HIGH PRESSURE PROCESSING IMPROVES THE EATING QUALITY OF SAUSAGE WITH REDUCED FAT

Huijuan Yang, Haibo Zheng, Xinglian Xu and Guanghong Zhou*

Synergetic Innovative Center of Food Safety and Nutrition, College of Food Science and Technology, Nanjing Agricultural University, Nanjing 210095, PR China

*ghzhou@njau.edu.cn

Abstract – This study investigated the role of high pressure processing (HPP) for enhancing the textural properties of sausages with reduced-fat and no fat replacement. Sausage emulsions were prepared with levels of fat contents from zero to 30%. Experiments were carried out to investigate the effect of 200 MPa HPP on cooking loss, shear force and the state of water by low field nuclear magnetic resonance (LF-NMR). Cooking loss were significantly reduced (P < 0.05) by HPP. Textural tests showed that sausages were exhibited better sensory properties at all levels of fat content treated at 200 MPa than control, and shear force of sausages treated at 200 MPa with 20% fat content were similar to the 30% original fat content. LF-NMR suggested that HPP significantly changed (P < 0.05) the P_2 peak ratio of the three water component. These findings show that HPP has potential in transforming the free water (P_{22}) to immobilized water (P_{21}), resulting in reduced cooking loss and improved textural properties of emulsion-type sausages with reduced-fat content.

Ⅰ. INTRODUCTION

High pressure processing (HPP), is a relatively new non-thermal food treatment that can have beneficial effects on the shelf life and quality of many products (1). With consumers' growing awareness of a link between diet and health, HPP used in meat products with low fat content achieved its aim mainly by stabilizing substantial of water and fats in a gel-like matrix, resulting in some properties similar to those observed at higher fat levels (2). As 200 MPa HPP appears to be optimal for many functionality attributes, this pressure was selected for determining the optimal minimum fat content in the range 0 to 30% (3). The main objectives of this study were to investigate the effects of HPP on eating properties of sausage formulations with low fat content.

Ⅱ. MATERIALS AND METHODS

Pork meat from Su Shi group was trimmed free of connective tissues and excess fat. The preparation procedures for pork sausage batters were as followings: added fat levels were zero, 10, 15, 20 and 30%, protein levels were maintained constant throughout by replacing fat with water. 200 MPa high-pressure processing was carried out in a 0.3 L capacity 850 Mini FoodLab high pressure vessel for 2 min at 10°C. In this work, the raw sausages (with or without HPP) was termed 'batter' and the cooked batters were termed 'sausages'. NMR was tested with meat batters, cooking loss and shear force were tested with sausages.

The data were analyzed using one-way analysis of variance (ANOVA), and means were compared by Duncan's multiple-range test at 5% level.

Ⅲ. RESULTS AND DISCUSSION

The results of cooking loss of the samples treated with and without HPP with increasing fat contents are presented in Fig. 1. The lowest cooking losses of the samples treated with 200 MPa were at 20 and 30% added fat where losses were just 4 to 5%. These results suggested that the application of 200 MPa pressure with samples containing 15-20% could have beneficial effects for reducing cooking loss. In conclusion, the small but significant (*P* < 0.05) improvements in yields of emulsion sausages with lower fat contents found here with the application of HPP is an important outcome of this study. In this work, treatment of the samples at 200 MPa is likely to dissociate of oligomeric structures into subunits states and partially unfolded and denatured monomeric structures, as reported by Bajovic et al. (4). A similar effect has been reported for HPP (200 MPa) of low-fat (4-7%) beef sausage batters where cooking losses were less than 10% compared with 30% for control (5). Recently, a similar beneficial effect of HPP on reducing cooking loss has been reported for intact beef steak (6).

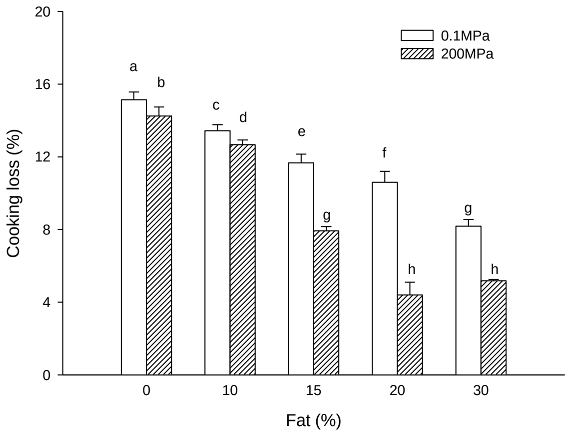

Fig. 1. Changes in cooking losses of pork sausage containing various fat levels in samples subjected to 0.1 or 200 MPa pressure for 2 min at 10°C.

