Effect of Pressure on Quality, Protein Functionality, and Microbiological Properties of Honey Garlic Pork Chops

H. Wang[1], J. Yao[1] and M. Gänzle [2]

[1]Food Processing Development Centre, Food and Bio Processing Division, Alberta Agriculture and Rural Development, Leduc, AB, T9E 7C5, Canada

[2]Department of Agricultural, Food and Nutritional Science, University of Alberta, 410 Agriculture/Forestry Centre, Edmonton, AB T6G 2P5, Canada

Abstract – The effects of pressure on quality and shelf life extension of marinated pork chops was studied. Pork chops without further treatment was served as fresh. The remaining pork chops were tumbled with honey garlic marinade, individually vacuum packaged and subjected to high pressure processing (HPP) at control, 350, 400, 450, 500, 550 or 600 MPa for 3 min. Pork quality, and protein functionality were evaluated. Microbiological analysis was conducted at up to 86 days of storage at 2 °C.

Honey garlic marinade partially masked the meat discolouration due to HPP. Honey garlic pork chops treated with HPP had higher water binding capacity than control and fresh pork chops. The fresh samples had higher expressible moisture compared to control and 350 MPa treated pork chops. Control pork chops had a lower cook loss compared to other treatments except for the samples treated with 400MPa. Marination improved the tenderness of the pork chops. HPP did not affect the tenderness of marinated samples. Microbiological results showed that pork chops treated with 450 MPa/3min had shelf life up to 31 days. In conclusion, HPP at 400 – 450 MPa/3min extends the shelf life with minimal effect on the quality of marinated pork.

Key Words – HPP, marination, shelf life extension.

I. INTRODUCTION

The growing demand by consumers for safe, natural, minimally processed and convenient food products has stimulated food industry interest in high pressure processing (HPP). HPP is a cold pasteurization technique which consists of subjecting food, previously sealed in a flexible and water-resistant packaging, to a high level of hydrostatic pressure (pressure transmitted by water) up to 600 MPa for several minutes. HPP is a commercially available process and is becoming a promising approach for extending the shelf life of food (1). Generally speaking, application of high pressure at low or moderate temperatures causes the inactivation of vegetative microbial cells, without markedly altering the taste and flavour of cooked foods. Pressure effects on the structure, texture, colour and lipid oxidation of foods are more marked and variable, being beneficial in some cases and detrimental in others (2). Fresh muscle foods are susceptible to pressure-induced colour change which has limited the adoption of HPP for raw meat applications (3). Marinating is commonly used by the meat industry to enhance moisture and improve the texture of meat products (4). Colour imparted by the marinade may partially mask undesirable discoloration caused by the HPP treatment. The objective of the study was to determine the effects of hydrostatic pressure treatments (up to 600 MPa/3min) on quality, protein functionality, microbiological properties and shelf life of marinated pork chops.

II. MATERIALS AND METHODS

Each fresh pork loin (*m. longissimus dorsi*) muscle was cut into eight 2 cm thick pork chops and one treatment was reserved as fresh pork chop. The remaining seven treatments were arranged for marination processing. After tumbling for 15 min with honey garlic marinade (Griffith Laboratories Ltd. ON, Canada) in DVTS R2-50 Tumbler (Daniels Food Equipment, MN, USA) and marinating overnight in a 2°C cooler, pork chops were individually vacuum packaged in HPP approved nylon/ethylene vinyl alcohol pouches by a R126 Multivac Rollstock Thermoformer (Multivac Group, ON, Canada). Packaged samples were immediately subjected to HPP at 350, 400, 450, 500, 550 or 600 MPa for 3 min at 8°C in a Hiperbaric 135 HPP unit (Hiperbaric España, Burgos, Spain). One treatment after marination and packaging was not subjected to HPP and served as control. As shown in Fig. 1, in order to minimize the possible biological variations between animals and within the same muscle, all treatments were applied to each muscle with location within muscle balanced to ensure that all treatments were assigned to all locations. There were eight replications for each treatment. Instrumental colour was measured on the surface of the pork chops after each treatment by using a Minolta handheld spectrophotometer (Minolta CM-2500C, Osaka, Japan) and expressed as CIE L^* (lightness), a^* (redness) and b^* (yellowness) values according to the method described in the literature (5). The pH, thaw loss, water binding capacity (WBC) (5), expressible moisture (EM) (4), cook loss (4), total protein solubility and sarcoplasmic protein solubility (6) and Warner-Bratzler shear force (WBSF) (4) were measured according to the methods in the literature cited. Data were subjected to analysis of variance using the General Linear Model procedure of SAS. The Tukey test was used to compare the differences ($p \leq 0.05$) between the treatments.

