PE6.02 The effect of high pressure on microbial population and sensory characteristics of chicken meat 62.00

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Abstract— High hydrostatic pressure (300, 450 and 600 MPa) was used to investigate its effect on microbial population and sensory characteristics of chicken breast fillets. Commercially available samples were completely sterilised by irradiation and then inoculated with either *Escherichia coli*, *L.isteria monocytogenes* or *Salmonella typhimurium* for pathogen resistance experiments. Another set of samples was only pressurised, grilled and served to semi-trained sensory panels for assessment of sensory attributes. The increased pressure of 450 and 600 MPa almost completely inactivated all 3 strains of pathogens and improved safety of chicken breast fillets. The 600 MPa treatment reduced bacteria count by 6-8 log (CFU/g) for 7-14 days and the 450 MPa treatment reduced bacteria count by 4-8 log (CFU/g) for 3-14, depending on the micro-organism. The increased pressure impacted on flavour, aroma strength and juiciness. The 300 MPa pressure significantly reduced flavour, pleasantness and juiciness, and 450 MPa produced breast fillets with the weakest aroma. The results demonstrate that high pressure treatment is an effective technology in inactivating bacterial spoilage and extending safety of chicken breast fillets, however, it may have a negative impact on some sensory characteristics.

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***Index Terms*—Chicken, HPP, Meat, Sensory.**

I. INTRODUCTION

HIGH pressure processing technology (HPP) was originally developed in 1899 and successfully used in chemical, ceramic, steel and plastic industries [9]. It has also been implemented in the food industry to control bacterial populations in food products. The capacity of HPP to inactivate microorganisms regardless of the geometry of the product, to be performed at ambient or even lower temperatures without causing heat damage, and consequently extend shelf life without use of preservatives/additives [12], made this technology quickly accepted as safe and consumers friendly [9]. However, it has been reported that HPP can impact structural, physiochemical, morphological and textural characteristics of the meat and can cause partial discolouration of fresh red meat [3][6]. Such altered characteristics may have an affect on consumer sensory perception of HPP treated meat. Although Hayman et al. (2004) reported that there was no effect on sensory attributes of beef treated with 600 MPa at 20°C. There is limited information available on the sensory attributes of chicken meat treated with HPP. Therefore, the aim of this study was to investigate the effect of varying pressure levels (300, 450 and 600 MPa) on the microbial population of chicken breast fillet and on the sensory attributes of chicken meat as judged by semi-trained consumer taste panels.

II. MATERIALS AND METHODS

Sample preparation and pathogens inoculation

Commercially available chicken breast fillets, were purchased from the local market (Orpum Co. Ltd., Sangju, Korea) and samples used for the pathogens experiment were completely sterilized by gamma irradiation (35 kGy) using a cobalt-60 gamma irradiator (AECL, IR-79, MDS Nordion International Co. Ltd., Ottawa, ON, Canada). The source strength was 320 kCi with a dose rate of 20 kGy/h at 10±0.5 °C. Three pathogens, *Salmonella Typhimurium* (KCTC 1925), *Escherichia coli* (KCTC 1682), and *Listeria monocytogenes* (KCTC

3569) obtained from the Korean collection for type culture (KCTC, Daejeon, Korea) were cultivated at 37°C for 18 h in a tryptic soy broth (Difco, Laboratories, Sparks, MD, USA). The activated cell cultures were centrifuged at 2,795 × g for 10 min at 4°C refrigerated centrifuge (Vs-5500, Vision Scientific, Co., Seoul, Korea). The pellet was washed twice with sterile saline (0.85%), and re-suspended in saline to a final cell density of approximately 10^8~10^9 CFU/mL. Radiation-sterilized chicken breast (10 g) was inoculated with 0.1 mL of *S. typhimurium, E. coli*, and *L. monocytogenes*, respectively, in 5 different areas then sealed and incubated at 10 °C for 1 h to facilitate attachment of microorganisms to the chicken breast. Samples used for the sensory evaluation were not subject to sterilization or microbial treatment.

