PE4.100 The Influence of High Pressure Processing on the Quality Attributes of Beef 368.00

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***Abstract*— The technology of high pressure applied to food products is currently being used by several companies worldwide to increase the safety of the final product. Though the preservative effects of high pressure processing (HPP) on meat are well established, at sufficiently high pressure meat becomes more susceptible to colour changes and lipid oxidation. The aim of this work was to determine the effects of combined pressure and temperature treatments on meat quality after processing and during storage. Beef *M. pectoralis profundus* samples were pressurised at 400 and 600 MPa at 35, 45 and 55°C. HPP at 600 MPa showed a more pronounced alteration of quality parameters with higher TBARS values, cook loss and WBSF values observed in samples pressurised at 600 MPa compared to those at 400 MPa. However HPP at higher temperatures (55°C) resulted in lower WBSF and cook loss values than processing at 35°C.**

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***Index Terms*—high pressure processing, lipid oxidation, meat quality**

I. INTRODUCTION

In recent years there has been a growing demand among consumers for meat products of high sensory and nutritional quality, microbiologically safe and with an extended shelf life [1]. This has encouraged research into technologies that provide an alternative to conventional heat processing. HPP is gaining in popularity with food processors as it improves the microbiological quality of food while retaining its original freshness and flavour [2]. A sound knowledge of the effects of high pressure on meat quality attributes is necessary for the successful implementation of HPP in the meat industry. Previous studies have suggested that high pressure treatment of meat may result in colour changes [3]. 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 the effect of pressure on individual quality parameters such as colour, lipid oxidation and texture [4, 5, 6, 7, 8]. However, this work investigates the effects of HPP on all quality parameters over an extended storage period.

II. MATERIALS AND METHODS

Meat sampling and high pressure treatment: Bovine *M. pectoralis profundus* muscles were obtained at 2 days *postmortem* from a local meat plant. Muscles were cut into steaks 2.5cm in thickness, vacuum packed and pressures of 400 and 600 MPa were applied at 35, 45 and 55°C for 20 min using a 1L Stansted high pressure unit (Stansted Fluid Power Ltd., Stansted, UK). Conventional cooking was performed in a moisture oven, until a core temperature of 72°C was reached. Non treated (NT) samples were kept as a control. Three replicates of each treatment were obtained.

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

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

Cook loss: Steaks were cooked in a water bath at 72°C, until an internal temperature of 70°C was achieved. Weight was recorded before and after

cooking. Cook loss was expressed as the percentage of the weight difference.

Warner Bratzler Shear Force (WBSF): WBSF was carried out according to the procedure of Wheeler et al. and AMSA [9, 10].

Microbiological analysis: Total Viable Counts (TVC's) were enumerated by plating on PCA agar (Merck, Darmstadt, Germany) and incubated at 30°C for 72 h. Lactic Acid Bacteria (LAB) were enumerated by plating on MRS agar (Oxoid, Basingstoke, Hampshire, England) and incubated at 37°C for 24 h; *Enterobacteriaceae* were enumerated by plating on Violet Red Bile Glucose agar (Merck) and incubated at 30°C for 24 h. The presence of *Listeria, Salmonella* and *Campylobacter* was determined according to ISO 11290-1:1996, ISO 6579:2002 and ISO 10272-1:2006 respectively.

Measurement of lipid oxidation: TBARS values were measured as an index of lipid oxidation according to the method of Siu and Draper [11]. The TBARS number was expressed as mg of malondialdehyde (MDA) per kilogram of sample. Analysis was carried out on two independent extracts from each sample. Each extract was measured twice.

Shelf life study: Vacuum packed samples were stored at 4°C for 30 days. Monitoring of TBARS, colour and microbiology was carried out during the shelf life.

Statistical analysis: Data were analysed 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 ($p<0.05$)

III. RESULTS AND DISCUSSION

Quality measurements after HPP

No interaction ($p>0.05$) between pressure and temperature was observed for cook loss, pH, WBSF, TBARS and colour (L*a*b) parameters. Thus pressure and temperature had an independent effect on these parameters. After pressure treatment no effect of pressure or temperature was observed on colour and pH values.

