preconditioning

가 가

3

가

200rpm, feed rate 20 30rpm

70 115

가

34.2%

85 115

10

CO2

50 350rpm

100rpm

가

(1)

, 31mm, L/D 22, 7.5 HP  
 (Fig. 20). 가 pump  
 roll mill  
 . 42% .  
 가 0.5kW  
 가 , 350rpm  
 300rpm . 4mm Die .  
 가  
 0.5 MPa .  
 ) ( .  
 , .  
 MPa 5  
 (- 15 ), , (Fig.  
 20). 0.5  
 MPa 10 가 .  
 가 0.5 MPa .



low-shear screw, medium-shear screw high-shear screw  
 가 90 115 , 50 350 rpm, 42% low-shear screw medium-shear screw  
 Fig. 21

high-shear screw (Fig. 21)

Table 3

circular type ( 2.2mm, 4mm) slit type (1.5mm x 30mm)

가

Table 3. Effect of CO2 injection pressure on product density of fried Bandegi.

Injection pressure (bar)	Particle density (g/cm <sup>3</sup> )
0	0.42
5	0.38
10	0.24
15	0.31

( 4mm) ,

0 15 bar

Table 4 .

0.15 cm<sup>2</sup>/g .

가 가 .

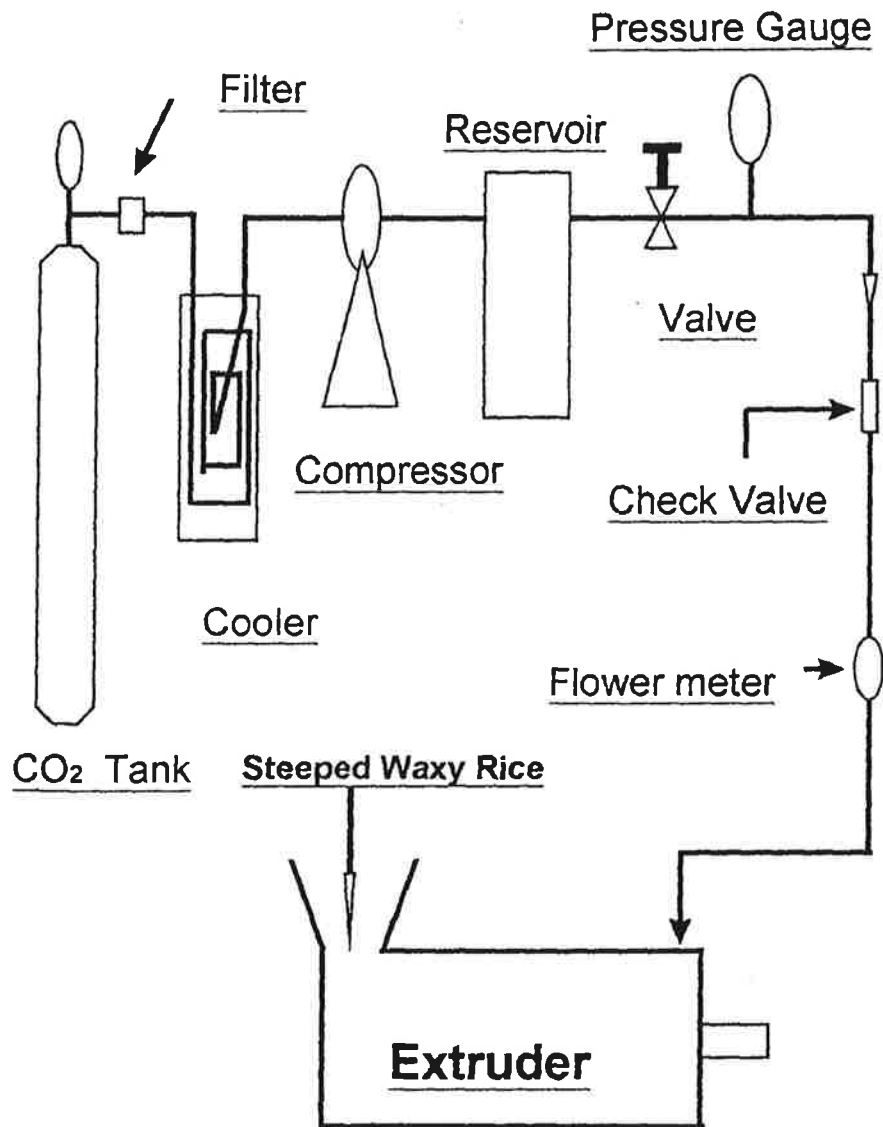


Fig. 20. Schematic for CO<sub>2</sub> gas injection system.

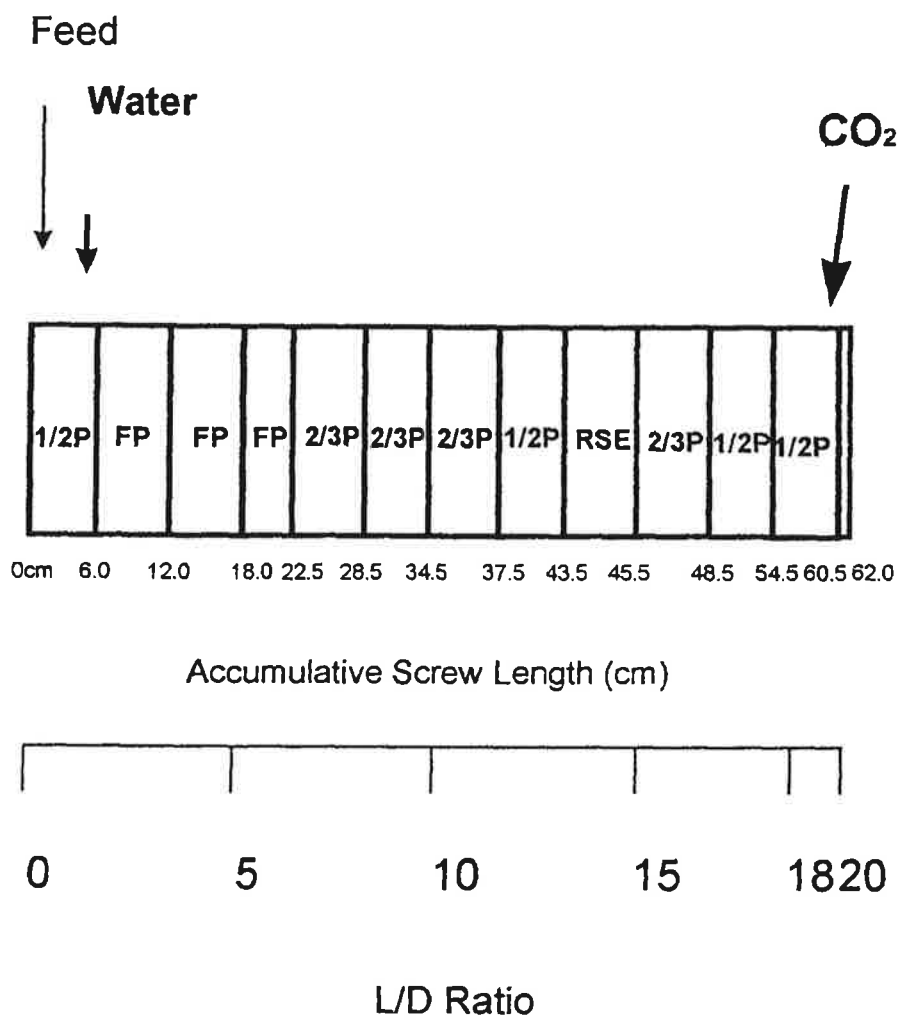


Fig. 21. Screw configuration of the gas injection for forming Bandegi (pellet).

Table 4. Effect of die dimension and injection pressure on particle density.

Injection Pressure (bar)	Circular type		Slit type (1.5mm x 30mm)
	2.2mm	3.2mm	
0	0.34	0.37	0.43
5	0.33	0.26	0.45
10	0.27	0.18	0.32
15	0.32	0.17	0.24

(2)

14 ) , , , , , , , , ( 7 ,  
 ) 7  
 가 (3 ) 가  
 ( ) ,

가 (0.1g/ml) 105 105

105 105

가 27% 가

38.2% 34.2%

가 가

가 가

1) 가 가

(melting) 42% ,

5 bar 70 115 가

가 가 105

0.1 g/cm<sup>2</sup>

가 가

가 (Fig. 22). 100% 가

가 .  
,  
105 가 가 105  
가 (Fig. 23).  
( , 1.5 MPa )

가  
가  
가  
105 가 105 5.0 KPa  
(Fig. 24).  
가 가

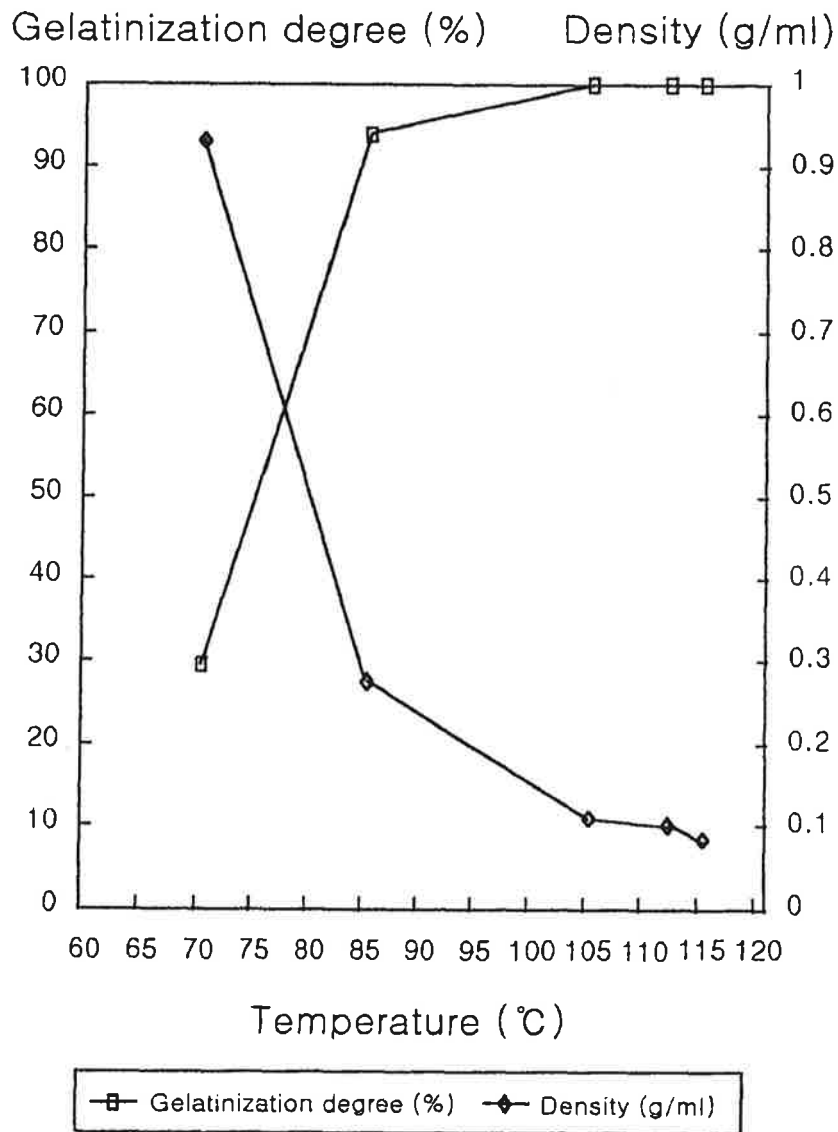


Fig. 22. Effect of barrel temperature on the degree of gelatinization and piece density of Yukwa.



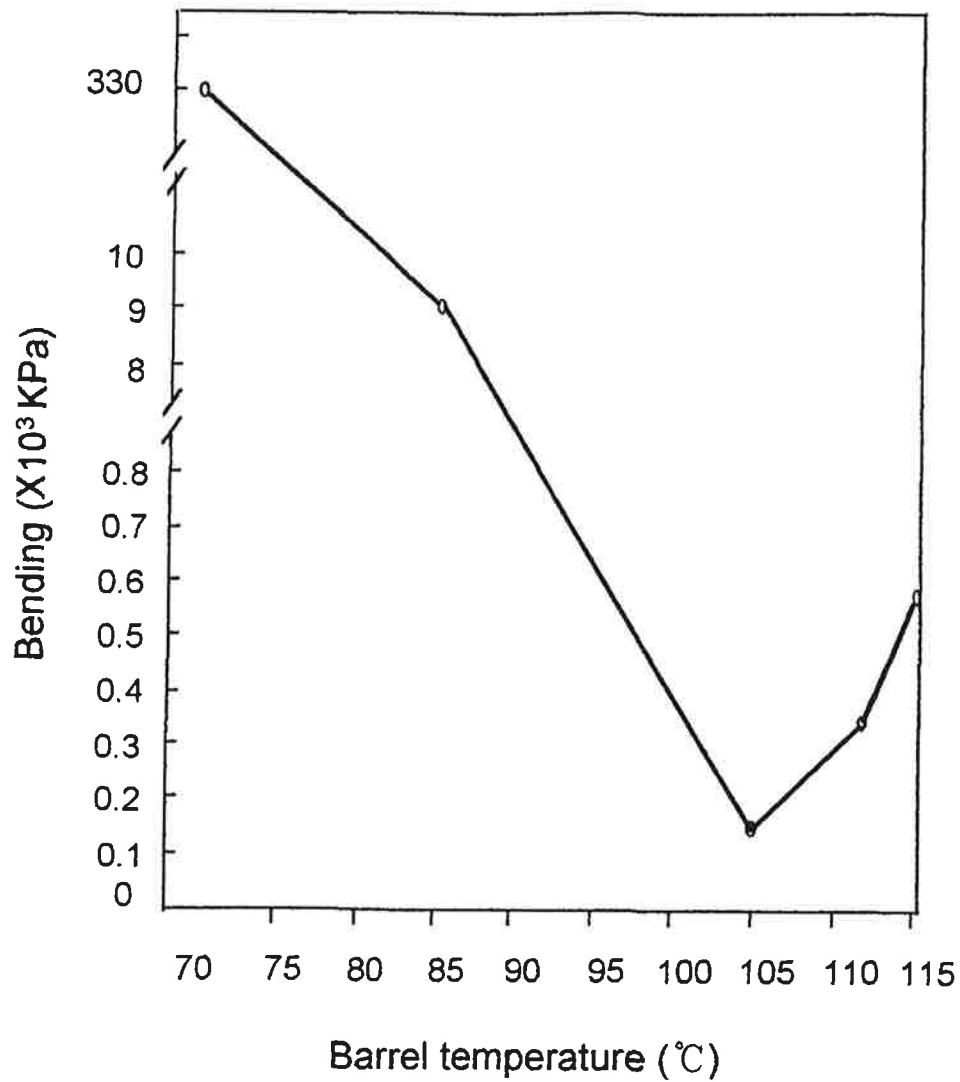


Fig. 23. Effect of barrel temperature on apparent elastic modulus of Yukwa.

