Effects of high pressure processing on physicochemical quality attributes of DFD beef loin

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Abstract – The objective of this study was to determine the effects of high pressure processing (HPP) in quality improvement of dark-firm-dry (DFD) beef loins. Samples were subjected to high pressure processing (HPP) at 200, 400 and 600 MPa and compared with control (0.1 MPa) for quality measurements. HPP increased cooking loss ($p<0.01$), pH ($p<0.05$), affected myoglobin (Mb) composition; increased met Mb ($p<0.05$), decreased oxy and deoxy myoglobin ($p<0.001$), affected instrumental surface color including lightness, redness and yellowness ($p<0.001$), improved tenderness ($p<0.001$) and cohesiveness ($p<0.01$). HPP up to 400 MPa might be considered to give the best quality improvement of DFD beef loin. However, the side effects of HPP on lipid oxidation should be observed.

Key Words – Longissimus dorsi, myoglobin, colour, processing technology, HPP.

I. INTRODUCTION

HPP, a non-thermal food preservation technology, has been widely applied as a cold-pasteurization with minimal effect on nutritional content and to obtain extended stability of food freshness without using chemical additives. Bajovic *et al*. [1] has summarized the understanding of the effects of high pressure on fresh and value added meat products. Many studies have been conducted to observe the particular effects of HPP on the quality parameters with impact on the meat quality such as color changes, tenderness and texture [2, 3].

DFD beef is known having undesirable sensory attributes and high pH (>6.0) as a result of depleted muscle glycogen reserves prior to slaughter. The weak beef flavor, less acceptable color and tenderness lowered the price. Moreover, it gets spoiled by microorganism faster than the normal one [4]. As the beef industry grows, the occurrence of DFD beef increases [5]. Chemical tenderization and color enhancement can be used to improve the quality. However, it may pose a problem, when recently the trend of additive-free products is increasing due to health issue. Chan *et al.* [6] suggested that HPP up to 200 MPa at 4°C could be used for quality improvement of pale, soft and exudative (PSE) turkey meat. The objective of present study was to determine the effects of HPP on physicochemical quality attributes of DFD beef loin.

II. MATERIALS AND METHODS

Sample

The under grade *longissimus dorsi* muscles (N = 12) with dark-firm-dry (DFD) characteristics were purchased from local slaughterhouse, vacuum packed (350 g each) and distributed to HPP plant (Hyungkuk F&B, Korea) within an ice box.

High pressure processing

Vacuum packed samples were treated at 0.1 MPa (atmospheric pressure) as control, 200, 300 and 400 MPa for 3 min in a 350 L chamber (QFP 350L-600, Avure Technologies, US) using a pressurization medium of water at 14-17°C. Pressurization, holding and depressurization times were 56.3 s, 180 s and 12.2 s, respectively.

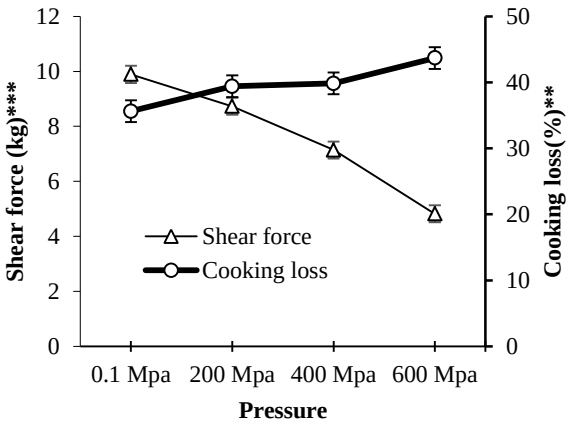
Instrumental surface color, pH and myoglobin content

The surface color was recorded by measuring CIE lightness (L*), redness (a*) and yellowness (b*) using a chromameter (CR-400, Konica Minolta Sensing Inc., Japan). The pH value of the homogenized samples were recorded using a pH meter (SevenEasy pH, Mettler-Toledo GmbH, Switzerland). Myoglobin content was determined from absorbance measurements of the sarcoplasmic extract at 525, 545, 565, and 572 nm as described by Krzywicki [7]. The presented values are the mean of triplicate samples.

Cooking loss, tenderness and texture analysis

The 2.5 cm thick-samples were cooked in the polyethylene zipper bags until internal temperature of 72°C was reached by immersing in a water bath. Cooking loss was expressed as the percentage of weight loss during boiling. The cooked samples were cut (1 x 1 x 1 cm^3) and subjected to texture profile analysis and shear force measurement using TA-XT2i Plus (Stable Micro Systems, UK). For shear force measurement, the cut sample was placed on the table, under the V blade, and was cut through as the blade moved down with a constant speed through the slit of the table (assay parameters were: pre-test speed: 2.0 mm/s; test speed: 1.0 mm/s; post-test speed: 5.0 mm/s). A cylindrical 10 mm-diameter probe was used for all texture profile analysis (TPA) tests in this study. The sample was placed under the probe that moved downwards at a constant speed of 2.0 mm/s (pre-test), 1.0 m/s (test), and 5.0 mm/s (post-test). Each sample was assessed 8 times.

