Monitoring beef quality attributes as affected by high pressure processing

R. McArdle[1*], B. Marcos[1], D.J. Troy[1] J.P. Kerry[2] & A.Mullen[1]
[1]Ashtown Food Research Centre, Teagasc, Ashtown, Dublin 15, Ireland.
[2]Department of Food and Nutritional Sciences, University College Cork, Cork, Ireland.
*Email: ruth.mcardle@teagasc.ie.

Abstract

High pressure processing (HPP) is becoming of increasing importance in the food industry as it offers the opportunity to obtain minimally processed food products with increased safety and extended shelf-life. A sound knowledge of the effects of high pressure on meat attributes is necessary for a successful implementation of HPP in the meat industry. The aim of this work was to determine the effects of combined pressure and temperature treatments on meat. Beef M. pectoralis profundus samples were pressurized at 200, 300 and 400 MPa at 20oC and 40oC. Both the degree of pressure and temperature applied had a significant effect on cook loss, oxidation and colour measurements. Cook loss increased at higher levels of pressure. Under pressure conditions, lower cook loss was observed at 40oC compared to 20oC. An increase of TBARS values was observed at the higher pressure levels (300, 400 MPa). Pressurization at 200 MPa produced a lower impact on colour parameters than higher pressurization levels. These results show that mild pressure treatments would minimally affect meat quality parameters, suggesting that HP technology could be applied to raw meat as a pre-treatment for obtaining prepared meals, allowing a reduction of cooking process.

Introduction

In recent years there has been a growing demand among consumers for ready to eat meat products of high sensory and nutritional quality, microbiologically safe and with an extended shelf life (Crehan et al., 2000). This has encouraged research into technologies that provide an alternative to conventional heat processing. One such technology is high pressure processing which improves microbiological quality of food (Cheftel & Culioli, 1997). A sound knowledge of the effects of high pressure on meat attributes is necessary for a successful implementation of HPP in the meat industry. The effect of high pressure treatment on appearance must also be considered. Previous studies have suggested that high pressure treatment of meat may result in colour changes (Serra et al., 2007). Lipid oxidation is a major cause of deterioration in the quality of meat, especially of processed meat products. Several studies have been carried out on various muscle foods to determine critical pressure levels (Ma et al., 2007, Cheah and Ledward., 1996, Beltran et al., 2003, Cruz-Romero et al., 2008). This work investigates the effects of high pressure processing at 20 and 40 ^{o}C on meat quality with particular attention to fat oxidation.

Materials and methods

Meat sampling and high pressure treatment: Post rigor beef *M. pectoralis profundus* muscles were obtained from a local meat plant. Muscles were cut into steaks 2.5cm in thickness. After vacuum packaging, samples were treated with a combination of different levels of pressure and temperature. 200, 300 and 400 MPa of pressure applied at 20^{o}C and 40^{o}C for 20 min using a 1L Stansted high pressure unit (Stansted Fluid Power Ltd., Stansted, UK). Three samples for each pressure / temperature combination were treated. Non treated samples were kept as a control.

pH measurement: pH values were measured using a glass probe (Orion pH meter 250A, Orion Research Inc.) by direct insertion into the meat. Six measurements were made for each sample.

Colour measurements: Internal colour of samples was using the CIE L*a*b* system with a dual beam xenon flash spectrophotometer (Ultra Scan XE, Hunter lab). Three measurements for each treatment were taken for each sample.

Cook loss: Steaks were cooked in a water bath at 72^{o}C, until an internal temperature of 70^{o}C was achieved. Weight was recorded before and after cooking. Cook loss was expressed as the percentage of the weight difference.

Microbiological analysis: Ten g of meat sample were added to 90 ml of maximum recovery diluent and homogenised. After appropriate dilutions Total Viable Counts (TVC) were enumerated by plating on PCA agar (Merck, Darmstadt, Germany) at 30^{o}C for 72 h. Lactic Acid Bacteria (LAB) were enumerated by plating on MRS agar (Oxoid, Basingstoke, Hampshire, England) incubated at 37^{o}C for 24 h; *Enterobacteriaceae* were enumerated by plating on Violet Red Bile Glucose agar (Merck) at 30^{o}C for 24 h. The presence / absence of *Listeria*, *Salmonella* and *Campylobacter* was analysed according to ISO 11290-

1:1996, ISO 6579:2002 and ISO 10272-1:2006 respectively. Vacuum packed samples were stored at 4ºC, samples for microbial counts were taken at day 0, 1 and 7 after HPP.

Measurement of lipid oxidation: TBARS values were measured as an index of lipid oxidation according to the method of Siu and Draper, 1978. The TBARS number is expressed as mg of malondialdehyde (MDA) per kilogram of sample. Two independent extracts from each sample was carried out. Each extract was measured twice.

Statistical analysis: Data were analyzed using the GLM procedure from the SAS statistical package (SAS 9.1 version). The model included temperature, pressure, temperature×pressure interaction, and treatment as fixed effects. Non significant interactions ($p>0.05$) were dropped from the model. Differences were assessed using the Tukey test ($p<0.05$)

Results and discussion

No interaction between pressure and temperature were observed for the cook loss, pH, L* and b* values. Table 1 shows main effects means for these parameters. Under pressure conditions, lower cook loss and b* values were observed at 40^{o}C than at 20^{o}C; while L* values were higher at 40^{o}C (Table 1). The highest pressure levels tested (300, 400 MPa) induced a significant increase of cook loss, pH and L* values ($p<0.05$) than processing at 200 MPa, independently of the temperature of the pressure treatment.