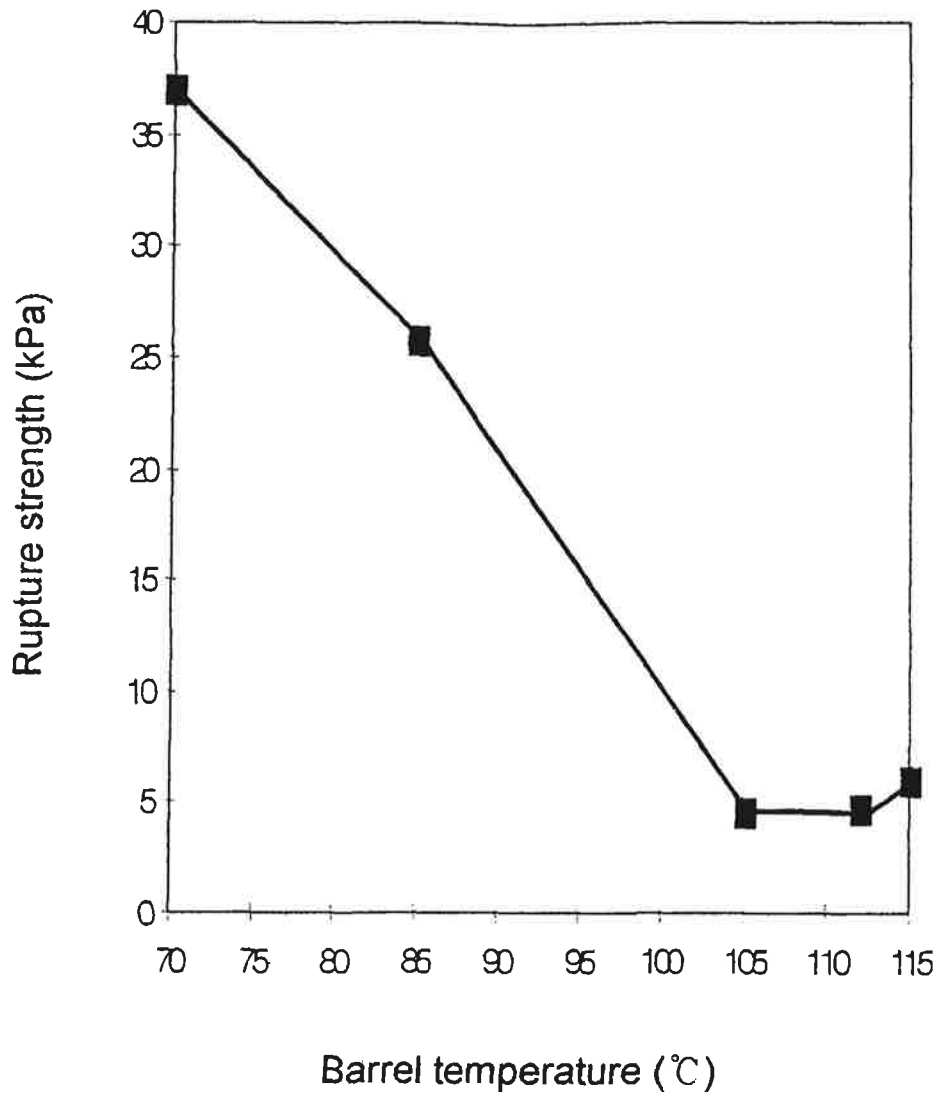


Fig. 24. Effect of barrel temperature on rupture strength of Yukwa.

가

27%

30 가 35%

가 , 가

가

가

가

가

34.2 42.2% Fig. 25

42.2% 0.13g/cm<sup>2</sup> 가

, 34.2% 166kPa 가

, 38.2% 4kPa 가

34.2%

0.23g/cm<sup>2</sup> 0.13 g/ml ,

가

166kPa 276kPa 가 , 9kPa 13kPa

가 .(Figs. 26, 27).

가

가

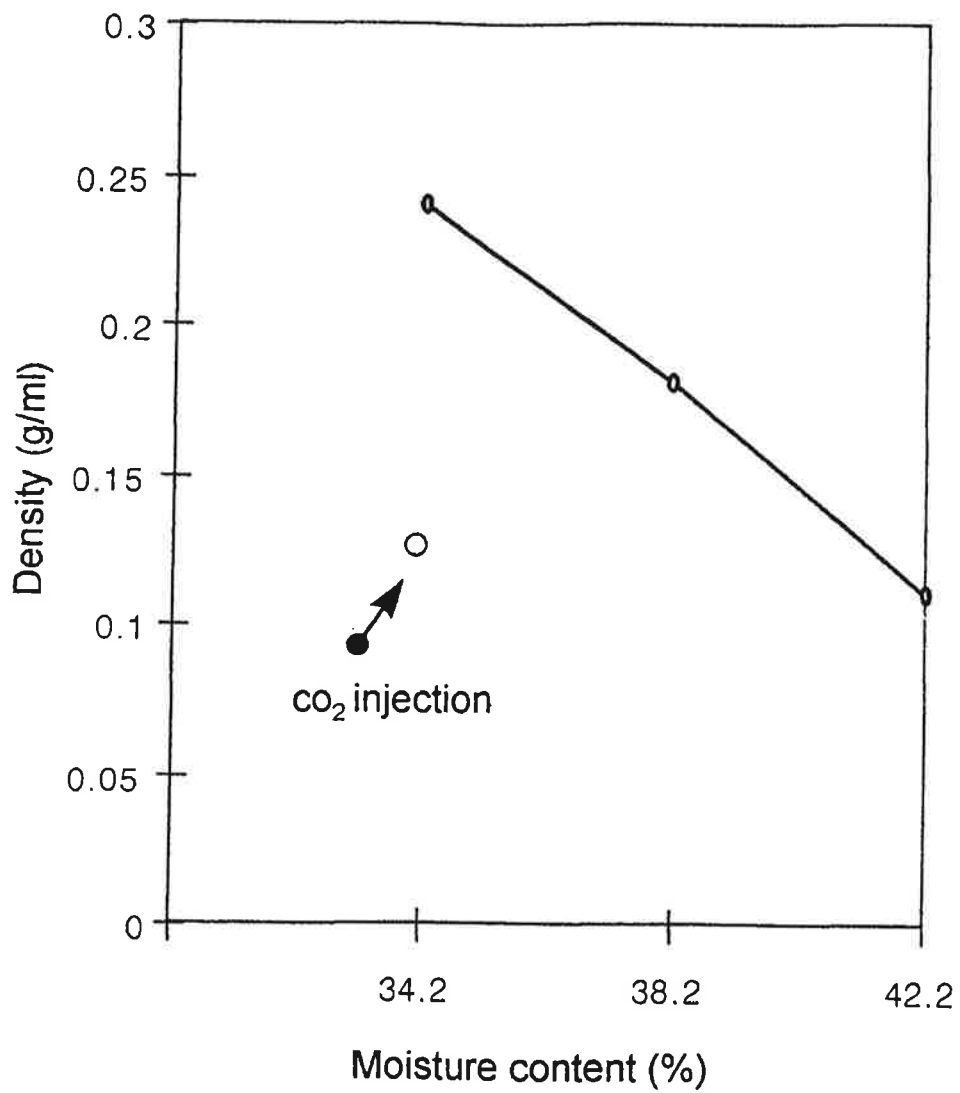


Fig. 25. Effect of dough moisture content on piece density of Yukwa

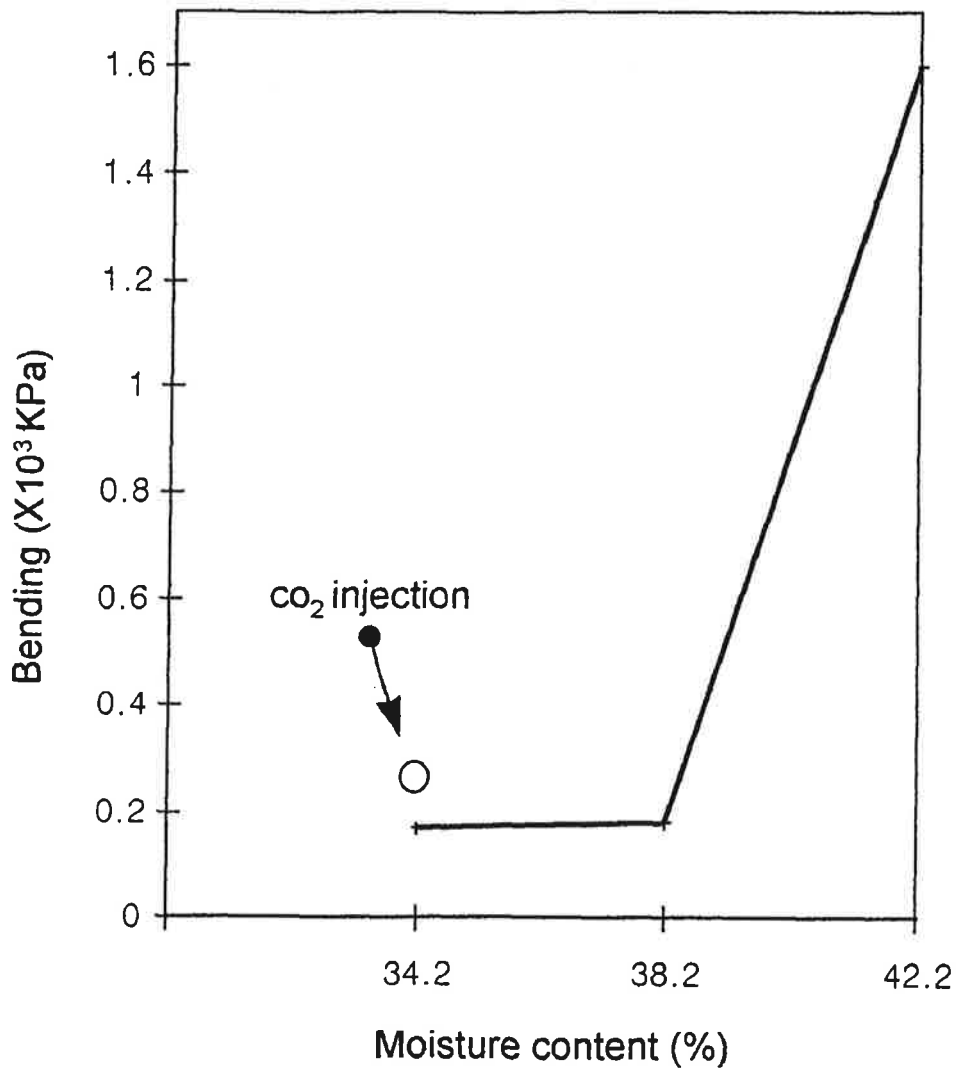


Fig. 26. Effect of dough moisture content on apparent elastic modulus of Yukwa.