Shear force significantly decreased (*P* < 0.05) with increasing fat levels both in 200 MPa treated samples and control samples in Fig. 2. Further, there was no significant difference (*P* > 0.05) between the 20% fat content samples and 30% fat content samples subjected to 200 MPa for 2 min at 10°C. The reduction in shear force was probably due to partially protein structure modification, with unfolding and subsequent folding. Various researches investigated the effect of high pressure on textural properties, and the relationship between water binding and texture properties, especially at 200 MPa, results showed that proper high pressure processing caused depolymerization, solubilization, denaturation and aggregation in myofibrillar (7-8).

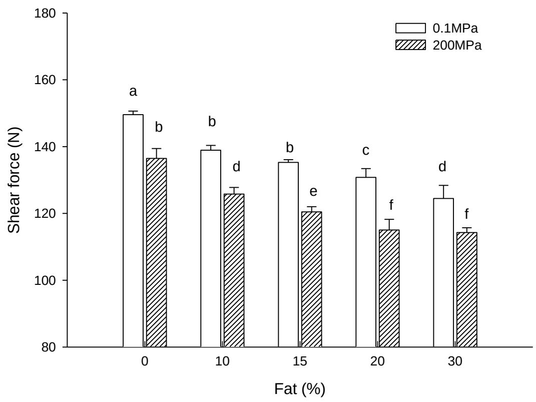

Fig. 2. Changes in shear force of pork sausage having various fat levels when subjected to pressures of 0.1 and 200 MPa for 2 min at 10 °C before cooking.

The LF-NMR T_2 relaxation curves for batter samples exhibited a multi-exponential distribution with four distinct water populations in Tab. 1. T_{2b1} and T_{2b2} were protein-associated water, T_{21} was immobilized water, T_{22} was free water (9-11). T_{21}, as the relaxation time of the predominant water component, decreased its relaxation time from 90.82 to 75.14, and from 64.28 to 53.87, respectively at control and 200 MPa treated samples with increasing fat levels.

Tab.1. LF-NMR parameters of meat batters with low fat after treatment at 0.1 or 200 MPa at 10℃ for 2 min.

Fat %	T2 relaxation times (ms) T_{2b}	T_{21}	T_{22}
	Pressure 0.1 MPa		
0	3.19±0.42^{a}	78.61±4.42^{a}	350.79±5.76^{bc}
10	2.57±0.14^{bc}	70.73±4.41^{b}	351.12±0^{bc}
15	2.17±0.34^{bc}	69.20±3.37^{b}	383.92±25.95^{a}
20	2.16±0.46^{bc}	63.90±2.72^{c}	389.10±20.65^{a}
30	2.01±0.77^{c}	52.58±7.20^{d}	392.02±20.84^{a}
	Pressure 200 MPa		
0	3.54±0.44^{a}	82.52±1.51^{a}	337.19±17.27^{c}
10	3.27±0.47^{a}	70.67±1.86^{b}	351.48±30.02^{bc}
15	3.21±0.21^{a}	65.75±1.74^{c}	367.25±22.08^{ab}
20	2.39±0.28^{bc}	49.10±4.41^{d}	375.13±24.43^{ab}
30	2.62±0.44^{b}	54.18±3.50^{d}	372.51±17.04^{ab}

Fat %	Proton compartment sizes (%) P_{2b}	P_{21}	P_{22}
	Pressure 0.1 MPa		
0	0.63±0.12^{g}	74.60±3.41^{f}	24.78±3.5^{a}
10	0.78±0.24^{fg}	78.37±2.01^{e}	20.86±2.07^{b}
15	0.94±0.22^{def}	81.35±2.98^{de}	17.73±3.12^{c}
20	1.15±0.21^{abcd}	83.80±1.35^{bcd}	14.99±1.42^{cde}
30	1.22±0.16^{abc}	88.58±4.02^{a}	10.29±0.21^{f}
	Pressure 200 MPa		
0	0.93±0.12^{ef}	78.01±2.27^{e}	21.07±2.35^{b}
10	1.03±0.03^{cde}	83.35±0.55^{cd}	15.63±0.55^{cd}
15	1.28±0.12^{ab}	86.20±0.98^{abc}	12.53±1.03def
20	1.33±0.18^{a}	86.82±3.58^{ab}	11.87±3.73^{ef}
30	1.09±0.07^{bcde}	85.14±1.36^{bc}	13.79±1.38^{de}

