# Influence of High Pressure and Papain Treatment on Some Aspects of Beef Meat Quality

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**Abstract**: Influence of post-rigor injection of papain solution and/or high pressure treatment (100, 200, 300 MPa for 10 min) on the quality of beef meat (*musculus longissimus lumborum et thoracis*) was studied in terms of texture, microbial quality and some physico-chemical parameters (pH, drip loss, water holding capacity). Injection of papain and pressurisation to 100 MPa led to a significant increase of meat tenderness. Application of higher pressures did not lead to further tenderisation. After the 300 MPa pressure treatment the total flora of pressurised compared to untreated samples decreased of 2.5 log cycles.

**Keywords**: papain; pressure; beef; texture

## INTRODUCTION

High pressure technology, defined as a pressure treatment between 100 and 1000 MPa, is of increasing interest to food processing because of its potential to decrease the level of microbial contamination without any heat treatment and the opportunity to produce foods of high sensory and nutritional quality. Industrial high pressure food products are mainly manufactured in Japan (fruit jams and juices, sake, ham, fish and rice products), the USA (oysters and fruit juices), Mexico (fruit juices) and Spain (ham and other meat products) [1].

High pressure meat processing appeared in the 1970s reporting the improvement of pressurised meat tenderness [2]. It has been reported that the pressurisation of *post mortem* beef meat could modify the gelation properties of myofibrillar proteins, the microbiological quality and the texture and ultrastructure of meat. Structural changes due to pressure treatment of meat are very dependent on the *post mortem* time, temperature, pressure and, to a lesser degree, on animal species or on muscle type. If pressure treatment is applied prae rigor there is extensive contraction of four different sheep and beef muscles groups, with 103 MPa causing shrinkage of up to 48% [3] and disruption of the sarcolemma. Treatment of meat *post rigor* does not result in extensive contraction [4] and can improve tenderness. High pressure processing effectively inactivates spoilage microorganisms as well as food borne pathogens [5]. The effect of high pressure on bacterial survival is influenced by the number of interacting factors such as magnitude and duration of the treatment, temperature, environmental conditions, bacteria species and development phase [6].

The objectives of this study were to determine the influence of *post rigor* injection of papain solution and/or high pressure treatment (100, 200, 300 MPa for 10 min at 10°C) on some aspects of the quality of beef meat.

## EXPERIMENTAL

***Samples preparation***. A 96 months old cow was slaughtered at a local abattoir. At 2 days *post mortem*, two pieces of *musculus longissimus lumborum et thoracis* (MLLT) weighing approx. 1.5 kg were treated with the solution of papain, as well as not treated samples cut into pieces weighing approx. 500 g, vacuum sealed in polyethylene pouches and stored at 4°C before high pressure treatment.

***Papain treatment***. The 0.01% (w/v) papain solution (VERON S 50 containing 50.00% of refined

papain; Röhm Enzyme, Germany) was injected into the pieces of meat at 48 h *post mortem* by a common injection machine to 20 wt. %.

***Pressure treatment***. High pressure treatments were performed after one hour of papain acting at 2 days *post mortem* in an isostatic press CYX 6/0103 (Žďas, Czech Republic) equipped with a cylindrical pressure chamber (2 l, 90 mm diameter and 320 mm height). As the compression fluid was used water. Samples were pressurised at 100, 200 and 300 MPa held for 10 min. Control samples were maintained at 4°C while the samples were being treated. Soon after treatment, all the samples were stored at atmospheric pressure at 4°C until required.

***Texture measurements***. Warner-Bratzler shear force and myofibril fragmentation index was used to test the effects of the treatments on the meat texture. The myofibril fragmentation index (MFI) was measured according to Culler *et al*. [7], shortly as follows. The myofibril extraction was performed by homogenisation in MFI buffer (0.1M KCl, 20mM potassium phosphate pH 7, 1mM EDTA, 1mM $MgCl_2$ and 1mM $NaN_3$) and centrifugation, turbidity was measured at 540 nm. Warner-Bratzler shear force measurements were taken on at least seven test samples measuring 1.5 cm height × 3 cm wide × 5 cm long cut parallel to the longitudinal orientation of the muscle fibers. The crosshead speed of the testing machine (Instron Model 5544, Instron Ltd., UK) was fixed at 80 mm/min.

***Water holding capacity***. Water holding capacity was determined according to a modified Grau and Hamm pressure method [8]. The modification consists in replacing of planimetry evaluation by VIA technology according to Pipek *et al.* [9].

***Microbiological analysis***. Standard bacteriological techniques (ČSN ISO 2293 and ČSN 13 721, for total count and lactic acid bacteria, respectively) were used for the microbilogical analysis. The sample was homogenised in physiological solution using a Stomacher type homogenisator. Serial 10-fold dilutions were prepared and the following culture media were employed:

– Total count: Plate Count Agar (PCA, Merck, Germany),
– Lactic acid bacteria: de Man Rogosa Sharpe Agar (MRS agar, Merck, Germany).

## RESULTS AND DISCUSSION

### Texture measurements

Myofibril fragmentation index (MFI) is a useful indicator of the extent of myofibrillar protein degradation [10]. The values of MFI and the Warner-Bratzler shear force values (characterising the tenderisation level of meat) at 3 days of *post mortem* as a function of pressure are presented in Figure 1. The results indicate that the most significant improvements in meat tenderness occur after 100 MPa treatment for both control and papain treated samples.