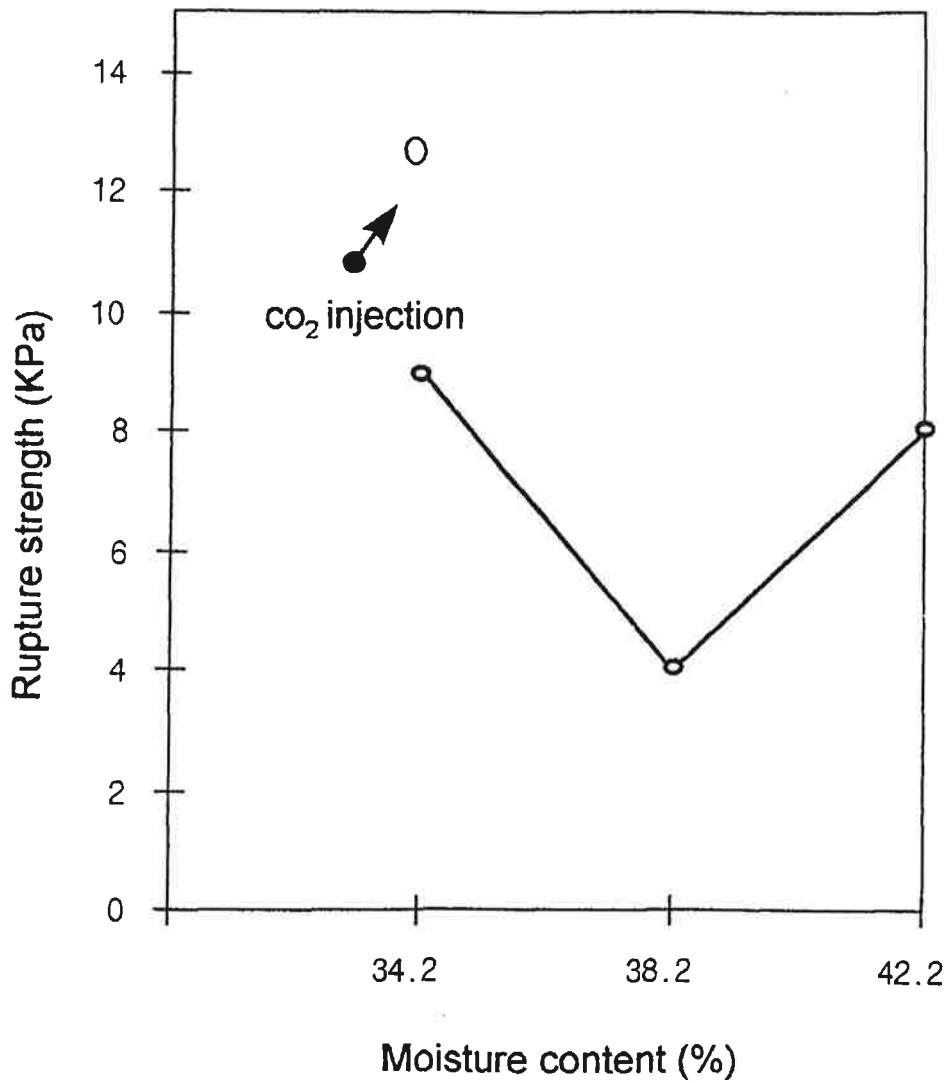
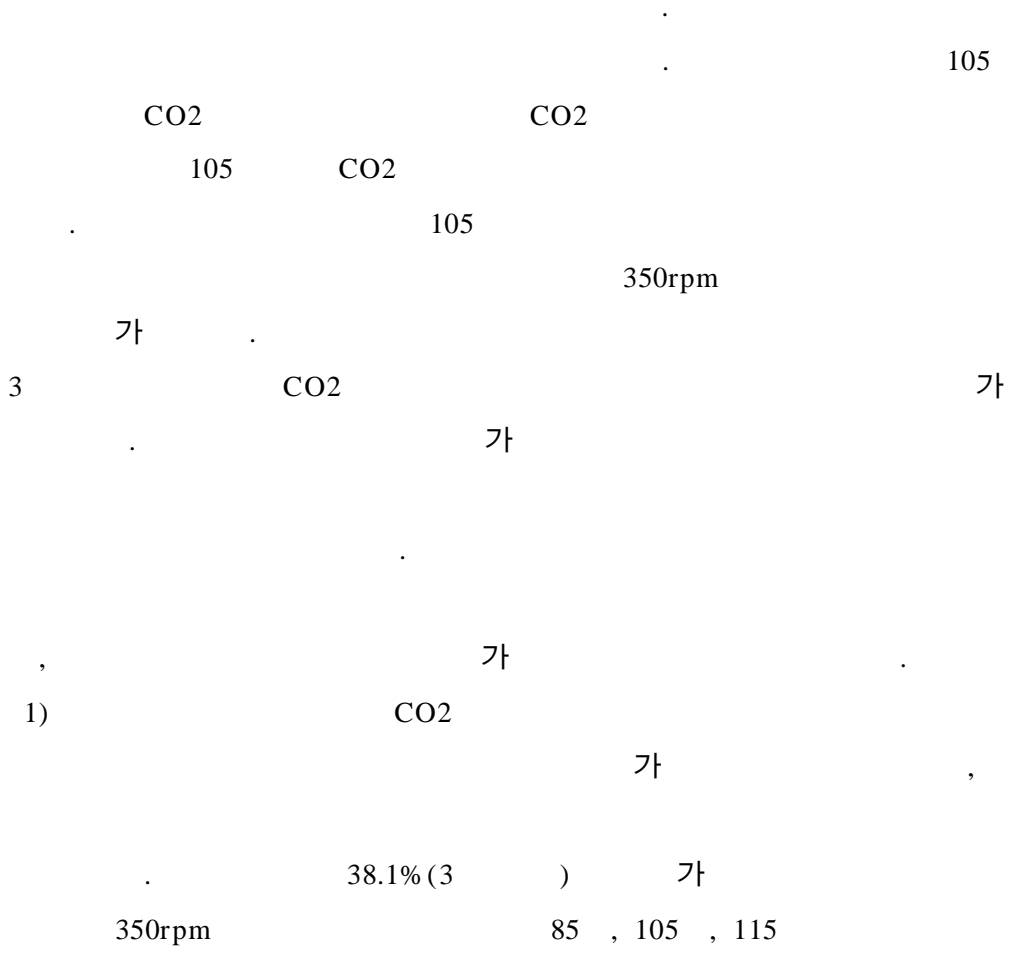
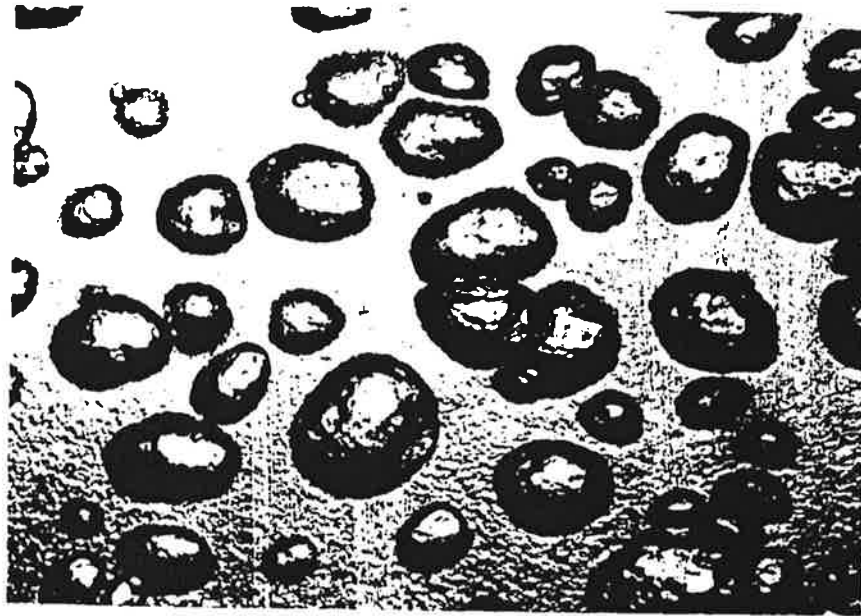


Fig. 27. Effect of dough moisture content on rupture strength of Yukwa



100 Fig. 28 , 가 가 가 가



(a) without CO<sub>2</sub>



(B) with CO<sub>2</sub>

Fig. 28. Effect of CO<sub>2</sub> injection on the size and distribution of air bubbles in Bandegi. (barrel temp. ; 115°C)



die swelling

55 4 2 conditioning

( , )

105 0.38g/ml , CO2

0.11g/ml (Fig. 29).

가

105 793kPa , CO2

1609kPa CO2 가

, 115 가 1718kPa

3160kPa (Fig. 30).

가

가

CO2 가 가 105 65kPa CO2

105 63kPa 115 46kPa (Fig. 31).

가

105 CO2

가 CO2

Fig. 32 105

가

가

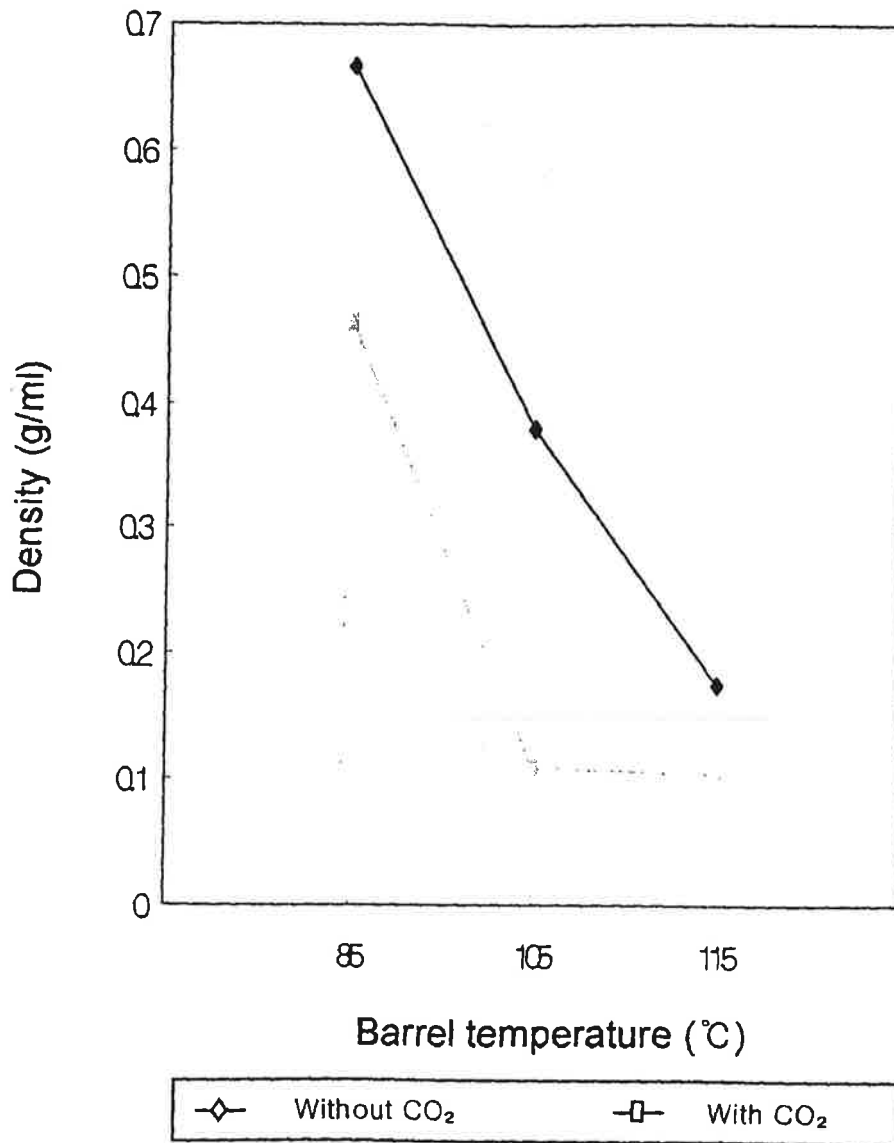


Fig. 29. Effect of barrel temperature and CO<sub>2</sub> gas injection on piece density of Yukwa.

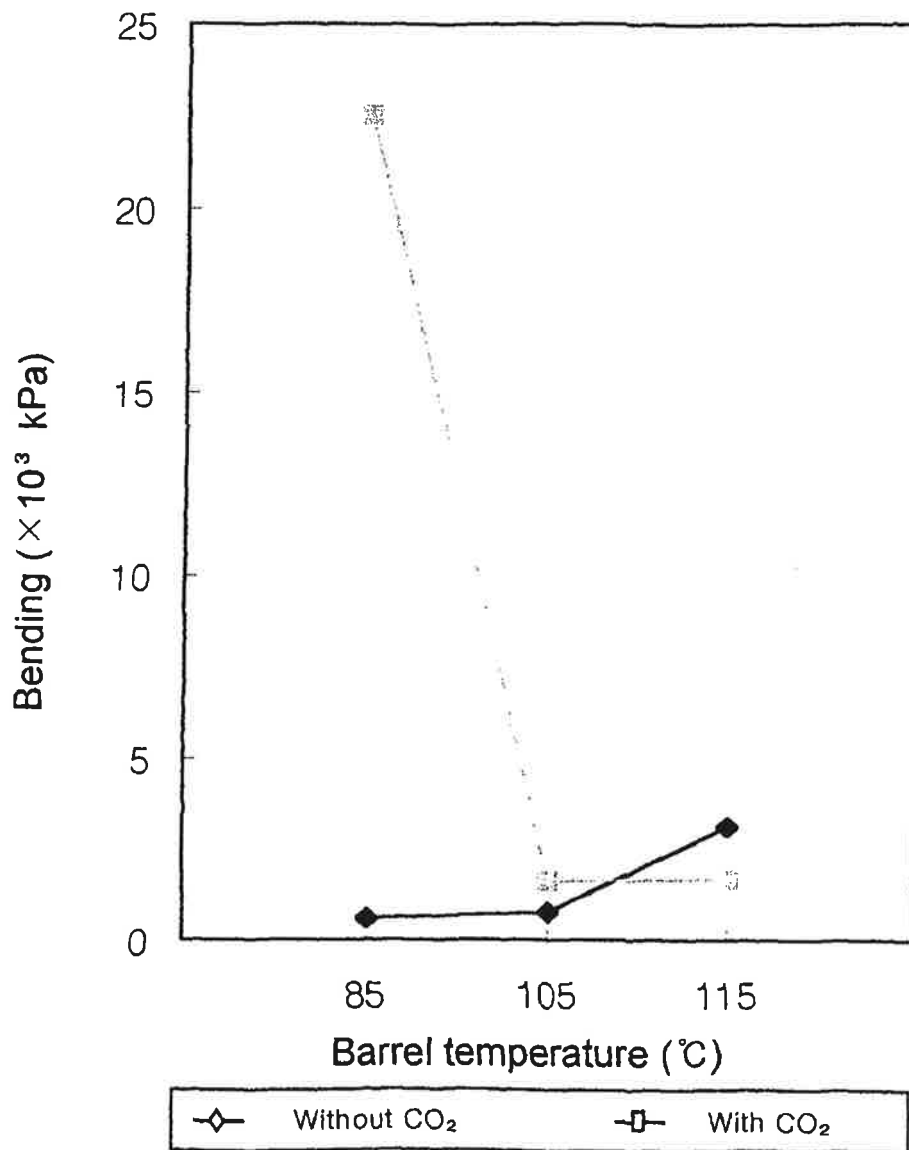


Fig. 30. Effect of barrel temperature and CO<sub>2</sub> gas injection on apparent elastic modulus of Yukwa.

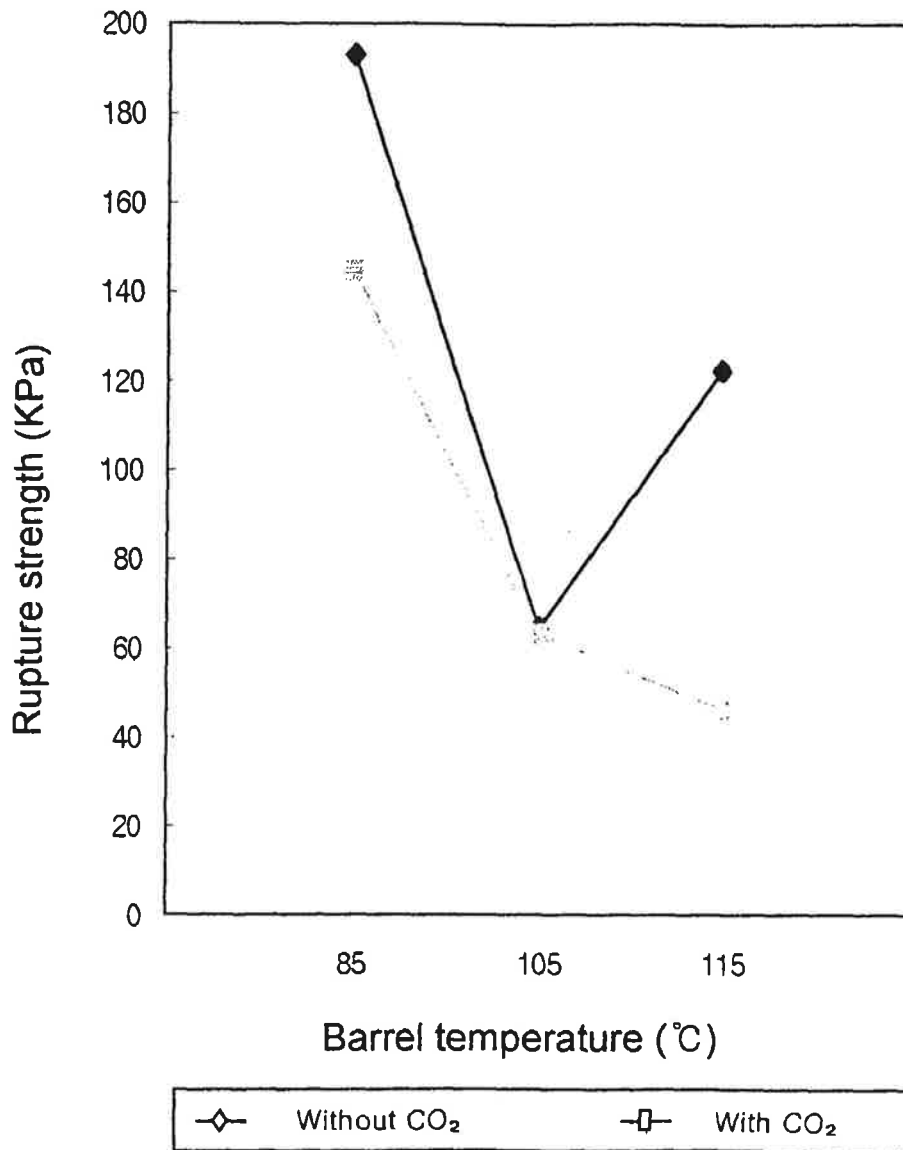


Fig. 31. Effect of barrel temperature and CO<sub>2</sub> gas injection on rupture strength of Yukwa.