HPP at 600 MPa showed a more pronounced alteration of quality parameters. Table 1 shows higher cook loss and WBSF values were observed in samples pressurised at 600 MPa compared to those treated at 400 MPa ($p<0.05$). The higher pressure level also resulted in higher TBARS values ($p<0.05$) independently of the temperature treatment. HPP at the higher temperature of 55°C resulted in better quality in terms of cook loss and WBSF than processing at 35°C (Table 1). Although HPP at the higher pressure level of 600 MPa has been shown to increase the toughness of meat these effects could be minimised by HPP at a higher temperature (55°C).

Table 1: Effect of temperature and pressure effects on beef quality attributes.

Treatment		WBSF (N)	Cook loss (%)	*TBARS (mg MDA/Kg)*
Temperature	35°C	73.48^{a}	33.97^{a}	1.22
	45°C	67.76^{ab}	31.10^{ab}	1.30
	55°C	59.97^{b}	30.20^{b}	0.83
	SE	2.48	0.97	0.13
	p	<0.01	<0.05	NS
Pressure	400 MPa	57.60^{b}	29.36^{b}	0.94^{b}
	600 MPa	76.54^{a}	34.15^{a}	1.29^{a}
	SE	2.03	0.01	0.11
	p	<0.001	<0.01	<0.05

Results are mean values of six (temperature) and nine (pressure) replicates. SE: standard error. NS: non significant. Different letters within a column indicate differences among values.

Table 2 shows the results of quality measurements significantly affected by processing of meat. NT samples presented lower L* and higher a* values than all of the processed samples. Other authors have reported increases in L* values HP meat [3, 6, 12]. The increase in L* values or "whitening" effect of pressure was attributed to globin denaturation, heme displacement or release, and ferrous atom oxidation [3, 6]. Goutefongea et al. [12] also attributed the increase in L* values by pressure to a loss of active pigment or to protein coagulation. This affected the structure and surface properties of pressure treated beef and as a result increased the ratio of reflected verses absorbed light. In this study however no differences in colour among the pressurised treatments were observed ($p<0.01$).

Conventionally cooked samples resulted in higher TBARS and pH values ($p<0.001$) than all other treatments. Both processing techniques (HPP and oven cooking) affected meat quality however in the case of TBARS and pH, HPP affected meat quality to a lower extent than oven cooking.

Table 2: Quality measurements after processing of beef samples.

Treatment	TBARS (mg MDA/Kg)	pH	L*	*a**
Non treated	0.273^{d}	5.49^{c}	33.40^{b}	15.88^{a}
35°C, 400 MPa	1.247^{bc}	5.66^{bc}	50.31^{a}	8.25^{b}
35°C, 600 MPa	1.190^{bc}	5.70^{bc}	49.46^{a}	8.97^{b}
45°C, 400 MPa	1.020^{bcd}	5.70^{bc}	51.74^{a}	8.28^{b}
45°C, 600 MPa	1.583^{ab}	5.68^{bc}	51.83^{a}	7.48^{b}
55°C, 400 MPa	0.543^{cd}	5.71^{b}	51.32^{a}	7.69^{b}
55°C, 600 MPa	1.110^{bcd}	5.76^{ab}	53.94^{a}	6.56^{b}
Oven cooked	2.300^{a}	5.93^{a}	51.98^{a}	5.19^{b}
SE	0.179	0.04	1.25	0.91
p	<0.001	<0.001	<0.001	<0.001

Results are mean values of triplicates. SE: standard error. Different letters within a column indicate differences among values.