### Effect of pressurisation on pH and water holding capacity

At two days *post mortem* the pH value of control meat sample was 5.6. After that the pH of the control samples began to grow, according to a standard behaviour of meat. In contrast to it, the pH of pressurised samples began to drop and reached their pH minimum at the eighth day *post mortem*,

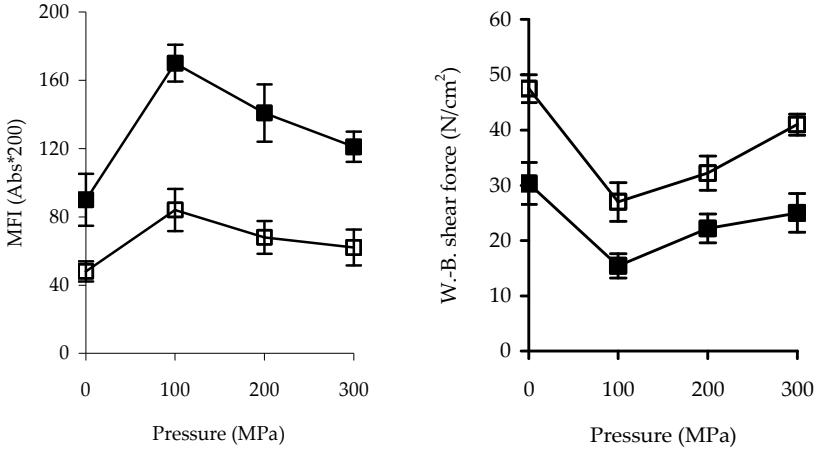


Figure 1. Warner-Bratzler shear force values and myofibril fragmentation index after papain and/or pressure treatment (300 MPa, 10 min)

Table 1. Pressure effects on drip loss and water holding capacity (%)

| Pressure (MPa) | Pressure drip loss (%) | | Water holding capacity (%) | |
|---|---|---|---|---|
| 0 | 0.04 | 4.63P | 79.2 | 31.8P |
| 100 | 0.64 | 6.18P | 58.3 | 32.9P |
| 200 | 1.10 | 7.87P | 52.6 | 34.5P |
| 300 | 0.17 | 5.54P | 73.5 | 43.3P |

P – papain treated samples

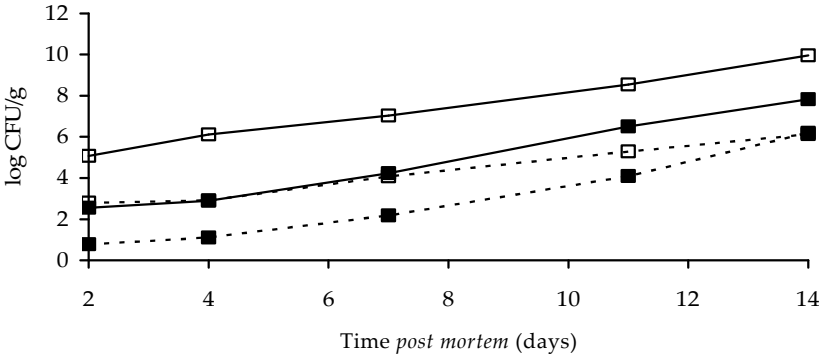


Figure 2. Effects of high pressure on inactivation of total flora (full line) and lactic acid bacteria (dotted line) in beef muscle during storage at 4°C

however, the pH values of 100 and 200 MPa treated samples were significantly lower than those of 300 MPa treated meat, probably also resulting in lower water holding capacities (Table 1). In case of meat treated with papain the values of water holding capacities do not follow the course mentioned above and seems to be approximately twice lower than those of papain untreated meat, however, this is probably the result of 20 wt. % papain solution injection and unability of meat to bind so huge amount of water.

### Microbial growth

Figure 2 shows the growth of the total flora and the lactic acid bacteria during storage at 4°C. After pressure processing at 300 MPa (10 min) the total flora of pressurised compared to control meat samples decreased of 2.5 log. The 10 min pressure treatment of 100 and 200 MPa led to a decrease of 0.9 and 2.1 log, respectively (data not shown). These results confirm that the higher intensity of pressure, the greater reduction in meat bacteria, which is in agreement with the studies of Shigehisa *et al.* [11]. After approximately nine days of storage the samples treated at 300 MPa had the same total flora as the control at the day of the treatment. This shows the effectiveness of 10 min application of a 300 MPa pressure in the shelf-life extend for more than one week. In case of lactic acid bacteria the cell survival was reduced by 2.0 log cycles due to a pressure treatment of 300 MPa, 10 min (Park *et al.* [12] reported the 2.0 og cycles reduction for the pressure treatment of 400 MPa, 5 min).

## CONCLUSIONS

In this study, high pressure treatment of post rigor papain treated bovine muscles caused a significant increase in meat tenderness, especially in case of 100 MPa pressurised samples. The 10 min application of a 300 MPa pressure showed the effectiveness in the extend of meat shelf-life for more than one week.

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