

소금과 Glucono- δ -Lactone의 첨가 및 초고압 처리가 재구성 돈육의 이화학적 특성에 미치는 효과

Effects of Salt, Glucono- δ -Lactone and High Pressure Treatment on Physico-Chemical Properties of Restructured Pork

Geun-Pyo Hong, Sung-Hee Park, Jee-Yeon Kim, Se-Hee Ko, and Sang-Gi Min*
Department of Food Science and Biotechnology of Animal Resources, Konkuk University

Abstract

This study investigated the effect of salt and glucono- δ -lactone (GdL) on the cold-set binding of restructured pork washed and pressurized at 200 MPa. Binding strength, pH, water holding capacity (WHC) and color were determined. NaCl improved pH, WHC and binding strength. GdL also increased binding strength while decreased WHC and pH significantly ($p < 0.05$). However, low GdL level combined with NaCl showed high pH and WHC, compared to control. In color, NaCl decreased L*-value with increasing a*-value significantly ($p < 0.05$). In contrast to NaCl, GdL increased L*-value and decreased a*-value. GdL tended to decrease b*-value and significant differences were found when GdL was added above 1%. Pearson's correlation coefficients presented that NaCl had a significant effect on binding strength (0.6632) and lightness (0.7330) while GdL had a significant correlation with all parameters barring binding strength. The results indicated that under washing and pressure treatments, GdL had a potential effect on cold-set binding with reducing NaCl concentration, especially when low GdL concentration combined with NaCl was added.

Key words : glucono- δ -lactone, salt, cold-set, restructured meat, binding

(hot-set) (cold-set) (Chen and Trout, 1991).
 cold-set 가
 가
 hot-set binding cold-set binding
 (Boles and Shand, 1998). transglutaminase(TGase) 가
 가 hot-set 가
 myofibrillar 가 가
 myosin hot-set (Nielsen et al., 1995).
 가 TGase 가
 가 , 가
 가 가
 (Means and Schmidt, 1986). hot- (Kuraishi et al., 1997). TGase
 set 가 algin/calcium 가
 (Hunt and cold- set (Boles
 Kropf, 1987), 가 , 가 and Shand, 1988; Clarke et al., 1988).
 (Gray and Pearson, 가 가
 1987) 가 .
 가 (Sheard, 2002).
 가
 , 가
 2% 가 . 가 cold-set
 가 carrageenan
 가 .

*Corresponding author : Sang Gi Min, Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Korea. Tel: 82-2-450-3680, Fax: 82-2-455-1044, E-mail: foodeng301@paran.com

carrageenan 가 가 (Perez-Mateos and Montero, 2000),

가 (Montero et al., 2000).

, 가 (Montero et al., 2002).

Lullien-Pellerin Balny(2002) 가 .

가 . Macfarlane (1984) 가

가 , Hong (2006) 200 MPa

가 가 , 50 ℃ 가

surimi (washing)

sarcoplasmic myofibrillar ,

(Park and Morrissey, 2000).

Glucono- -lactone(GdL) 가 가 pH (Ngapo et al., 1996). cold-set

가

Lee(1984) Song (1987) 가

(Lee et al., 1987), PSE (Mueller and Chin, 2003) (Hur et al., 2004)

cold-set binding Lee Chin(2004) TGase 가가

GdL 가

(*M. longissimus dorsi*)
 24 가 22 15 30 18 ° C
 Table 1 5
 50 ° C 24 , 4 ° 4.5 cm fibrous
 C 48 polyethylene bag
 pH 4 ° C
 1 cm 30
 Mackie(1992) 3
 (washing process) 가
 0.5% NaHCO₃ , 0.5% 가
 NaCl 4 ° C 10 가 pressure vessel,
 pressure intensifier controller
 3:1(v/w) , 가 ethanol
 (compression) 가 200 MPa 30

Table 1. Experimental design and formulation ingredients used

Treatments ¹⁾	Additives (%)			
	NaCl	Glucono- -lactone	Carrageenan	Phosphate
C	0	0	0.5	0.3
S	1	0	0.5	0.3
G	0	1	0.5	0.3
LSLG	0.5	0.5	0.5	0.3
LSHG	0.5	1.5	0.5	0.3
HSLG	1.5	0.5	0.5	0.3
HSHG	1.5	1.5	0.5	0.3

¹⁾ C; control, S; salt, G; GdL, LSLG; low salt low GdL, LSHG, low salt high GdL, HSLG; high salt low GdL, HSHG; high salt high GdL.