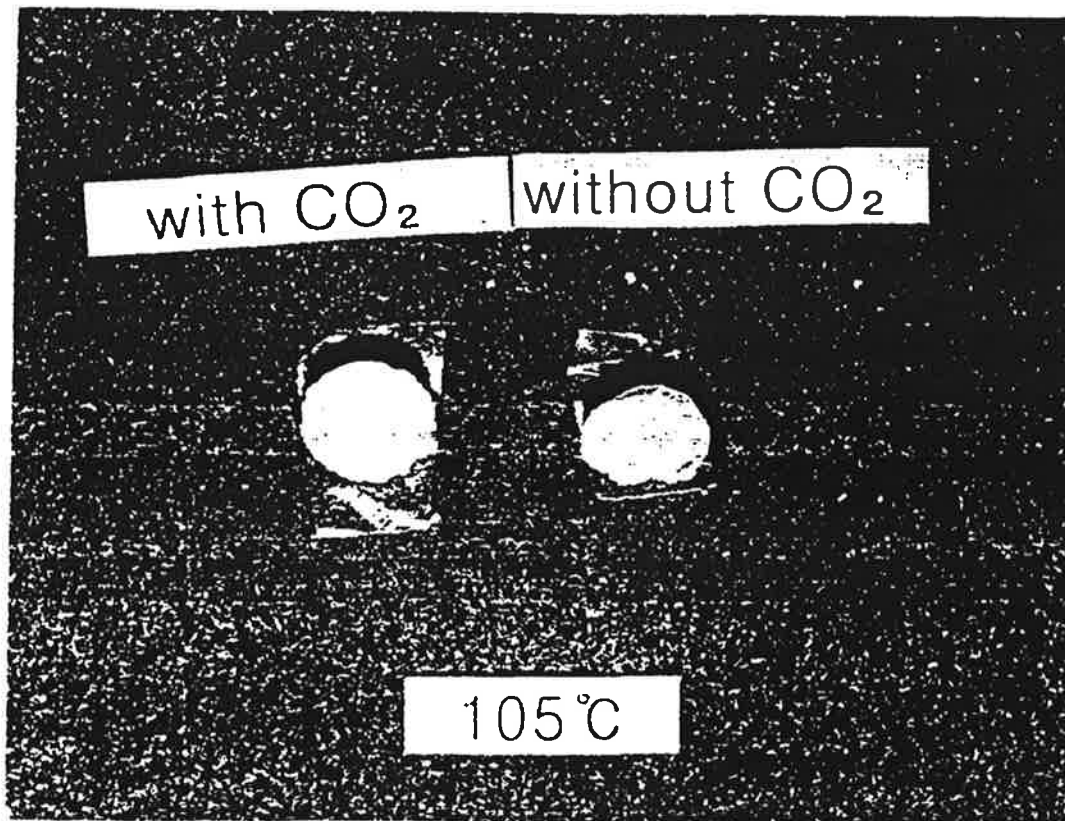
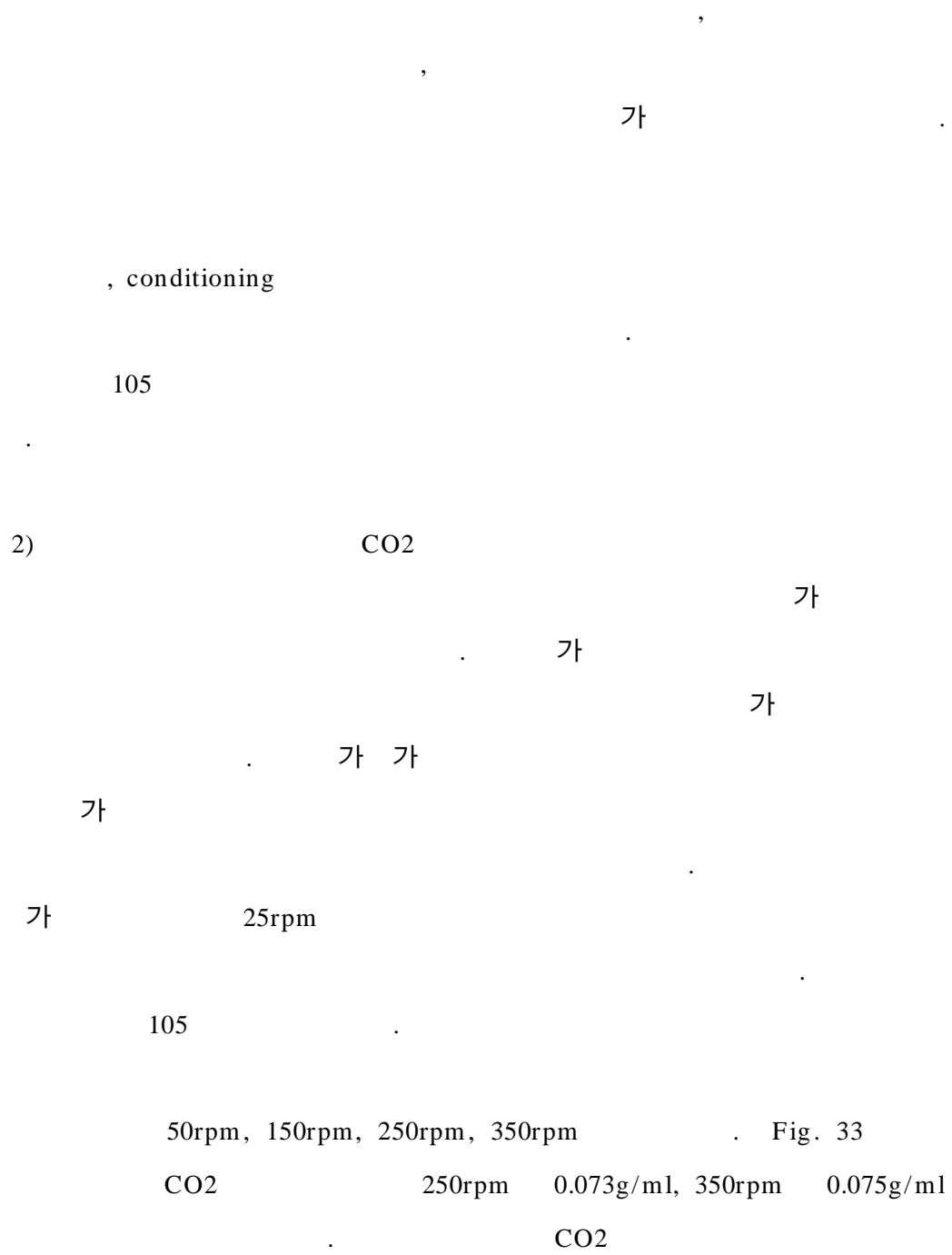


Fig. 32. Effect of CO<sub>2</sub> injection on Cross-section of Yukwa  
(barrel temp. ; 105°C)



50rpm, 150rpm, 250rpm, 350rpm . Fig. 33  
 CO2 25rpm 0.073g/ml, 350rpm 0.075g/ml  
 CO2

250rpm      350rpm  
 .  
 250rpm      32kPa, 350rpm      27kPa      250rpm      367kPa ,  
 (Figs. 34, 35).  
 CO2      250rpm      350rpm  
 .      가      25rpm  
 가 300rpm      가  
 가  
 가

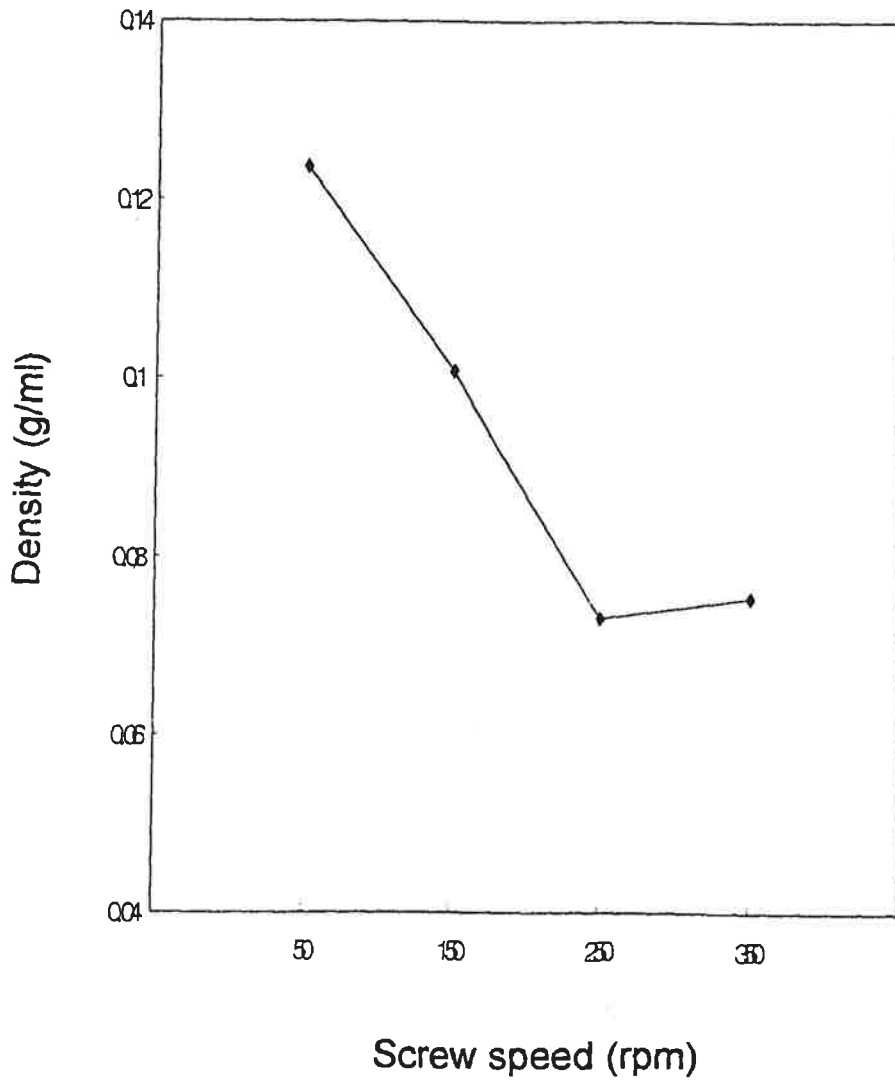


Fig. 33. Effect of screw speed and CO<sub>2</sub> gas injection on piece density of Yukwa.



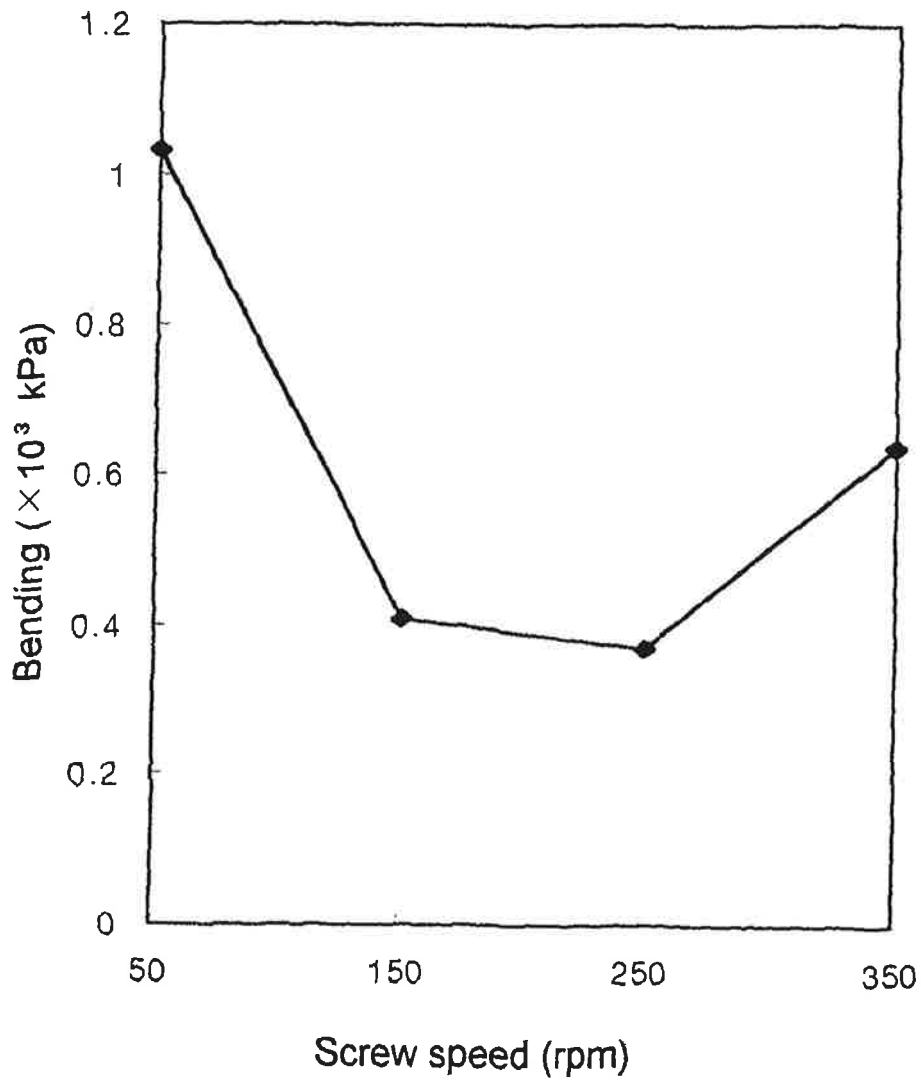


Fig. 34. Effect of screw speed and CO<sub>2</sub> gas injection on apparent elastic modulus of Yukwa.