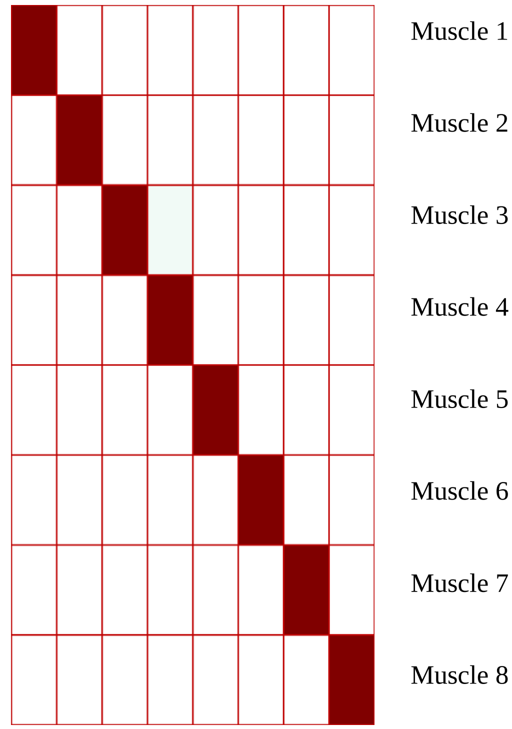

Figure 1. Pork chop was arranged to minimize the possible biological variations between animals and within the same muscle. The filled rectangles (pork chops) represent one treatment. The steaks were cut from 8 different loin muscles and 8 different locations in the muscle.

Microbiological testing was conducted on the duplicate samples after 7, 21, 31, 49, 70, 86 days of storage in the 2 °C cooler. Aerobic colony count, lactic acid bacteria, yeast, mold, coliforms, *E. coli, Listeria monocytogenes,* and *Salmonella spp.* were enumerated according to Health Canada protocols (7).

III. RESULTS AND DISCUSSION

HPP marinated pork chops and control pork chops, in the package, had similar L^* value. However, they were all paler (higher L^*) than the fresh pork chop due to marinades and/or HPP. There were no significant differences among marinated samples on a^* (redness) and b^* (yellowness) values except that control samples had the lower a^* and b^* values. As shown in Fig. 2, the honey garlic marinade partially masked meat discolouration due to HPP.

Figure 2. Packaged pork chops subjected to the 8 treatments

The pH of marinated pork chops treated with 450, 500, 550 and 600 MPa/3min was significantly (p < 0.05) higher than the control pork chops. HPP cause a slight increase of the meat pH (2). Our results showed that HPP may also increase the pH in marinated pork. The pH of the seven marinated pork chops was 0.2-0.3 units higher than the fresh steaks, likely due to the marinade. The thaw loss was the highest for 600 MPa/3min treated pork chops with a value of 4.8%. Samples treated with 400MPa/3min had the lowest thaw loss at 2.5%. Surprisingly, HPP marinated pork chops had a higher water binding capacity than the fresh and control samples. Pork treated with 600 MPa/3min bound 28.8% extra water, as compared to the fresh pork which bound 10.5% of extra water. Similar result was found in marinated beef (8) and may need further investigation. Fresh pork chops had the highest expressible moisture at 18.3%, while control and 350 MPa/3min treated samples had the lowest expressible moisture at 5.8% and 5.5%, respectively. This result is similar to earlier reports on HPP treated marinated beef (8). The control pork chops had a lower cook loss compared to all other treatments except for the samples treated with 400MPa/3min. As shown in Fig. 3, the fresh pork and control pork had the highest total protein solubility at 14.1% and 13.6%, respectively. The marinated pork chops treated with 600 MPa/3min and 550 MPa/3min had the lowest total protein solubility at 5.3% and 5.4%, respectively. The total protein solubility decreases with increasing pressure. This result was in agreement with the literature (9) which reported similar trends for beef.

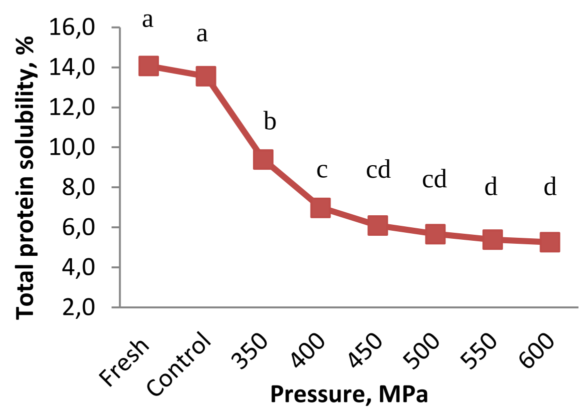

Figure 3. Total protein solubility of pork chops treated with marination and high pressure. Values with different superscripts are significantly different (p < 0.05).