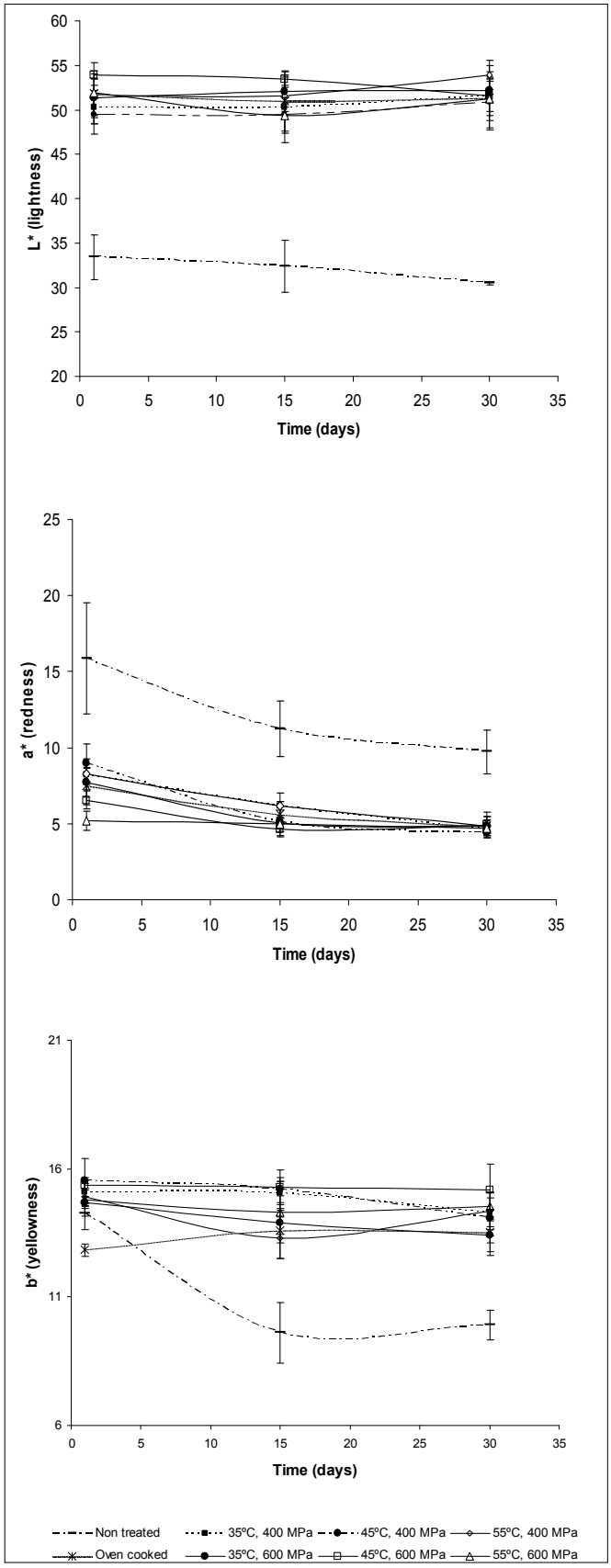
Quality measurements during shelf life

L* remained stable through out storage for all of the studied samples. L* values of NT sample remained lower than processed samples during storage ($p<0.001$) (Fig. 1).

The difference in a* measurements between NT and treated samples were kept during storage. In NT samples a* is higher than all processed samples. All pressurised samples showed a decrease ($p<0.05$) of a* values during storage. Similar results were recorded by Jung et al. [8] who reported a decrease in a* values in HPP beef (520 MPa) after 7 days of storage at 4°C.

Fig. 1 shows an important decrease ($p<0.01$) of b* values was observed during the shelf life of NT beef. While b* values of all treated samples remained stable over storage. From day 15 of storage b* values of NT samples were lower than all processed samples. Similar observations were made by Carlez et al. [3] who reported that b* values of minced beef after HPP (500 MPa) remained constant while b* value for NT samples decreased during storage. This effect has been related to changes in chemical state of myoglobin [3].