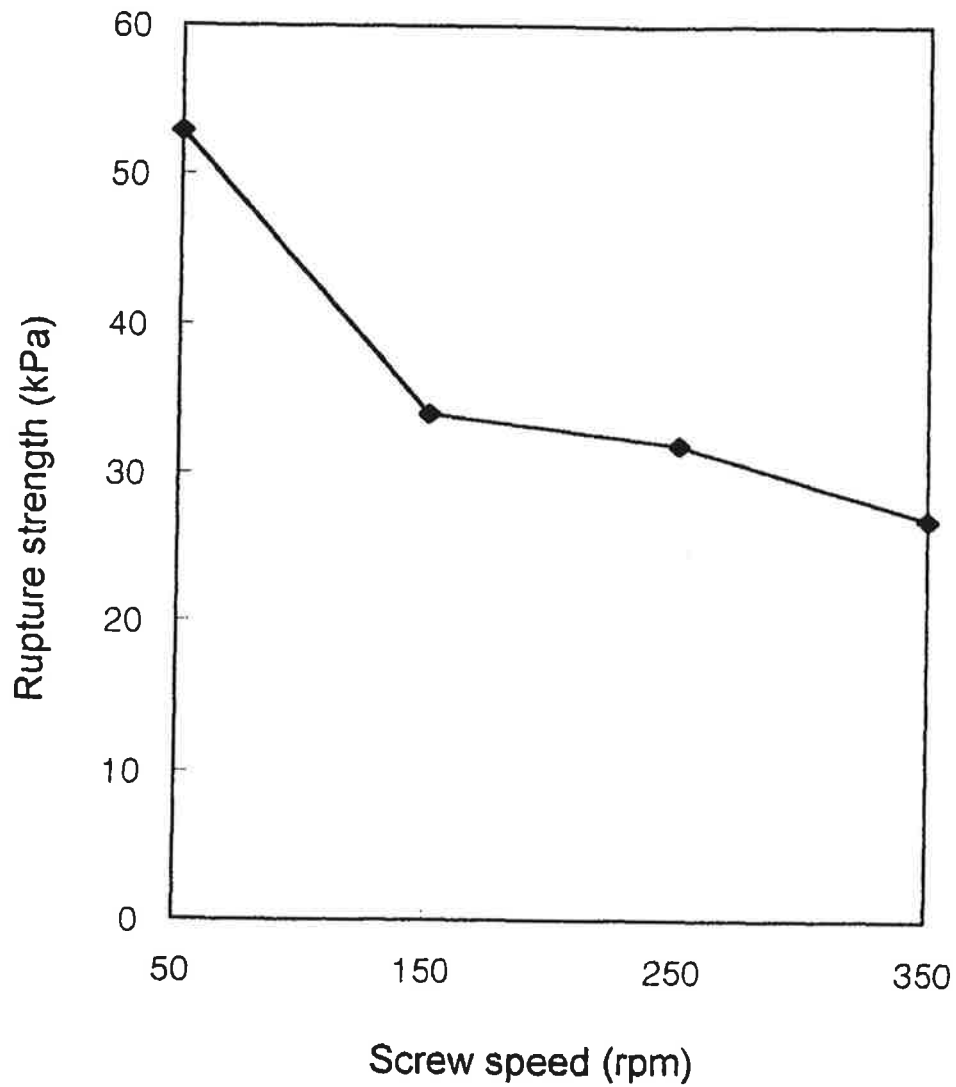


Fig. 35. Effect of screw speed and CO<sub>2</sub> gas injection on rupture strength of Yukwa.

3)

CO2

7 14 가

가 가  
가

0 , 3 , 24 , 72 , 144  
, CO2

Fig. 36

CO2 72 가

0.08g/ml

CO2

72 (3 )

355kPa ,

CO2

72

23kPa 가

(Figs. 37, 38).

72

, 3

, Fig

38 98

0 ,

가

CO2

, 0.17g/ml,

1228kPa

Fig. 39

CO2

3

가

. 3

Fig. 40

가

가

3

size

가 가

3

(Fig. 41).

가 CO2 ,  
가

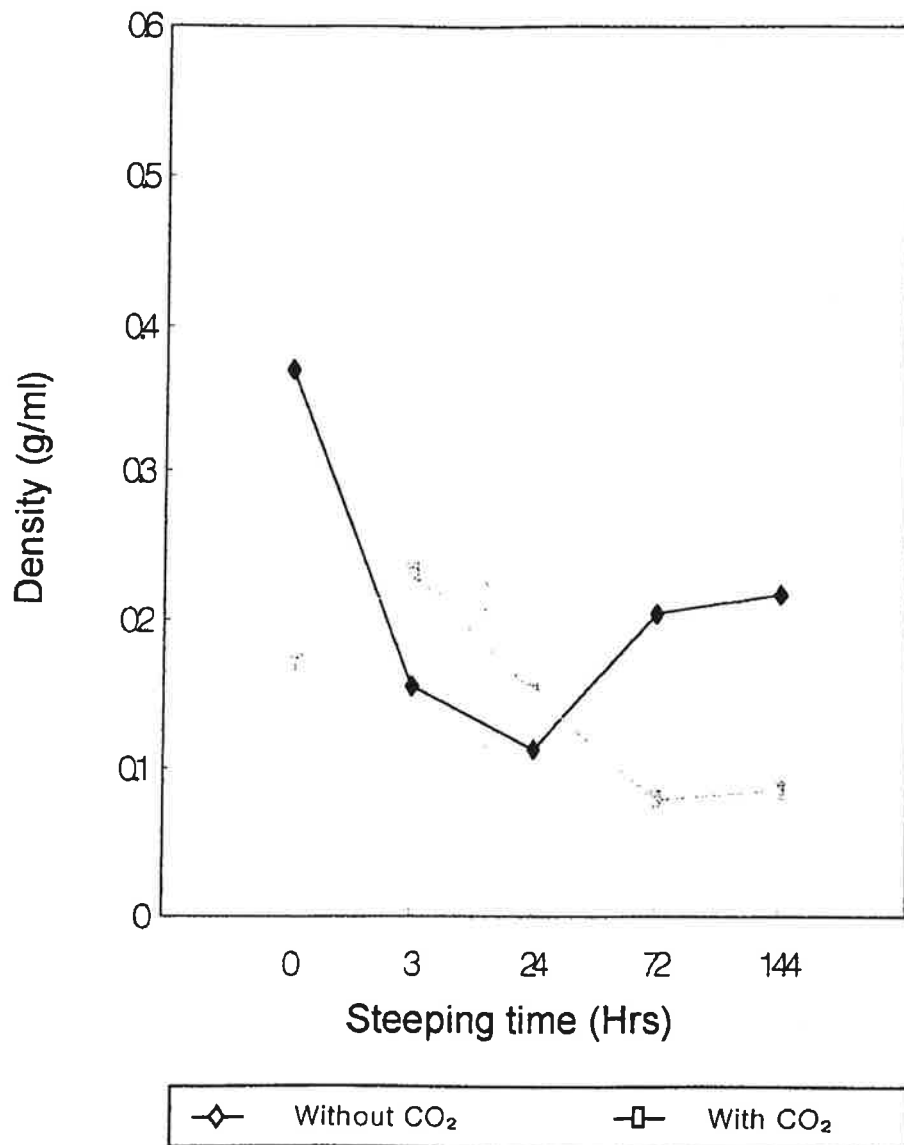


Fig. 36. Effect of steeping time and CO<sub>2</sub> gas injection on piccc density of Yukwa.

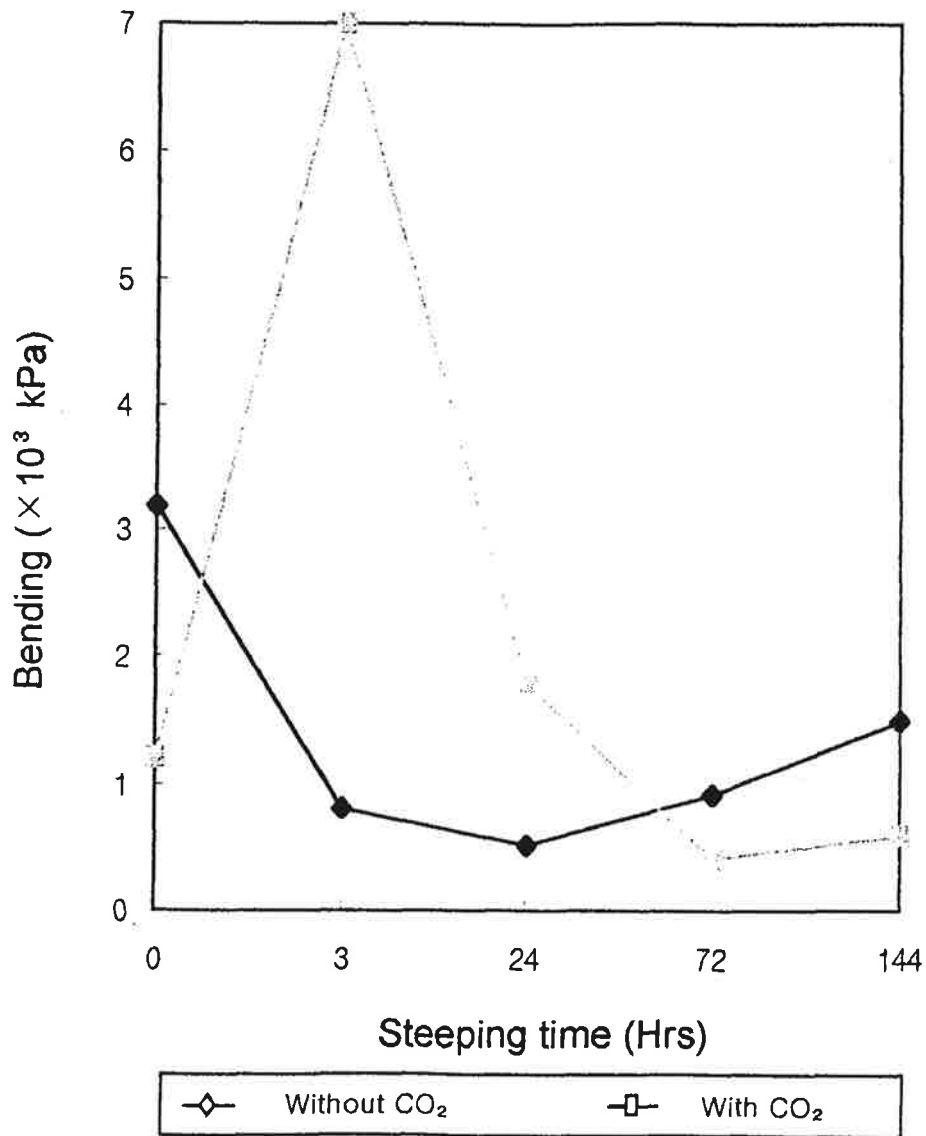


Fig. 37. Effect of steeping time and CO<sub>2</sub> gas injection on apparent elastic modulus of Yukwa.

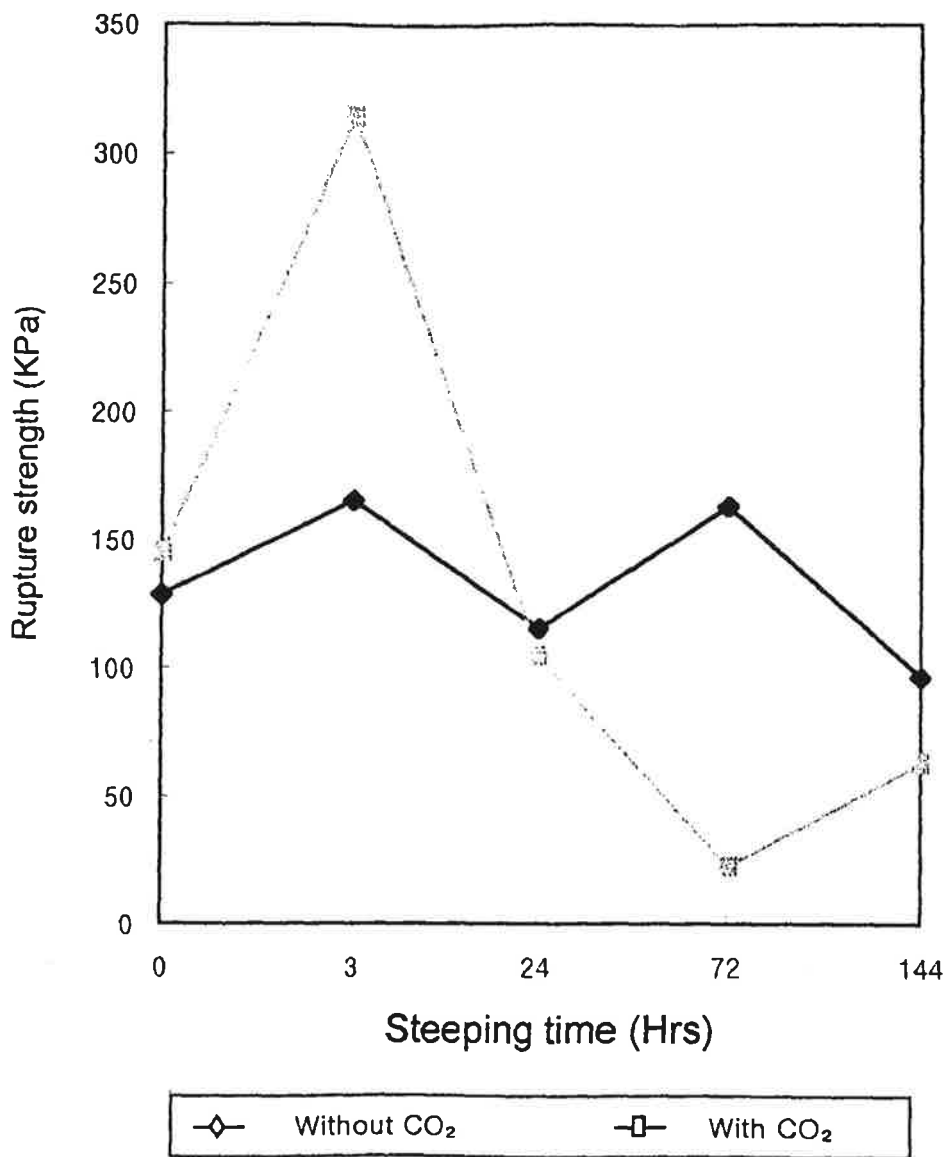


Fig. 38. Effect of steeping time and CO<sub>2</sub> gas injection on rupture strength of Yukwa.