Hydrostatic pressure (HPP) treatment

The samples were transported to the Korean Food Research Institute in a cooled container and they were subjected of HPP treatment. They were placed in a pressure vessel submerged in hydrostatic fluid medium (Quintus food processor 6; ABB Autoclave Systems, Inc., Columbus, OH, USA) and pressurized at 300, 450 and 600 MPa for 5 min with the initial temperature of the pressure vessel at 15 ± 3°C. Control samples were maintained under atmospheric pressure at 4°C while the other samples were treated. Immediately after treatment, all samples were transported on ice to Chungnam National University Laboratory, those for sensory evaluation were stored at 4°C until required, and samples for microbial analysis were immediately prepared.

Microbial analysis

After high pressure treatment, samples were blended with sterile saline using a stomacher (BagMixer ® 400, Interscience Ind., St. Nom, France) for 2 min. Serial dilutions were prepared with sterile saline. Each dilute (0.1 ml) was spread on plates in triplicate. Media used for enumeration of microorganisms was tryptic soy agar (Difco Laboratories, Detroit, MI, USA). The plates were incubated at 37 °C for 48 h and microbial counts were expressed as log CFU/g.

Sensory evaluation

Two semi-trained sensory panels were used for analysis of chicken breast fillets. One panel consisted of students (15-25 years of age) containing approximately an equal number of males and females, and another consisting only of females, which were housewives between 26-45 years of age. Chicken breast samples were sliced into 1 cm thick portions and grilled on both sides (George Foreman Lean Mean Fat Reducing Grilling Machine, 2400 watts) for approximately 45 seconds to reach and internal temperature of 71-75˚C. Immediately after grilling, samples were provided to the sensory panel using a coded identifier. Before tasting, panelists were familiarized with the assessment criteria, the meat attributes to be rated, and how to complete the questionnaire. Each treated sample was tasted by at least by 3 different panelists. Water was provided to cleanse the mouth cavity between testing each sample. Panelists used a 9-point hedonic scale to assess various meat quality attributes. Sensory attributes scored were: meat colour (extremely light to extremely dark), aroma strength (very weak to very strong), aroma pleasantness (extremely dislike to extremely pleasant), tenderness (extremely tough to extremely tender), juiciness (extremely dry to extremely juicy), texture (extremely gooey to extremely smooth), flavour (extremely unpleasant to extremely enjoyable), overall satisfaction (disagreeable to enjoyable), and would you buy this meat (definitely not to definitely yes). Additionally, there was space provided for further flavour description and additional comments.

Statistical analysis

The microbial and sensory data was analyzed using general linear models (Proc GLM. SAS Institute, 1989). Treatment pressure was the only design effect in this trial and was tested as a fixed level factor, with significance defined as the 5% level.

III. RESULTS AND DISCUSSION

The increase of hydrostatic pressure had an effect on all three pathogens that were used for the inoculation of chicken breast fillets (Table 1). The most dramatic effects were observed with 450 and 600 MPa pressures which completely inactivated *E .coli* and *L. monocytogenes* (to below detectable levels). A similar trend was observed for *S. typhimurium* except that there was no difference between the control and 300 MPa treatments, and the 450 MPa pressure significantly reduced the pathogens by 55% however, they were still detectable (Table 1).

Pressure also effected storage time (Table 1). Three hundred MPa reduced *E. coli* at days 3 and 7 of storage, however, it was not significantly different from the control on day 14^{th}. *S. typhimurium* was more resistant at this pressure and was only reduced significantly at day 3 of storage.

On days 7 and 14 the levels were not different from the initial (day 0) level. No effect was observed on *L. monocytogenes*. The population of this strain was reduced in relation to non-pressurised control levels by approximately 34%, however, storage time did not lead to a significant increase *L. monocytogenes* population.