2.7 20 MPa/s 가

Homogenizer(SMT Process Homogenizer, SMT Co. Ltd., Japan) 13,000 rpm 1 pH-meter(pH Meter 440, Corning, U.K)

Gornall (1949)
 biuret . Biuret
 1.5 g CuSO₄ · 5H₂O 6 g
 NaKC4O6?4H2O 500 mL
 , 300 mL 10% NaOH
 가 1 L mass
 up 1 mL
 4 mL biuret 가 30
 540 nm
 , standard curve bovine
 serum albumin

AOAC(1990)
 102 ° C
 Pietrasik Shand(2004)
 3 1 g
 , 4 ° C Automatic refrigerated
 centrifuge (RC-3, SORVALL Co., USA)
 3,000 rpm 10

(2×1×4.5 cm)
 1
 cm 2 holder
 , Digital force gauge(DPS-20,
 IMADA Co., Japan)
 table 60 mm/min
 head speed 가
 (N)
 12

(Color)
 Color meter(JC801S,
 Color Techno System Co. Ltd., Japan)
 L*, a* b* 5
 L* 97.83, a* -0.43,
 b* +1.98 calibration plate

pH
 5 g 20 mL

GdL
 가

SAS(Statistics Analytical System, USA, 1989 ~ 1996) (Ver. 9.1) Duncan multiple range test
 Pearson's correlation coefficients
 GdL

Fig. 1
 74.72% , 1
 77.05% 가
 가
 78.27%
 , 3
 85.82 mg/mL
 가 Lin
 Park(1996)

Table 2. Effects of NaCl and glucono- -lactone level on color¹⁾ of restructured pork washed and pressurized at 200 MPa

Treatments ¹⁾	Additives (%)		
	L*-value	a*-value	b*-value
C	63.25±0.86 ^c	7.08±0.40 ^a	10.18±0.61 ^{ab}
S	60.10±1.09 ^d	6.88±0.81 ^a	10.83±0.58 ^a
G	68.70±0.10 ^a	5.18±0.81 ^c	9.48±0.60 ^b
LSLG	66.44±2.08 ^b	7.44±0.21 ^a	11.03±0.15 ^a
LSHG	66.90±0.73 ^{ab}	5.75±0.49 ^{bc}	10.26±0.67 ^{ab}
HSLG	60.14±1.26 ^d	6.54±1.17 ^{ab}	10.10±0.17 ^{ab}
HSHG	64.12±1.60 ^c	4.73±0.12 ^c	8.10±1.01 ^c

¹⁾ Mean ± S.D. of three replicates.

²⁾ C; control, S; salt, G; GdL, LSLG; low salt low GdL, LSHG, low salt high GdL, HSLG; high salt low GdL, HSHG; high salt high GdL.

^{a-d} Means with different superscripts in the same column are significantly different (p<0.05).

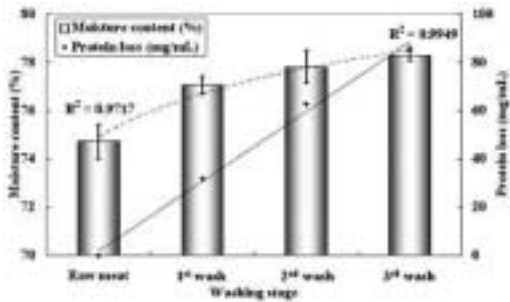


Fig. 1. Changes in moisture content and protein loss during washing process of raw meat.

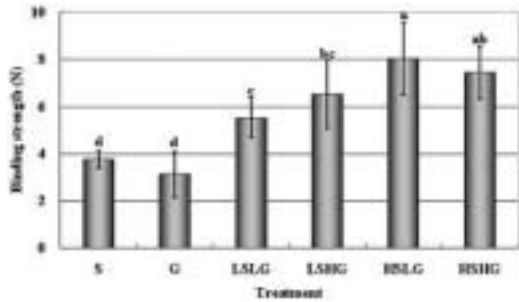


Fig. 2. Effects of NaCl and glucono- -lactone level on binding strength of restructured pork washed and pressurized at 200 MPa.