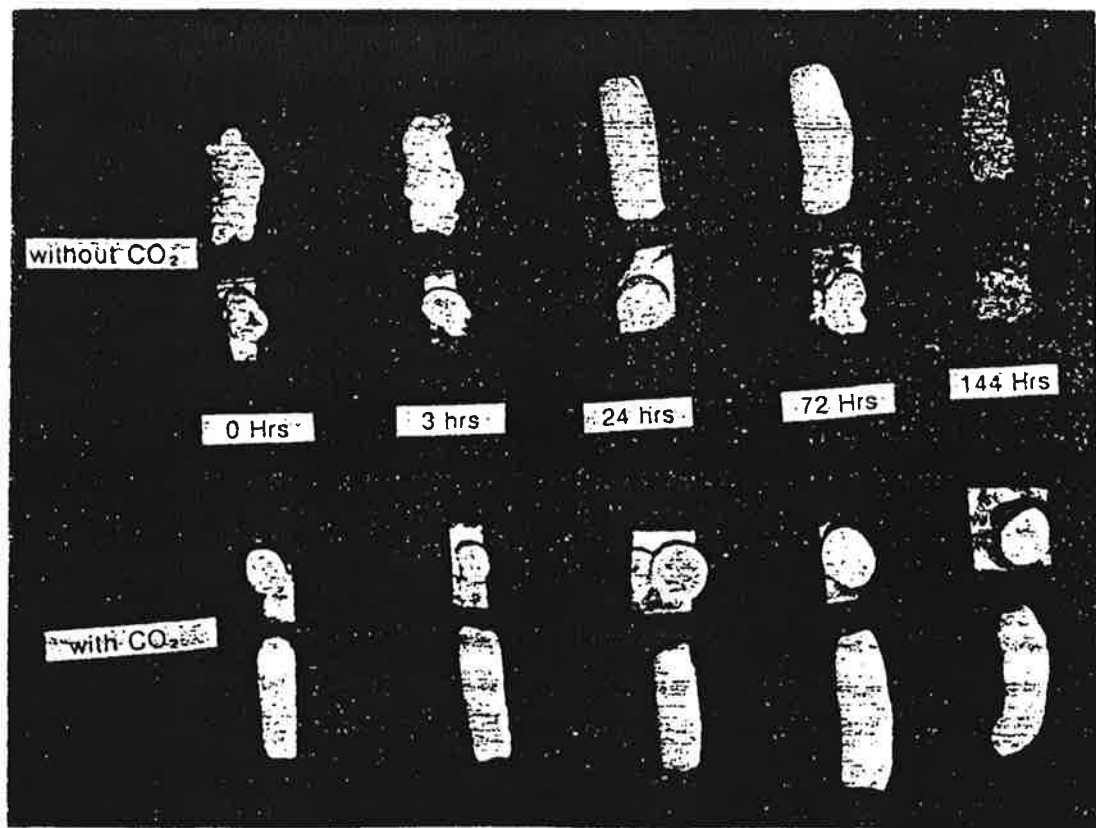


Fig. 39. Effect of steeping time on appearance of extruded Yukwa.





Fig. 40. Effect of CO<sub>2</sub> injection on appearance of extruded Yukwa  
(3-day steeping)

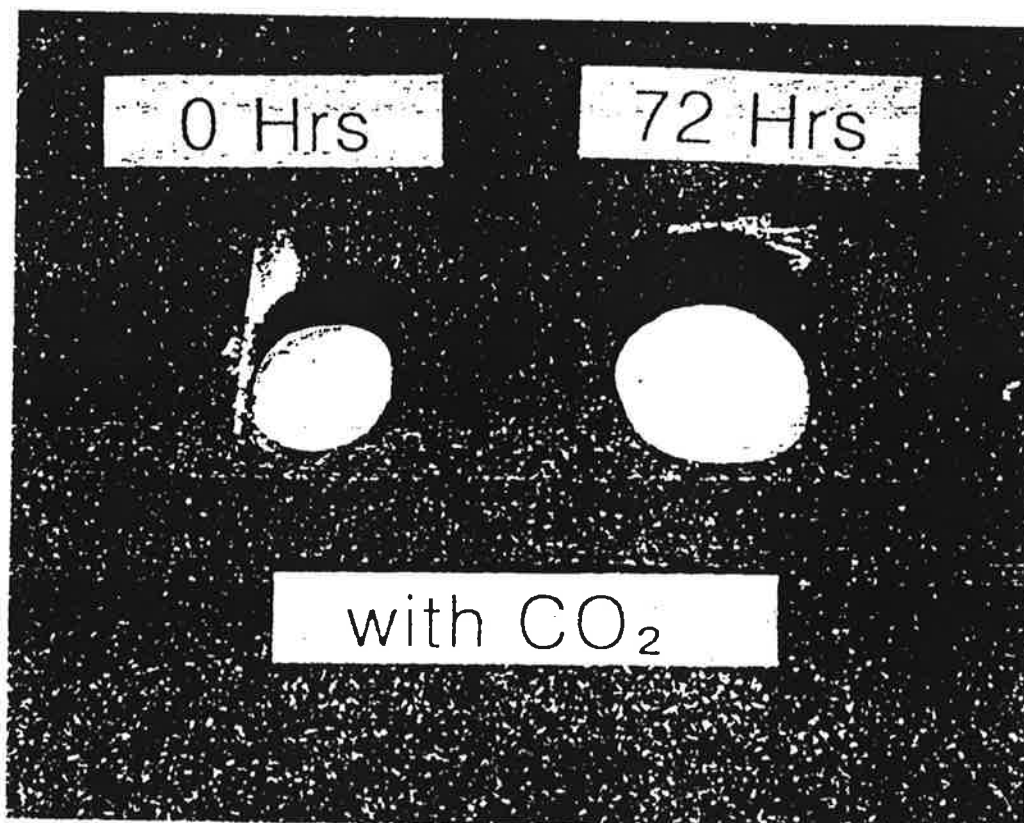


Fig. 41. Effect of steeping time on Cross-section of extruded Yukwa

4) 가 가 CO2  
가 ( 가 )  
가 가

14.7% 가 ( 1: 7)  
40% ,  
105 300rpm

Fig. 42 가 ( 가 )

가 0.17g/ml , 가  
가 0.1g/ml .

가 3  
0.08g/ml 가

43, 44 Figs.  
가 가

984kPa , 3  
355kPa 가 가  
가 ( 가  
) 74kPa , 3  
23kPa

가  
가 가

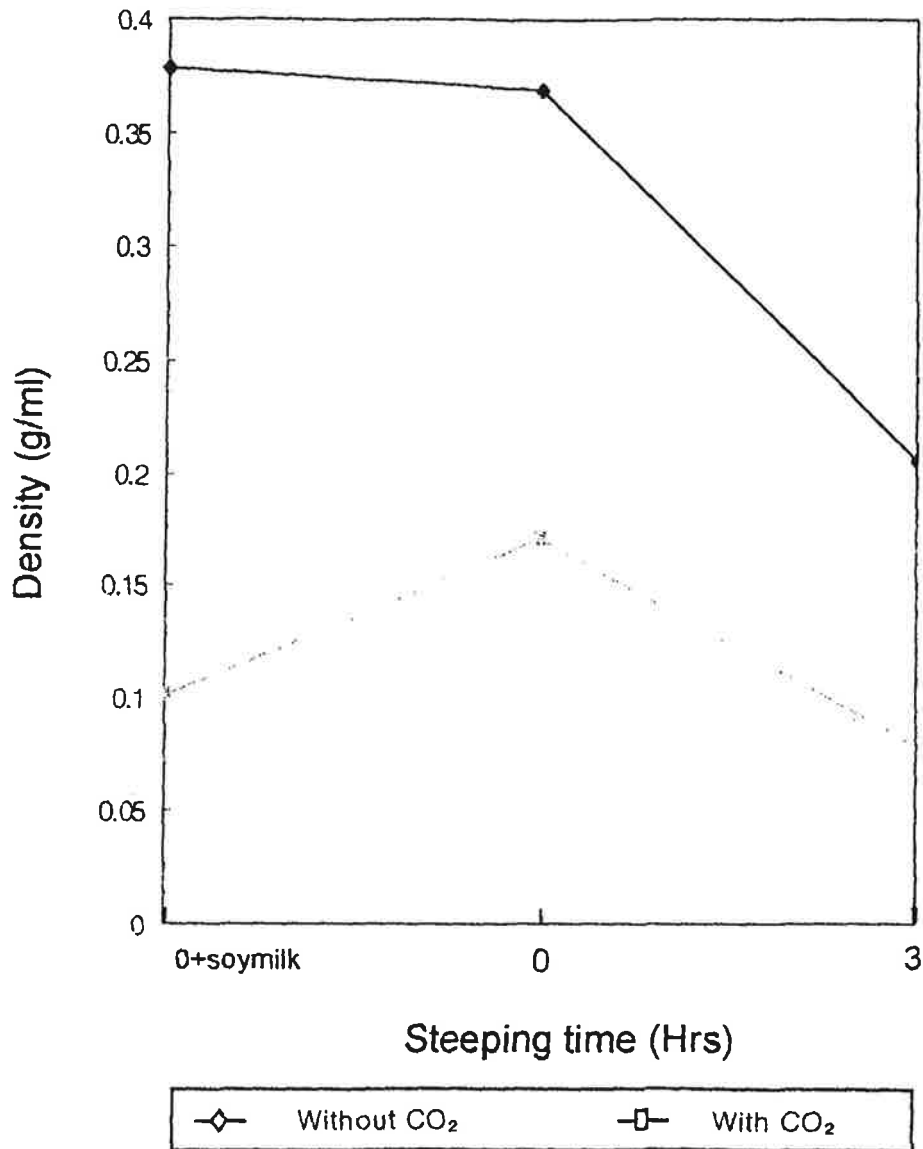


Fig. 42. Effect of soymilk addition and steeping time on density of Yukwa.

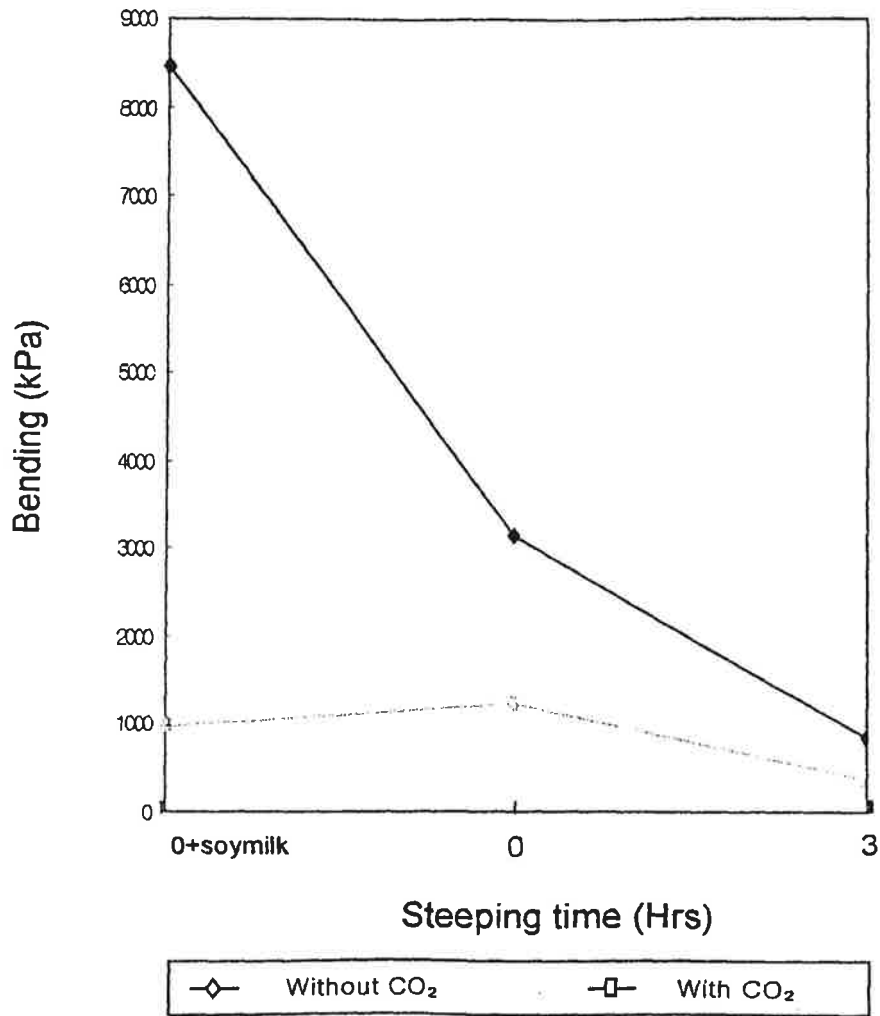


Fig. 43. Effect of soymilk addition and steeping time on elastic modulus of Yukwa.