Four hundred fifty MPa was more efficient pressure in inactivation of pathogens than the 300 MPa. At this pressure level, *E. coli* spoilage was reduced below the detectable levels on days 0 and 3, and to a very low level on day 7. The results of days 0 and 3 were significantly different from day 14 but the results from day 7 were not different from the other days. The population of *E. coli* on day 14 was also 55% lower than the control. *S. typhimurium* was non-detectable on day 3, however at days 0, 7 and 14 levels were the same and significantly less than the control. *L. monocytogenes* concentration at every single time point was below the detectable levels.

A similar trend for *L. monocytogenes* occurred at 600 MPa pressure. The effect of 600 MPa on *S. typhimurium* and *E.coli* was similar. Both strains were not detectable on days 3 and 7, and were significantly reduced on day 14 (84% and 86%) compared to the control. The 600 MPa treatment was the most efficient pressure for inactivating all 3 bacterial strains.

Although the resistance of micro-organisms to pressure was variable, the effect of pressure treatment on chicken breast fillets microbial populations in our study was in agreement with others [3] The most pronounced effect on bacteria inactivation was observed with increasing pressure (Table 1). The most effective pressures were 450 and 600 MPa, respectively, which inactivated all three bacterial strains to almost undetectable levels. Gola et al. (2000) demonstrated that increasing pressure between 400 MPa to 700 MPa caused significant reductions of eight *E. coli* strains mixed together. Malicki et al (2005) showed that pressure between 100-400 MPa efficiently reduced strains of *Salmonella*. Styles et al. (1991) reported a > 7-log reduction in *L. monocytogenes* at approximately 340 MPa pressure and Patterson et al. (1995) found a similar reduction of *L. monocytogenes* at 400 MPa pressure. Pressures of 450 MPa and 600 MPa were also very effective in increasing shelf life of chicken breast fillet up to 14 days of storage at 4°C. Pressure treatment of between 400-700 MPa was reported to increase shelf life of minced meat under refrigeration conditions [4]. The results clearly demonstrate that the increased hydrostatic pressure was able to inactivate microbial populations and extend the shelf life of chicken breast fillet.

High pressure processing affected flavour, juiciness and aroma strength of chicken breast fillet (Figure 1). The 300 MPa reduced the flavour pleasantness and was significantly lower than the 450 MPa treatment ($P<0.049$). The 600 MPa pressure also reduced flavour, and was not different ($P<0.0887$) to 450 MPa. Higher pressure influenced chicken fillet aroma strength. A significant difference was observed between 450 MPa and 600 MPa with the 450 MPa pressure giving the weakest aroma strength ($P<0.024$). There was no difference between the control, 300 MPa and 600 MPa treatments. High pressure treatment tended to reduce juiciness with increased pressure, however the only statistically significant effect was observed between the control and 300 MPa treatment, which was lower in juiciness ($P<0.044$). The remaining sensory attributes such as meat colour, texture, tenderness, aroma pleasantness and overall satisfaction were not affected by pressure.

No evidence for deteriorating effects of high pressure treatment on sensory quality on various meat products were observed by Hayman et al (2004), even if the products were treated with 600 MPa pressure. Crehan et al (2000) also concluded that high pressure processing does not markedly alter taste, flavour or nutrient content of food. However, our results demonstrate that pressure treatment impacted flavour, juiciness and aroma pleasantness of chicken breast fillet (Figure 1). Rivas-Canedo et al. (2008) showed that pressurization of minced beef and chicken breast (400 MPa) significantly changed the levels of some volatile compounds, a few alcohols and aldeydes were decreased whereas other compounds were more abundant in highly processed meats. This could have an impact on flavour, especially, aroma strength as observed in this study. High pressure treatment may also accelerate other reactions that impact food flavour. Cheah and Ledward (1996) stated that the changes leading to catalysis of lipids oxidation in pressure processed meat were initiated at around 300 MPa at room temperature. In our study, aroma pleasantness was significantly lower at 450 MPa and flavour less acceptable at 300 MPa pressures, respectively (Figure 1). The effect of pressure on juiciness has been reported by Crehan et al (2000), who demonstrated that the application of 300 MPa pressure significantly increased juiciness of frankfurters. Our results demonstrate that pressure of 300 MPa significantly decreased juiciness. The discrepancy between these results could be due to the salt content differences between the products having an impact on juiciness characteristics [2]. The effect of high pressure treatment on sensory attributes of chicken meat has variable effects that are beneficial in some cases and detrimental in others. The mechanism of these variable effects is not fully understood and requires further research [3].