The sarcoplasmic protein solubility had a similar trend as total protein solubility (data not shown). It is generally understood that higher protein solubility corresponds to less protein denaturation.

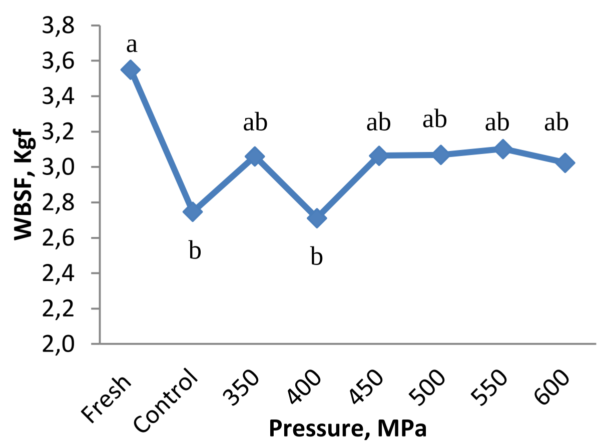

Figure 4. WBSF of the pork chops treated with marination and high pressure. Values with different superscripts are significantly different (p < 0.05).

Figure 4 shows the WBSF of pork chops treated with marination and HPP. The control and 400MPa/3min treated samples had the lowest WBSF value at 2.75 and 2.70 kgf, respectively, while fresh pork chops had the highest WBSF value at 3.55 kgf. Marination can improve the tenderness of the pork chops. HPP did not affect the tenderness of the marinated pork chops.

Pathogens (*E, coli*, *Listeria monocytogenes*, *Salmonella spp.*) were below the detection limit in all pork chop samples. The level of coliforms in 350 MPa/3min treated honey garlic pork chops remained at 2 – 3 log10 (CFU/g) throughout the storage period, however, coliforms, yeast and mold were not detected (limit of detection: 0.17 log 10 CFU/g) in the samples treated with 400 MPa/3min or higher at any storage days tested. After 31 days of refrigerated storage, the aerobic colony count reached log 5 log 10 CFU/g, while lactic acid bacteria remained below the limit of detection (1.7 log 10 CFU/g). Microbiological results showed that HPP can significantly extend shelf life of marinated pork chops from 10 days to 31 days with pressure at 450 MPa/3min or higher.

IV. CONCLUSION

HPP can extend shelf life of honey garlic pork chops with pressure ranging from 400 - 450 MPa/3min with minimal effect on meat quality.

ACKNOWLEDGEMENTS

Financial support for this study by the Alberta Livestock and Meat Agency (ALMA), Beef Cattle Research Council (BCRC) and Freybe Gourmet Foods Ltd are gratefully acknowledged. Thanks are expressed to personnel from the Food Processing Development Centre A. Worobec and B. Marshall for meat processing and instrumental analyses. Microbiological analysis was performed by Agri-Food Laboratories Branch, Alberta Agriculture and Rural Development.

REFERENCES

1. Grant, S., Patterson, M., and Ledward, D. A. (2000). Food processing gets freshly squeezed. Chemistry and Industry 24: 55-58.
2. Cheftel, J. C., and Culioli, J. (1997). Effects of high-pressure on meat: A review. Meat Science 46: 211-236.
3. Ma, H., Ledward, D. A., Zamri, A. I., Frazier, R. A., and Zhou, G. H. (2007). Effects of high pressure/thermal treatment on lipid oxidation in beef and chicken muscle. Food Chemistry 104: 1575-1579.
4. 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 Science 66: 871-879.
5. Wang, H., Pato, M. D., and Shand, P. J. (2005). Biochemical properties of natural actomyosin extracted from normal and pale, soft and exudative pork loin after frozen storage. Journal of Food Science 70: C313-320.
6. Farouk, M. M., and Swan, J. E. (1998). Effect of rigor temperature and frozen storage on functional properties of hot-boned manufacturing beef. Meat Science 49: 233–247.
7. Health Canada. (2014). HPB methods for the microbiological analysis of foods. Available from: http://www.hc-sc.gc.ca/fn-an/res-rech/analy-meth/microbio/volume2-eng.php
8. Wang, H., Yao, J., Erin, K. and Gänzle, M. 2015. Effect of pressure on quality and shelf life of marinated beef semitendinosus steaks (Abstract). In: Abstracts from the Canadian Meat Council's 94th Annual Conference, May 7-9, 2014, Toronto, Ontario, Canada. Meat Science 99: 148.
9. Marcos, B., and Mullen, A. M. (2014). High pressure induced changes in beef muscle proteome: correlation with quality parameters. Meat Science 97: 11-20.