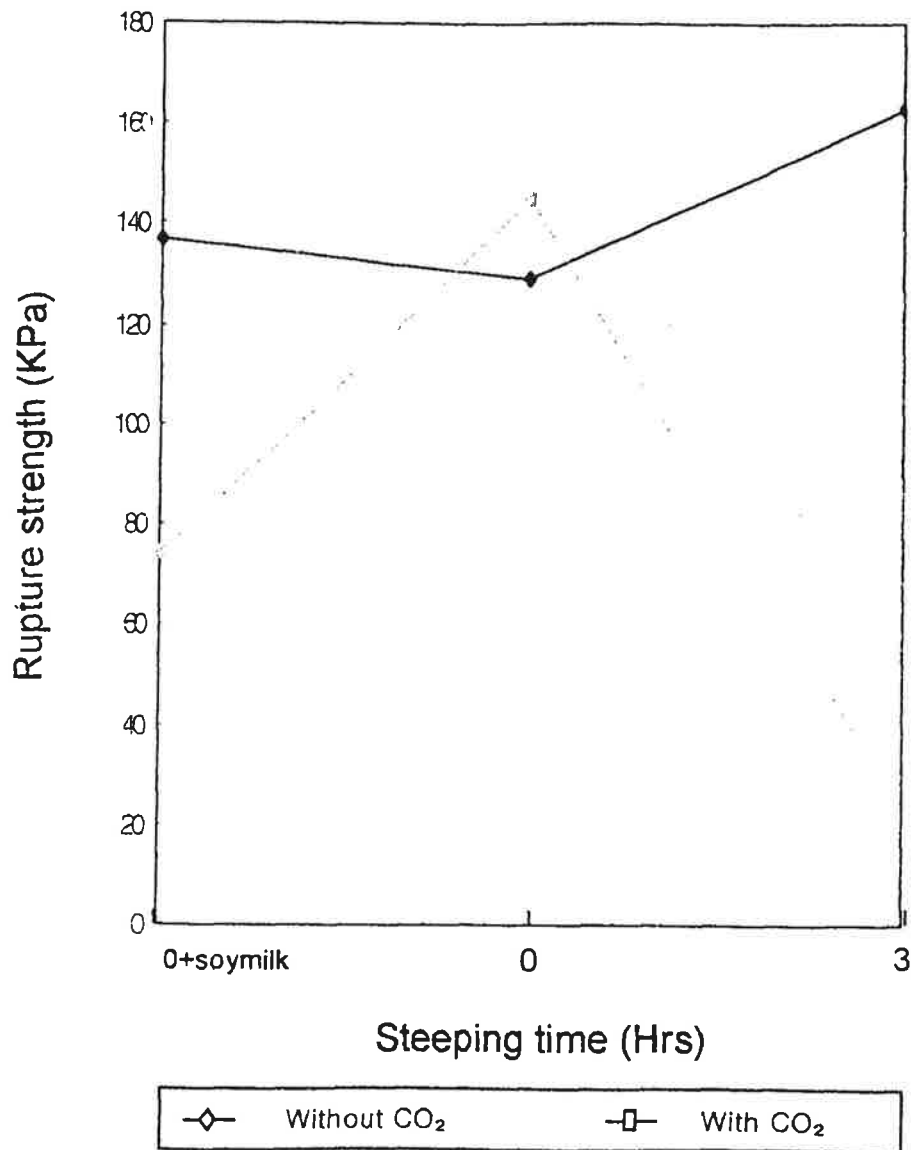


Fig. 11. Effect of soymilk addition and steeping time on rupture strength of Yukwa.

6.

“ ”, “ 95 ”, “ ”, “ ”, “ rack 30 ” 4), “ ” 14) , 가 , 가 가 가 1 , 16% 60 , 4 2 110 1 180 2

(1)

가  
 가 . 가  
 가  
 가  
 가  
 가 72.6% rH  
 1  
 가

(Fig. 45).

Fig. 46

60

60

16 18% 가  
 , 16 18%

가 0.079g/ml  
 60 4

(Fig. 47).

conditioning

(Fig. 48).

conditioning 2

가 가

Fig. 49

2 conditioning





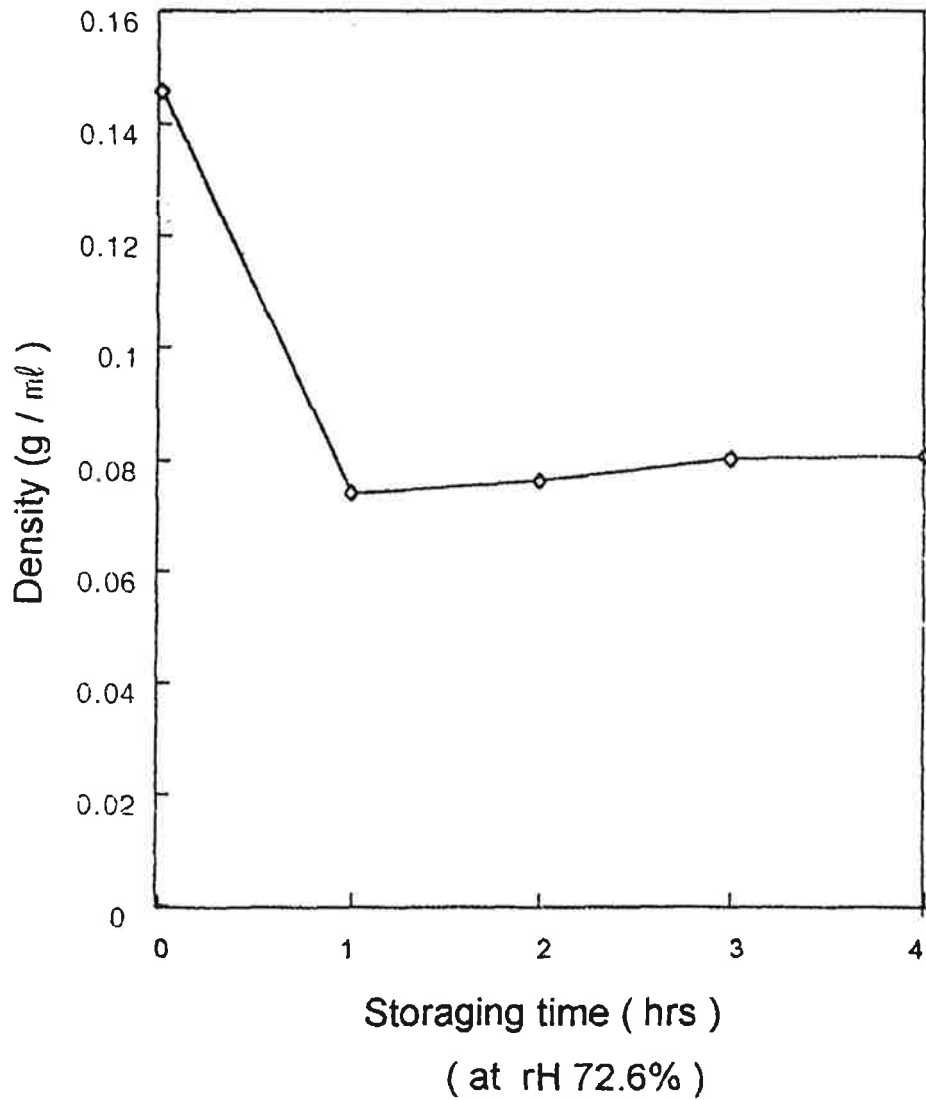


Fig. 45. Effect of storage time of extruded Bandegi on density of Yukwa

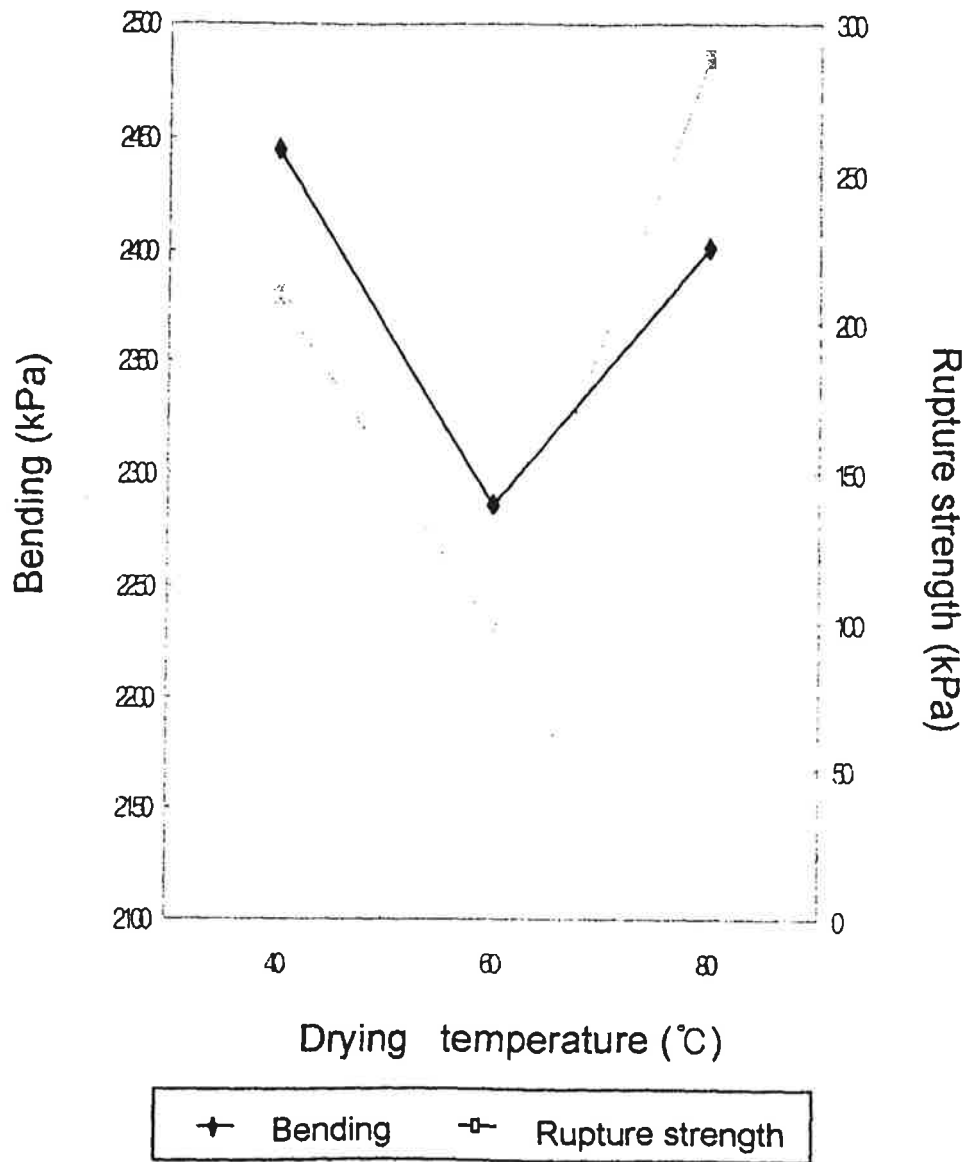


Fig. 46. Effect of drying temperature on elastic modulus and rupture strength of Yukwa

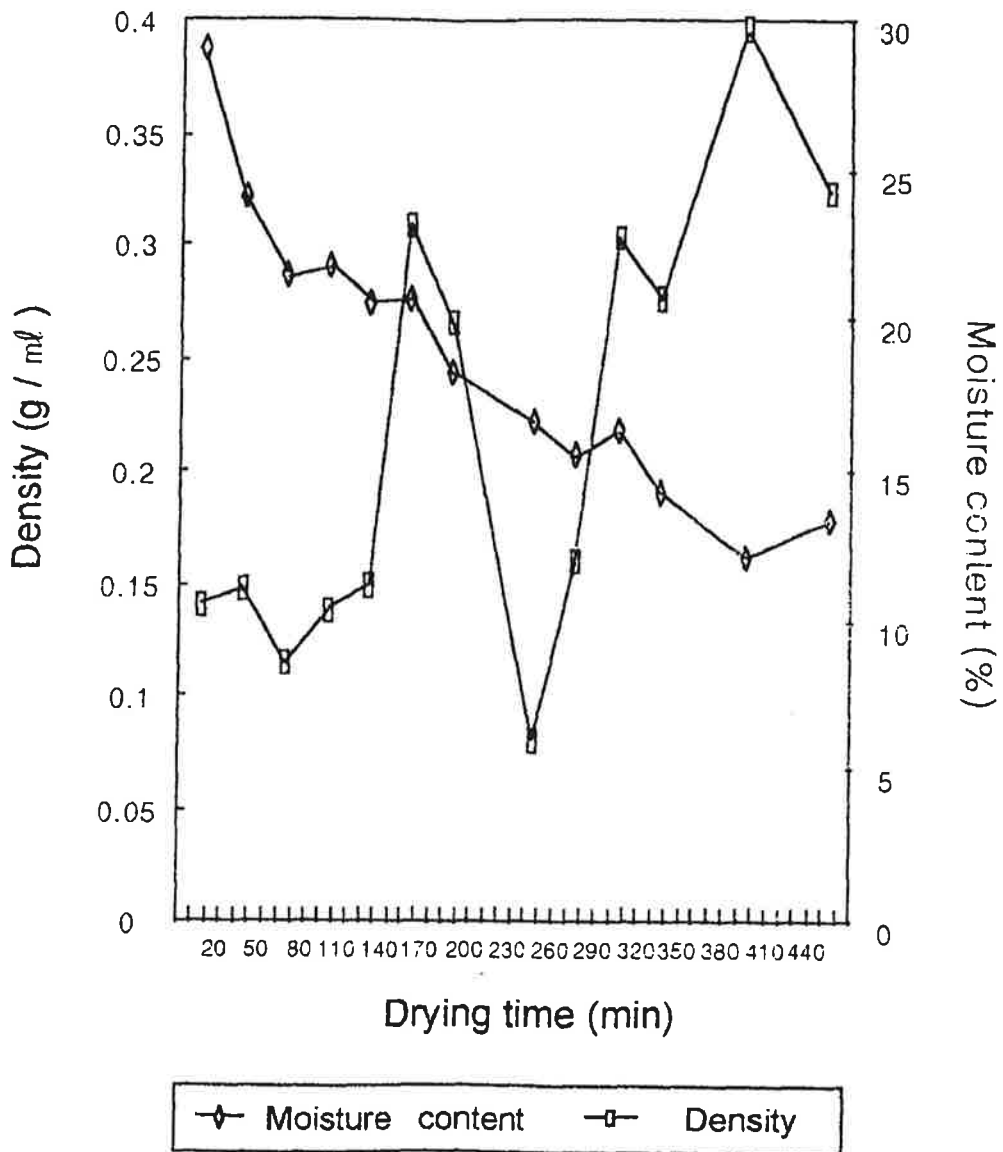


Fig. 47. Effect of drying time on moisture content of Bandegi and density of Yukwa