Further, the 200 MPa treated samples were shorter in relaxation time compared with the control samples. This revealed that HHP and increasing fat content both resulted in a fast relaxation rate for T_{21}, indicating that both 200 MPa HPP and increasing fat contents could lead to an increase in relaxation time, resulting in a migration of water from the loosely bound water (T_{22}) to a more tightly bound water (T_{21}).Compared with the control, pressure at 200 MPa for 2 min at 10°C caused a significant increase ($P < 0.05$) in all fat levels. Further, addition of fat from zero to 20% significantly ($P < 0.05$) increased water population P_{2b1}, P_{2b} and P_{21} in samples treated with 200 MPa, but further additions to 30% fat showed no further improvement ($P > 0.05$). These results suggested that the application of 200 MPa pressure with samples containing 15-20% could have beneficial effects for reducing extra-myofibrillar water to increase bound water and myofibrillar water, resulting in altered cooking loss and textural properties.

IV. CONCLUSION

This study investigated the application of HPP (200 MPa) at 10 °C for 2 min to improve textural properties of pork emulsion sausages with reduced-fat content. The application of HPP in sausage emulsions with low fat content exhibited reduced cooking loss and shear force, as well as altered water distribution than control samples at all fat levels, with a large improvement for the samples having 15% and 20% added fat. These results indicated the suitability of HPP for production of emulsion sausages having low fat content, with reduced cooking loss and improved textural properties.

ACKNOWLEDGMENTS

This work was financed by the National Science and Technology Support Program (2013BAD28B03) and the Three New Agricultural Project of Jiangsu Province (SX(2011)146).

REFERRENCES

1. Aymerich, T., Picouet, P. A., & Monfort, J. M. (2008). Decontamination technologies

for meat products. Meat Science, 78(1–2): 114-129.

2. Ashie, I. N. A. & Lanier, T. C. (1999). High pressure effects on gelation of surimi and turkey breast muscle enhanced by microbial transglutaminase. Journal of Food Science, 64(4): 704-708.
3. Villamonte, G., Simonin, H., Duranton, F., Cheret, R. & Lamballerie, M. D. (2013). Functionality of pork meat proteins: Impact of sodium chloride and phosphates under high-pressure processing. Innovative Food Science and Emerging Technologies, 18: 15-23.
4. Bajovic, B., Bolumar, T. & Heinz, V. (2012). Quality considerations with high pressure processing of fresh and value added meat products. Meat Science, 92(3): 280–289.
5. Sikes, A. L., Tobin, A. B. & Tume, R. K. Use of high pressure to reduce cook loss and improve texture of low-salt beef sausage batters (2009). Innovative Food Science & Emerging Technologies, 10(4): 405-412.
6. Sikes, A. L. & Tume, R. K. (2014). Effect of processing temperature on tenderness, colour and yield of beef steaks subjected to high-hydrostatic pressure. Meat Science, In press.
7. Bajovic, B., Bolumar, T. & Heinz, V. (2012). Quality considerations with high pressure processing of fresh and value added meat products. Meat Science 92: 280–289.
8. Bak, K. H., Thulstrup, P. W. & Orlien, V. (2014). Spectroscopic studies on the effect of high pressure treatment on the soluble protein fraction of porcine longissimus dorsi. Food Chemistry 148: 120-123.
9. Bertram, H. C., Whittaker, A.K., Shorthose, W. R., Andersen, H. J. & Karlsson, A. H. (2004). Water characteristics in cooked beef as influenced by ageing and high-pressure treatment—an NMR micro imaging study. Meat Science 66: 301–306.
10. Pearce, K. L., Rosenvold, K., Andersen, H. J., & Hopkins, D. L. (2011). Water distribution and mobility in meat during the conversion of muscle to meat and aging and the impacts on fresh meat quality attributes-A review. Meat Science, 89(2): 111-124.
11. Sorland, G. H., Larsen, P. M., Lundby, F., Rudi, A. P., & Guiheneuf, T. (2004). Determination of total fat and moisture content in meat using low field NMR. Meat Science, 66(3): 543-550.