^{a-d} Means with different superscripts in the same column are significantly different ($p < 0.05$).

myofibrillar

myofibrillar
sarcoplasmic

GdL 가가

Fig. 2

carrageenan 가 ,
GdL 가 (C) 200
MPa 가 가

NaCl GdL 가

가

GdL 가 (G) 가

G

3.13 N(159.69 g/ cm²)

Kuraishi

(1997)

가

80 g/cm²

0.5% , 0.5% GdL 1%
carrageenan 가 200
MPa 30 ,

1.72 N ,

4.22 N 가

가 , washing

myofibrillar

GdL

가

acid-induced

GdL

가

가가 GdL

1.5%

GdL 가

, HSHG HSLG

($p > 0.05$).

Medynski (2000)

lactic acid 가 cold-
 가 0.5% 가 set binding
 lactic acid 가 pH 가 (Hong et al., 2006),
 , pH TGase(Kuraishi et al., 1997)
 , myofibrillar hydrocolloid(Boles and Shand, 1998)
 가 가 가
 carrageenan cold-set binding
 가 (Gray carrageenan 가
 and Crackel, 1992). , 가 가
 Macfarlane (1984) myofibrillar
 가 patty 가
 가 myofibrillar , GdL 가
 peak force pH 가
 work done 가
 가 , (Ngapo et al., 1996).

Table 3. Correlation coefficients between treated and measured variables¹⁾ of restructured pork

	NaCl	GdL	pH	BS	WHC	L*	a*
GdL	-0.0909						
pH	0.1981	-0.9648***					
BS	0.6632***	0.2583	-0.2353				
WHC	0.3529	0.8682*	0.9221**	0.0747			
L*	-0.7330***	0.5259**	-0.6969	-0.3203	-0.6998		
a*	-0.0923	-0.6403***	0.8424*	-0.0987	0.9107*	-0.3677	
b*	-0.3069	-0.5823**	0.7453	-0.3123	0.7049	-0.1510	0.9081*

¹⁾ GdL, Glucono- -lactone; BS, Binding strength; WHC, Water holding capacity.

* Significant at 0.05 level.

** Significant at 0.01 level.

*** Significant at 0.001 level.

GdL 2 가
 가 , GdL 가(HSHG)
 가
 GdL
 (Table
 3). 가
 0.6632
 ($p < 0.001$), GdL
 가 ($p >$
 0.05).
 가 가
 , GdL 가
 가
 가
 pH , 가
 GdL 가
 가
 pH
 HSHG 70.26% ($p < 0.05$). Fig.
 71.23% 가
 3 GdL 가
 가
 가
 ($p < 0.05$), 1% GdL 가
 가
 ($p < 0.05$).
 GdL 가

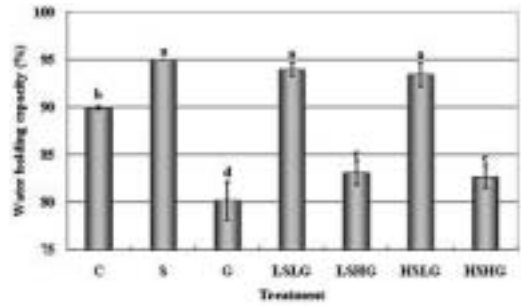


Fig. 3. Effects of NaCl and glucono- -lactone level on water holding capacity of restructured pork washed and pressurized at 200 MPa.
^{a-d} Means with different superscripts in the same column are significantly different ($p < 0.05$).

가 GdL
 (G)
 ($p < 0.05$).
 가
 ($p > 0.05$), GdL 가
 ($p < 0.05$).
 pH
 ($p < 0.01$).
 가 (S) pH 5.91 가
 , GdL 가 가 pH
 HSHG 4.91
 가 pH (Fig. 4).
 가 pH
 (Puolanne et al., 2001),
 가 (S) pH
 가
 pH 가

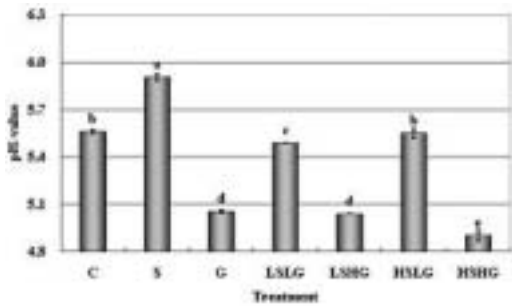


Fig. 4. Effects of NaCl and glucono- -lactone level on pH value of restructured pork washed and pressurized at 200 MPa.