IV. CONCLUSION

Pressure of 450 MPa inactivated *E. coli*, *L. monocytogenes* in chicken breast fillets to undetectable levels, and reduced *S. typhimurium* by > 3 log (CFU/g). The 600 MPa pressure inactivated all micro-organisms below delectable levels. Additionally, the 600 MPa treatment reduced bacteria count by 6-8 log (CFU/g) improving meat safety for 7-14 days. The 450 MPa treatment reduced bacteria count by 4-8 log (CFU/g), extending safety for 3-14 days, depending on the micro-fluora present. The most susceptible micro-organism to pressure was *L. monocytogenes* followed by *E. coli* and the least susceptible was *S. typhimurium*. The increased pressure also impacted sensory characteristics of chicken breast fillet. Flavour, aroma strength and juiciness were the major characteristics affected, although in a non-consistent manner. More research is needed, including instrumental analysis of meat parameters, in order to better understand the textural, structural, physiochemical and morphological changes occurring in pressurized meat and the effect of these changes on sensory characteristics of chicken breast fillets.

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Table 1. Effects of high pressure processing on microbial populations of chicken breast fillet log (CFU/g)

Pathogen	High pressure (MPa)	Storage (day)				SEM[1]
		0	3	7	14	
E. coli **KCTC 1682**	0	8.45^{w}	7.98^{x}	7.84^{x}	8.01^{x}	0.163
	300	6.76^{ax}	5.39^{by}	5.97^{bx}	6.88^{ax}	0.173
	450	nd^{bz}	nd^{bz}	1.30^{aby}	3.62^{ay}	0.717
	600	nd^{bz}	nd^{bz}	nd^{by}	1.95^{az}	0.125
	SEM[2]	0.149	0.110	0.670	0.327	
S. typhimurium **KCTC 1925**	0	6.17^{x}	6.74^{x}	6.69^{x}	6.84^{x}	0.348
	300	5.53^{x}	5.26^{y}	5.06^{x}	5.38^{x}	0.255
	450	2.82^{y}	nd^{z}	1.48^{y}	1.00^{y}	0.738
	600	nd^{bz}	nd^{bz}	nd^{by}	1.00^{ay}	0.500
	SEM[2]	0.230	0.224	0.763	0.543	
L. monocytogenes **KCTC 3569**	0	7.35^{ax}	6.08^{bx}	5.63^{bx}	6.92^{ax}	0.115
	300	4.13^{y}	4.38^{y}	4.40^{xy}	4.89^{y}	0.314
	450	nd^{z}	nd^{z}	nd^{z}	nd^{z}	-
	600	nd^{z}	nd^{z}	nd^{z}	nd^{z}	-
	SEM[2]	0.097	0.063	0.103	0.297	

Values with different letters (a-c) within the same row differ significantly ($P < 0.05$), values with different letters (w-z) within the same column differ significantly ($P < 0.05$), SEM[1] = standard errors of the mean (n = 16), SEM[2] = standard errors of the mean (n = 16), nd = not detected (< 2.0 log CFU/g).

Figure 1. The effect of pressure on flavour, juiciness and aroma strength of chicken breast fillet.