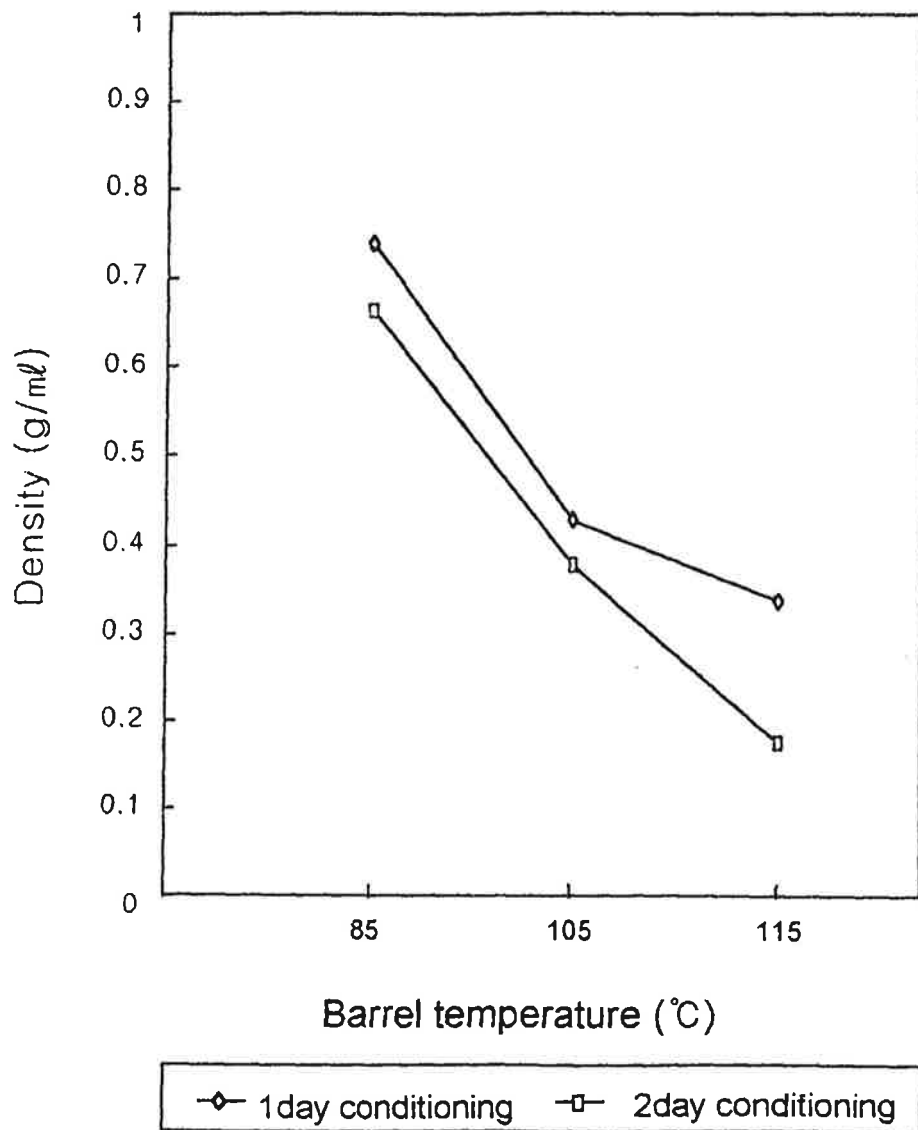


Fig. 48. Effect of barrel temperature on density of Yukwa

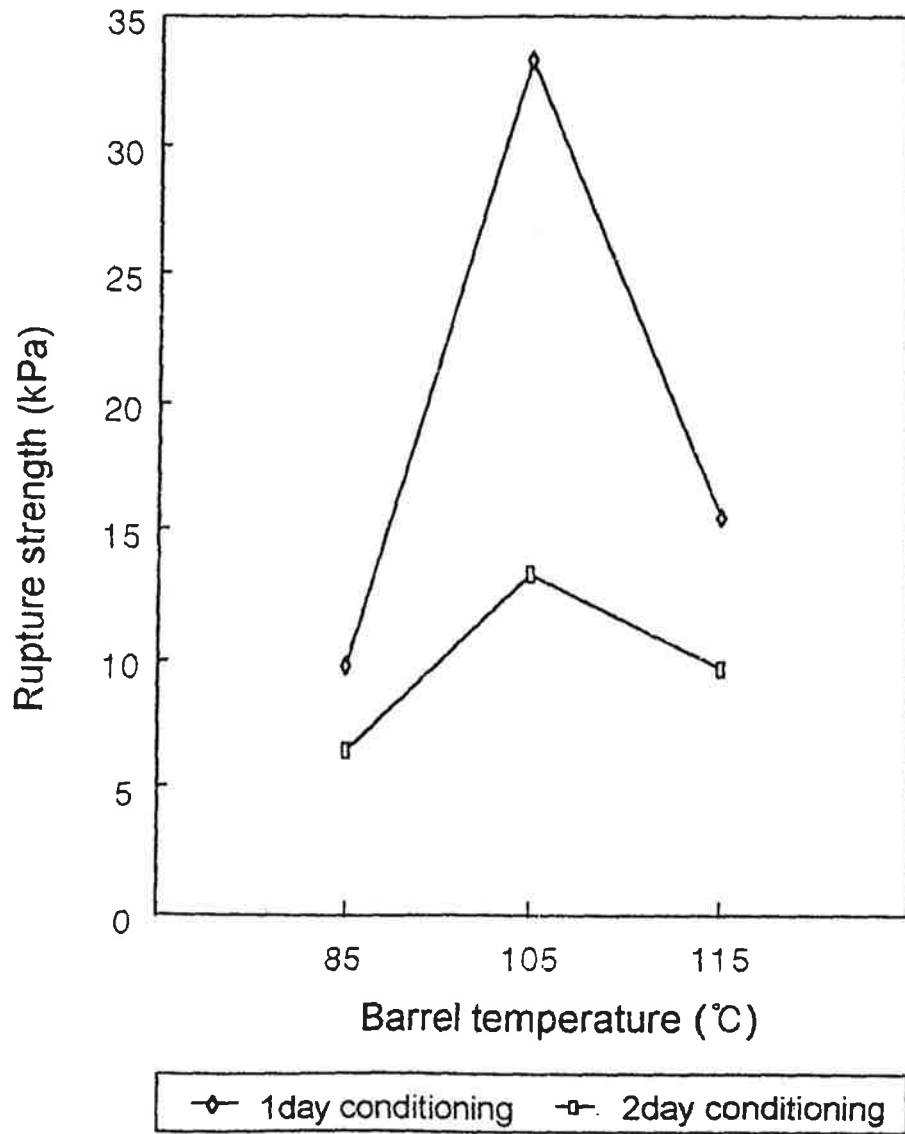


Fig. 49. Effect of barrel temperature on rupture strength of Yukwa

(2)

가

14	1	120	2
190		가	가
	.6)		

Fig. 50

110	1	180	2
			110

가

180

가

(Fig. 51)

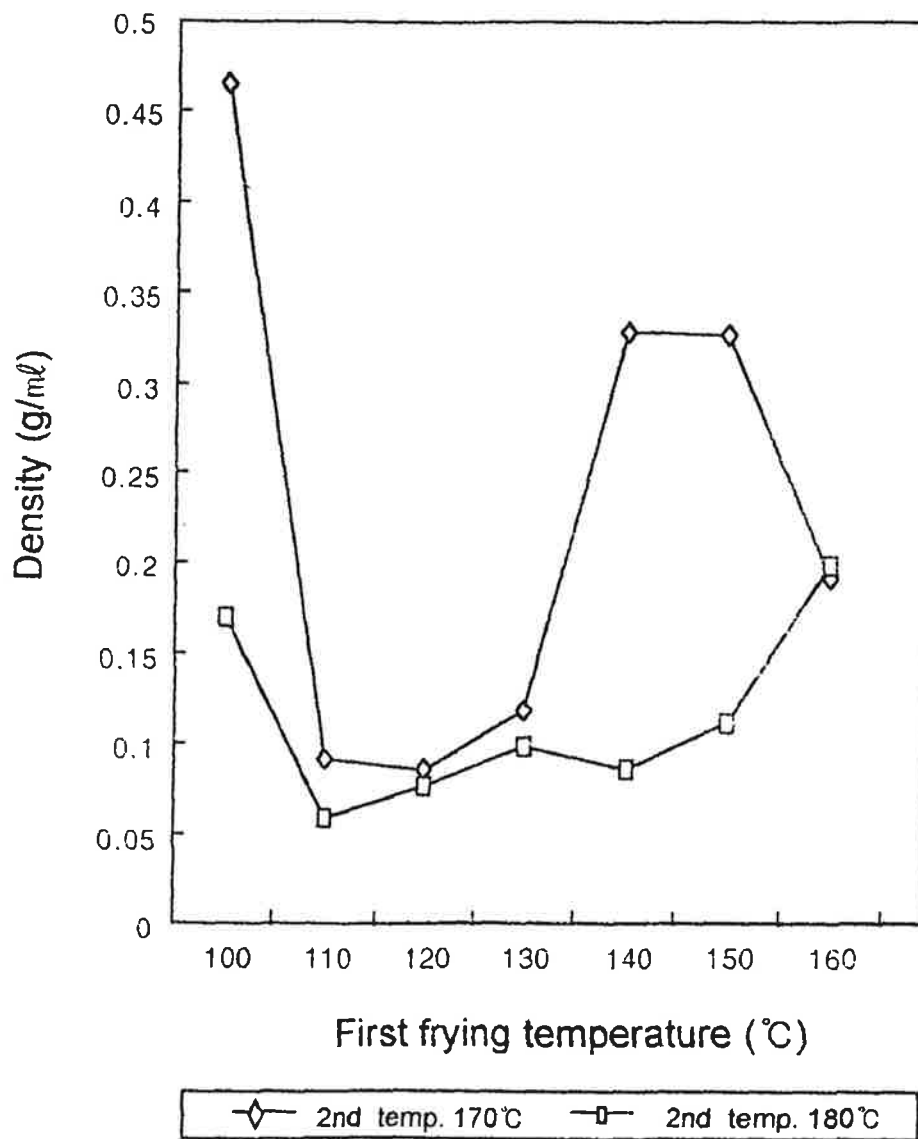


Fig. 50. Effect of frying temperature on density of Yukwa



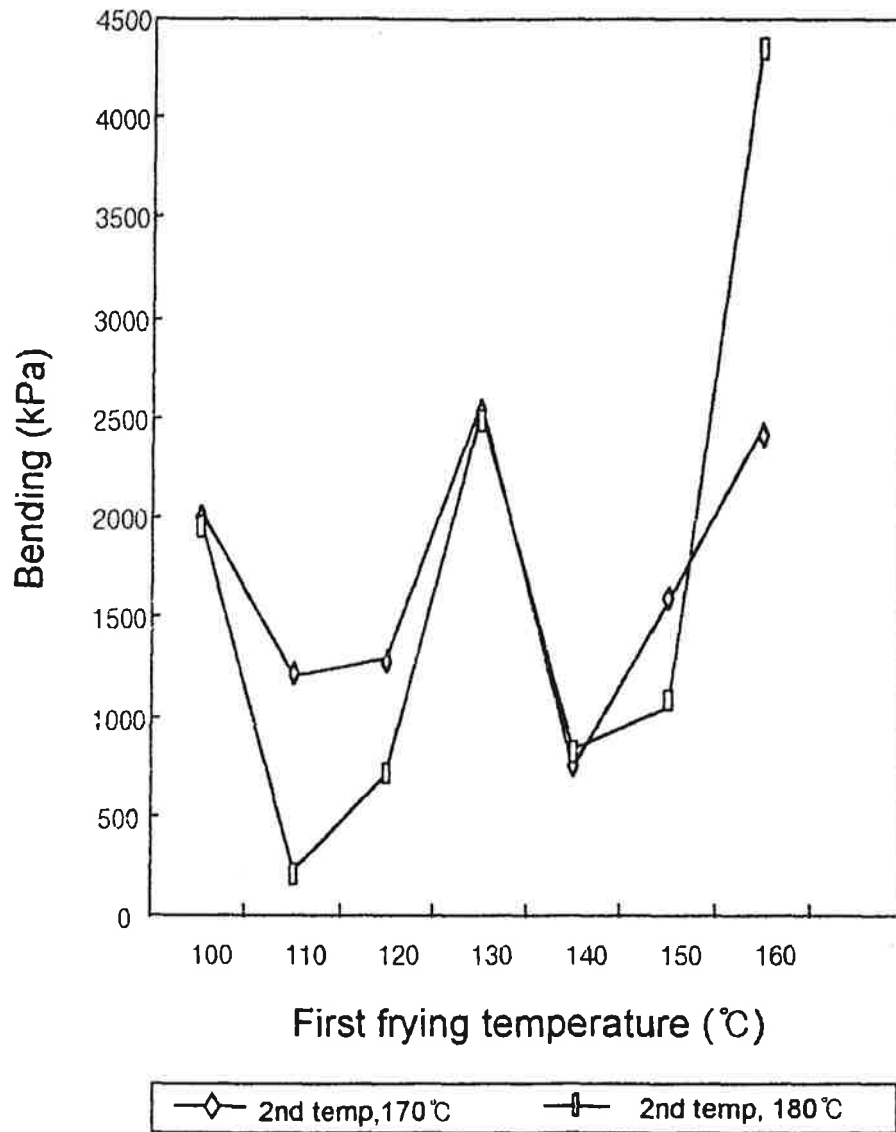


Fig. 51. Effect of frying temperature on elastic modulus of Yukwa.

### 3

가  
가  
가가      가  
가      가

3  
6  
7

가      가  
가      가  
가      가

pH가

( ) 14 17%  
( ) 2 가  
가 300SNU , 가

가

가

low-shear screw, medium-shear screw, high-shear screw

reverse screw

4mm

105

가

350rpm

3

가

feed rate 20 30rpm

, 105

350rpm

가

가

가

가 가

가 1  
17% 가  
2 (conditioning)

가 가

snack

가

가

가

,  
가

가

가

,

가

,

가

1. : .  
 , , PP.6- 9. 1995.
2. : , .
3. : . PP.34- 61
4. , : .  
( ) (2) , 15 2 , PP.33- 40. 1982.
5. : ( ). 가  
 , 19 3 , PP.63- 68. 1981.
6. : ( ). 가  
 , 20 2 , PP.119- 125. 1982.
7. , , : /  
 . , 27 6 , PP.1008- 1012. 1995.
8. , , , : 가  
 . , 22 3 , PP.272- 276. 1990.
9. , , , : .  
 , 21 6 , PP.820- 825. 1989.
10. , , , : .  
 , 22 3 , PP.266- 271. 1990.
11. , , : .  
 , 23 5 , PP.619- 621. 1991.
12. : - .  
 , Vol.11, No.4, PP.37- 41. 1982.

13. , , : . ,  
Vol.14, No.2, PP.141- 145. 1982.
14. , , :  
. , 3 , PP.224- 250. 1995.