^{a-e} Means with different superscripts in the same column are significantly different ($p < 0.05$).

myofibrillar pH
 (Pearson and Gillett, 1996).
 1% GdL
 pH
 가 , 가 carrageenan
 가 80%
 , 0.5% GdL
 가 ,

GdL (p<0.001)
 , GdL 가
 pH
 가

GdL 가가
 Table 2
 가 S
 L* (p<0.05), a* b*

pH myofibrillar
 가 CI?
 screen
 (King and Macfarlane, 1987).
 가
 GdL 가
 pH
 pH



가
 (p>0.05). GdL(G) L*
 가 , a*
 (p<0.05). GdL
 , 가
 (LSHG HSLG) 가 (S
 G)
 (p>0.05), 가
 (HSHG), a*
 b* (p<0.05). Baublits
 (2006) 가 가
 가 가 retention 가
 , Faustman
 Cassens(1990) retention GdL 가가 가
 .
 Ngapo (1996) GdL 가
 , GdL

가 가
 . GdL 가
 L a*
 b* GdL
 가 GdL 가가
 (Table 3). GdL
 가(HSHG)
 ,
 가 (LSLG)
 .
 GdL 가가 가
 . GdL
 가 , 가
 GdL 가
 . GdL 가
 가 ,
 GdL 가
 .
 가
 .
 GdL
 , 가
 carrageenan



1. AOAC (1990) Official Methods of Analysis. 15th ed., Association of Official Analytical Chemists, Washington D.C.
2. Baublits, R. T., Pohlman, F. W., Brown Jr., A. H., Yancey, E. J., and Johnson, Z. B. (2006) Impact of muscle type and sodium chloride concentration on the quality, sensory, and instrumental color characteristics of solution enhanced whole-muscle beef. *Meat Sci.* 72, 704-712.
3. Boles, J. A. and Shand, P. J. (1998) Effect of comminution method and raw binder system in restructured beef. *Meat Sci.* 49, 297-307.
4. Chen, C. M. and Trout, G. R. (1991) Sensory, instrumental texture profile and cooking properties of restructured beef steaks made with various binders. *J. Food Sci.* 56, 1457- 1460.
5. Clarke, A. D., Sofos, J. N., and Schmidt, G. R. (1988) Effect of algin/calcium binder levels on various characteristics of structured beef. *J. Food Sci.* 53, 711-713, 726.
6. Faustman, C. and Cassens, R. G. (1990) The biological basis for discoloration in fresh meat: a review. *J. Muscle Food.* 1, 217-243.
7. Gornall, A. G., Bardawill, C. Y., and David, M. M. (1949) Determination of serum proteins by means of the biuret reaction. *J. Biol. Chem.* 177, 751-756.
8. Gray, J. I. and Crackel, R. L. (1992) Oxidative flavour changes in meats: Their origin and preservation. In *The chemistry of muscle-based foods*, Johnston, D. E., Knight, M. K., and Ledward, D. A. (eds.), Royal Society of Chemistry, Cambridge, pp. 145-168.
9. Gray, J. I. and Pearson, A. M. (1987) Rancidity and warmed-over flavor. In *Advances in meat research*, Pearson, A. M. and Dutson, T. R.(eds.), Van Nostrand Reinhold, N.Y. Vol. 3, pp. 221-269.
10. Hong, G. P., Park, S. H., Kim, J. Y., and Min, S. G. (2006) The effects of high pressure and various binders on the physico-chemical properties of restructured pork meat. *Asian-Aust. J. Anim. Sci.* 19 (In printing).
11. Hunt, M. C. and Kropf, D. H. (1987) Color and appearance. In *Advances in meat research*, Pearson, A. M. and Dutson, T. R.(eds.), Van Nostrand Reinhold, N.Y. Vol. 3, pp. 125-159.
12. Hur, S. J., Kang, G. H., Yang, H. S., Jeong, J. Y., Park, G. B., and Joo, S. T. (2004) Evaluation of un-cooked restructured belly and cooked restructured bacon using a protein-emulsion material from

pork. Korean J. Food Sci. Ani. Resour. 24, 146-150.

13. King, N. L. and Macfarlane, J. J. (1987) Muscle proteins. In Advances in meat research, Pearson, A. M. and Dutson, T. R.(eds.), Van Nostrand Reinhold, N.Y. Vol. 3, pp. 21-72.