Table 1. Temperature and pressure effects on cook loss, pH and colour values

Treatment		Cook loss (%)	pH	L*	b*
Temperature	20^{o}C	34.15[a]	5.89	45.57[b]	15.81[a]
	40^{o}C	31.32[b]	5.92	47.85[a]	13.79[b]
	SE	0.86	0.01	0.68	0.45
	p	<0.05	NS	<0.05	<0.05
Pressure	200 MPa	28.98[b]	5.79[b]	36.91[b]	13.05[b]
	300 MPa	33.93[a]	5.95[a]	51.06[a]	16.19[a]
	400 MPa	35.29[a]	5.96[a]	52.16[a]	15.17[ab]
	SE	1.05	0.01	0.84	0.55
	p	<0.01	<0.001	<0.001	<0.01

L*=lightness, b*=yellowness. NS: non-significant. Results are mean values of triplicates. SE: standard error. Different letters within a column indicate differences among values.

Table 2 shows the effects of pressure treatments on all studied parameters, results for control (non-treated) meat were included. High pressure processing of samples at 400 & 300 MPa at both temperatures significantly increased TBARS values ($p<0.05$), compared to non-treated (NT) samples. On the contrary, HPP at the lower pressure level, 200MPa, had no effect on this index of oxidation (table 2). At 300 MPa, TBARS values increased with increasing temperature, showing an additive effect of pressure and temperature on oxidation levels. Temperature had no effect on TBARS values when pressurizing at 400 MPa. Pressure treatments at 200 MPa had no influence on pH values of meat, while higher pressure levels produced a significant increase of pH values (table 2). HPP also had a significant effect on the colour of samples. In general 200MPa had no effect on colour with the exception of an increase in L* value at 40^{o}C. Both 300 & 400 MPa increased L* values while a* values were decreased at 300 MPa and 40^{o}C. No changes in b* values were observed.

As expected microbial results from time 0 showed an absence of studied pathogens (*Salmonella*, *Listeria and Campylobacter*), and low counts of TVC, 3.6 log CFU/g. During one week of storage at 4^{o}C *Enterobacteriacae* and LAB counts were under the detection limit. At day 7, levels of TVC were 3.9 log CFU/g in NT meat, while all pressurized samples were under the detection limit. These results show improved hygienic quality of pressurized meat during refrigerated storage.

Table 2. Cook loss, pH, colour and TBARS values of pressure- temperature treatments

Treatment		Cook loss (%)	pH	L*	a*	B*	TBARS (mg MDA/ Kg)
Non-treated		29.42[bc]	5.69[b]	31.32[c]	13.33[ab]	13.33[ab]	0.2198 [c]
20°C	200 MPa	29.31[bc]	5.77[ab]	35.51[bc]	14.41[a]	14.84[ab]	0.3966[c]
	300 MPa	36.25[ab]	5.93[a]	50.34[a]	12.74[abc]	17.35[a]	1.0991[b]
	400 MPa	36.89[a]	5.95[a]	50.87[a]	9.93[bc]	15.25[ab]	2.1431[a]
40°C	200 MPa	28.65[c]	5.81[ab]	38.30[b]	10.06[bc]	11.26[b]	0.7900[bc]
	300 MPa	31.61[abc]	5.98[a]	51.79[a]	9.19[c]	15.03[ab]	1.8685[a]
	400 MPa	33.69[abc]	5.98[a]	53.45[a]	9.61[bc]	15.09[ab]	2.0051[a]
	SE	1.47	0.04	1.13	0.75	0.82	0.1176
	p	<0.01	<0.01	<0.001	<0.01	<0.01	<0.001

L*=lightness, a*=redness, b*=yellowness. Results are mean values of triplicates. SE: standard error. Different letters within a column indicate differences among values.

Conclusions

The reported results show that mild pressure treatments (200 MPa) would minimally affect meat quality parameters, while improving meat hygiene. These results suggest that HP technology may be useful as a pre-processing treatment in the production of convenience, prepared meals and hence helping reduce cooking process.

References

Beltran, E., Pla, R., Yuste, J., Mor-Mur, M. (2003). Lipid oxidation of pressurized and cooked chicken: role of sodium chloride and mechanical processing on TBARS and hexanal values. Meat Science, 64, 19-25.

Cheah, P.B. & Ledward, D.A. (1996). High pressure effects on lipid oxidation in minced pork. Meat Science, 43, 2, 123-134.

Cheftel, J.C. & Culioli, J. (1997). Effects of high pressure on meat: A review. Meat Science, 46, 3, 211-236.

Crehan, C.M., Troy, D.J., Buckley, D.J. (2000). Effects of salt level and high hydrostatic pressure processing on frankfurters formulated with 1.5 and 2.5% salt. Meat Science, 55, 123 - 130.

Cruz-Romero, M.C., Kerry, J.P., Kelly, A.L., (2008). Fatty acid, volatile compounds and colour changes in high-pressure-treated oysters *(Crassostrea gigas).* Innovative Food Science & Emerging Technologies, 9, 54-61.

Ma, H.J., Ledward, D.A., Zamri, A.I., Frazier, R.A., Zhou, G.H. (2007). Effects of high pressure/thermal treatment on lipid oxidation in beef and chicken muscle. Food Chemistry, 104, 1575-1579.

Serra, X., Grèbol, N., Guàrdia, M.D., Guerrero, L., Gou, P., Masoliver, P., Gassiot, M., Sárraga, C., Monfort, J.M., Arnau, J. (2007). High pressure applied to frozen ham at different process stages. Effect on the sensory attributes and on the colour characteristics of dry-cured ham. Meat Science 75, 21-28.

Siu, G.M. and Draper, H.H. (1978). A survey of malonaldehyde content of retail meats and fish. J. Food Sci, 43, (4), 1147-1149.