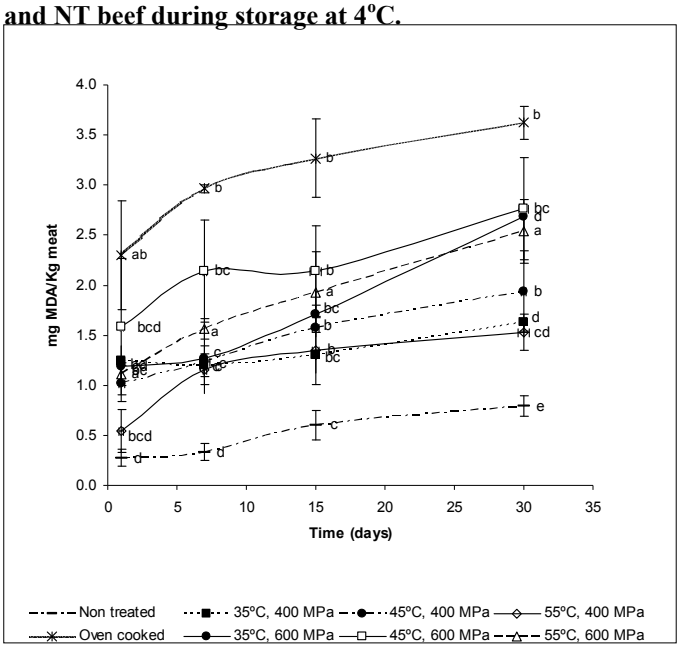
Fig. 1: Monitoring of L*a*b* values of processed and NT beef during storage at 4°C.



Results are mean values of triplicates ± standard deviation.

NT meat showed the lowest lipid oxidation levels ($p<0.001$) compared to all processed samples during storage. Oven cooking induced an increase in oxidation levels when compared to treatments ($p<0.001$). Monitoring of TBARS values during storage revealed an increase of TBARS values with time of storage in all samples studied (Fig. 2).

Fig 4: Monitoring of TBARS values of processed and NT beef during storage at 4°C.



Results are mean values of triplicates ± standard deviation.

Microbial analysis of the samples showed an absence of pathogens (*Listeria, Salmonella* and *Campylobacter*) in all studied samples. After 30 days of storage lower levels of TVCs for all HP treatments were observed ($p<0.05$) when compared to NT samples (3.8×10^5 cfu/g).

IV. CONCLUSION

The reported results show that even though HPP alters meat quality to some extent, it has a lower effect than conventional cooking on colour, pH and lipid oxidation measurements.

Thus, HPP may have potential to be used as a pre-treatment of meat in order to reduce the cooking time and thus quality deterioration.

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REFERENCES

[1] 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.

[2] Torres, J.A. & Velazquez, G. (2005). Commercial opportunities and research challenges in the high pressure processing of foods. Journal of Food Engineering, 67, 95 - 112.

[3] Carlez, A., Veciana-Nogues, T., Cheftel, J.C. (1995). Changes in colour and myoglobin of minced beef meat due to high pressure processing. Lebensmittel-Wissenschaft und Technologie, 28, 528 – 538.

[4] 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.

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

[6] Beltran, E., Pla, R., Capellas, M., Yuste, J., Mor-Mur, M. (2004). Lipid oxidation and colur in pressure- and heat – treated minced chicken thighs. Journal of the Science of Food and Agriculture, 84, 1285-1289.

[7] Jung, S., Ghoul, M., de Lamballerie-Anton, M. (2000) Changes in lysosomal enzyme activities and shear values of high pressure treated meat during ageing. Meat Science, 56, 239 – 246.

[8] Jung, S., Ghoul, M., de Lamballerie-Anton, M. (2003). Influence of high pressure on the colour and microbial quality of beef meat. Lebensmittel-Wissenschaft und Technologie, 36, 625 – 631.

[9] Wheeler, T.L., Shackelford, S.D., and Koohmaraie, M. (1996). Sampling, cooking and coring effects on Warner-Bratzler shear force values in beef. Journal of Animal Science, 74, 1553-1562.

[10] AMSA (1995), Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat.

[11] Siu, G.M. and Draper, H.H. (1978). A survey of malonaldehyde content of retail meats and fish. Journal of. Food Science 43, (4), 1147-1149.

[12] Gontefonga, R., Rampon, V., Nicolas, J., Dumont, J.P. 1995. Meat colour changes under high pressure treatment. Paper presented at 41st Intl. Congress of Meat Science and Technology. San Antonio, Texas. 1995 Aug 19 – 21; Chicago, III.: National Live Stock and Meat Board.