14. Kuraishi, C., Sakamoto, J., Yamazaki, K., Susa, Y., Kuhara, C., and Soeda, T. (1997) Production of restructured meat using microbial transglutaminase without salt or cooking. J. Food Sci. 62, 488-490, 515.

15. Lee, H. C. and Chin, K. B. (2004) Reduction of tumbling time and improvement of shear value for the manufacture of restructured hams using transglutaminase. Korean J. Food Sci. Ani. Resour. 24, 23-28.

16. Lee, M. H. (1984) Restructured meats technology. Food Sci. 17, 28-32.

17. Lee, M. H., Chung, M. S., and Jin, S. K. (1987) Effect of the addition of non-meat proteins on the quality of the restructured pork product. Korean J. Food Sci. Technol. 19, 257-262.

18. Lin, T. M. and Park, J. W. (1996) Extraction of proteins from pacific whiting mince at various washing conditions. J. Food Sci. 61, 432-438.

19. Lullien-Pellerin, V. and Balny, C. (2002) High-pressure as a tool to study some proteins ' properties: conformational modification, activity and oligomeric dissociation. Inn. Food Sci. Emerg. Technol. 3, 209-221.

20. Macfarlane, J. J., McKenzie, I. J. and Turner, R. H. (1984) Binding of comminuted meat: Effect of high pressure. Meat Sci. 10, 307-320.

21. Mackie, I. M. (1992) Surimi from fish. In The chemistry of muscle-based foods, Johnston, D. E., Knight, M. K., and Ledward, D. A. (eds.), Royal Society of Chemistry, Cambridge, pp. 207-221.

22. Means, W. J. and Schmidt, G. R. (1986) Algin/calcium gel as a raw and cooked binder in structured beef steaks. J. Food Sci. 51, 60-64.

23. Medy?ski, A., Pospiech, E., and Kniat, R. (2000) Effect of various concentrations of lactic acid and sodium chloride on selected physico-chemical meat traits. Meat Sci. 55, 285-290.

24. Montero, P., Hurtado, J. L., and Perez-Mateos, M. (2000) Microstructural behaviour and gelling characteristics of myosystem protein gels interacting with hydrocolloids. Food Hydrocolloid. 14, 455-461.

25. Montero, P., Fernandez-Diaz, M. D., and Gomez-Guillen, M. C. (2002) Characterization of gelatin gels induced by high pressure. Food Hydrocolloid. 16, 197-205.

26. Mueller, W. and Chin, K. B. (2003) Characterization of restructured meat products manufactured with PSE pork hams as compared to those with normal pork counterparts. *Korean J. Food Sci. Ani. Resour.* 23, 321-326.
27. Ngapo, T. M., Wilkinson, B. H. P., and Chong, R. (1996) 1,5-Glucono- -lactone-induced gelation of myofibrillar protein at chilled temperatures. *Meat Sci.* 42, 3-13.
28. Nielsen, G. S., Petersen, B. R., and Moller, A. J. (1995) Impact of salt, phosphate and temperature on the effect of a transglutaminase (F XIIIa) on the texture of restructured meat. *Meat Sci.* 41, 293-299.
29. Park, J. W. and Morrissey, M. T. (2000) Manufacturing of surimi from light muscle fish. In *Surimi and surimi seafood*, Park, J. W. (ed.), Marcel Dekker, N. Y. pp. 23-58.
30. Pearson, A. M. and Gillett, T. A. (1996) Sausage formulations. In *Processed meats*, 3rd ed., An Aspen Publication, Maryland, pp. 242-290.
31. Perez-Mateos, M. and Montero, P. (2000) Contribution of hydrocolloids to gelling properties of blue whiting muscle. *Eur. Food Res. Technol.* 210, 383-390.
32. Pietrasik, Z. and Shand, P. J. (2004) Effect of blade tenderization and tumbling time on the processing characteristics and tenderness of injected cooked roast beef. *Meat Sci.* 66, 871-879.
33. Puolanne, E. J., Ruusunen, M. H., and Vainionpaa, J. I. (2001) Combined effects of NaCl and raw meat pH on water-holding in cooked sausage with and without added phosphate. *Meat Sci.* 58, 1-7.
34. Sheard, P. (2002) Processing and quality control of restructured meat. In *Meat processing: improving quality*, Kerry, J., Kerry, J., and Ledward, D. (eds.), CRC press, F. L., pp. 332-358.
35. Song, K. W. (1987) Restructured meats. *Korean J. Food Sci. Ani. Resour.* 8, 15-2