Figure 1. Cooking loss and tenderness of DFD beef loin treated with different pressure. Significant differences were ** (p<0.01) & *** (p<0.001)



Statistical analysis

All data were subjected to one-way ANOVA using R-version 3.1.2 with "Agricolae" library (The R-foundation for Statistical Computing, Austria). The statistical significance of the differences between means from different treatments was determined by Duncan's multiple range test ($p \leq 0.05$).

III. RESULTS AND DISCUSSION

Quality attributes of raw meat such as color and tenderness are important to be enhanced through proper processing Zhang *et al*. [8]. This study presents the impact of HPP on some physicochemical characteristics of DFD beef loin. Table 1 shows that HPP increased meat pH and met Mb significantly (p<0.05), while oxy Mb decreased and was recorded very low (p<0.001) in samples treated with the highest pressure compared with control.

Table 1 pH and myoglobin composition of DFD beef loin treated with different pressure

Parameter	0.1 Mpa	200 Mpa	400 Mpa	600 Mpa	SEM
pH*	6.17^{b}	6.21^{a}	6.32^{a}	6.30^{a}	0.03
Total Mb (mg/g)	6.74	6.86	6.72	6.47	0.10
DeoxyMb (%)***	16.51^{c}	17.05^{c}	23.72^{b}	30.80^{a}	1.43
OxyMb (%)***	82.51^{a}	80.66^{a}	66.66^{b}	61.50^{b}	2.29
MetMb (%)*	2.93^{b}	6.87^{ab}	9.62^{a}	11.55^{a}	0.80

SEM, standard error of the means; [a-c] Means within each row with different superscripts are significantly different; * (p<0.05), *** (p<0.001).

High pressure processing has been known at promoting protein denaturation which causes a decrease of the acidic groups [9]. The elevation of pH occurs when actomyosin was denatured by pressure above 200 MPa [10].

Table 2 Instrumental surface color of DFD beef loin treated with different pressure

Parameter	0.1 Mpa	200 Mpa	400 Mpa	600 Mpa	SEM
Lightness (*L**)	34.05^{c}	40.92^{b}	44.46^{b}	50.18^{a}	1.01
Redness (*a**)	13.83^{b}	15.27^{ab}	16.28^{a}	11.49^{c}	0.27
Yellowness (*b**)	1.46^{c}	2.35^{c}	3.53^{b}	6.92^{a}	0.31

[a-c] Means within each row with different superscripts are significantly different (p<0.001).

Color, which is the first characteristic noticed by consumers, plays an important role as an indicator of meat quality. Surface color of DFD treated with different pressure was shown in Table 2. Surface lightness, redness and yellowness increased as pressure raised up (p<0.001). Samples treated at 400 MPa had redder surface than control (p<0.001). This, however, is contrast with myoglobin composition. It might be caused by color was merely recorded on the surface instead of whole meat part.

Figure 1 shows the effect of HPP on cooking loss and tenderness. HPP affected cooking loss (p<0.01)

and shear force values ($p<0.001$). The highest cooking loss and the most desirable tenderness loin was found in samples treated with the highest pressure (600 MPa). These agree with previous finding by Kim *et al.* [10] that HPP at 400 MPa and 600 MPa increased the moisture loss during cooking. Although HPP gave a negative effect on water binding properties of meat, in this study, the shear force values decreased to desirable point.

Texture profile of DFD beef loins treated with different pressure is shown in Table 3. No significant differences were found on hardness, springiness, gumminess and chewiness ($p>0.05$). HPP only affected beef cohesiveness ($p<0.05$), in which samples treated at 400 MPa had significant higher cohesiveness than control.

Table 3 Texture profile of DFD beef loin treated with different pressure

Parameter	0.1 Mpa	200 Mpa	400 Mpa	600 Mpa	SEM
Hardness (kg)	22.86	21.4	20.91	19.78	0.63
Springiness	0.5	0.5	0.49	0.47	0.01
Cohesiveness	0.48 [b]	0.49 [b]	0.53 [a]	0.47 [b]	0.01
Gumminess	11.14	10.44	11.04	9.37	0.37
Chewiness	5.60	5.24	5.36	4.43	0.23

[a-c] Means within each row with different superscripts are significantly different ($p<0.05$).

IV. CONCLUSION

HPP influenced some quality attributes of DFD beef loin such as color and tenderness enhancement, which are main factors affecting consumer preferences. HPP at 400 MPa could be applied for improving the quality of DFD beef.

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