QUALITY IMPROVEMENT EFFECT BY SUPERHEATED STEAM AND HIGH HYDROSTATIC PRESSURE ON THE BULGOGI PRODUCT

Eun Mi Kim[1*], Young Boong Kim[1], Jong Dae Park[1], Jin Young Hwang[2] and Eun Kyung Cho[2]

[1] Processing Technology Research Group, Korean Food Research Institute, Kyunggi, Korea

[2]Dason Inc, Bucheon 421-741, Korea

Abstract – This study was conducted to investigate the effect of superheated steam (SHS) and high pressure processing (HPP) on the improvement of quality during the manufacturing process of Bulgogi products. As a result, compared to the conventional cooking Bulgogi, the overall product quality and hygiene were more improved that underwent SHS and HPP processed Bulgogi due to the increased preference and anti-bacterial effect. SHS processing showed that increasing water content, decreasing crude protein, fat and ash content. The sample which processed SHS and HPP Bulgogi was increased crude fat content. As for color, a difference in coloring was observed between the Bulgogi that underwent HPP and SHS and conventional cooking process Bulgogi ($p<0.05$). As for texture, the hardness increased more in the Bulgogi that underwent SHS and HPP than conventional cooking process. In addition, a significant difference in the gumminess and shear force were also found between the samples ($p<0.001$, $p<0.01$). As for preference, the preference on juiciness and appearance was higher in the Bulgogi that underwent SHS. The results of antiseptic effects after SHS, SHS processing inhibited bacteria, such as *E-coli, Salmonella, Staphylococcus aureus,* and *Listeria monocytogenes.*

Key Words – Inhibitory effect, Minimal processing technology, Physicochemical property

I. INTRODUCTION

The most important matter in food industry is to secure product safety during shelf life and to extend the shelf life while maintaining the quality as much as possible. To this end, minimal process technology has been recently actively investigated to achieve both the maintenance of the freshness of food materials and products, and the extension of shelf life.

Minimal process technology refers to the least possible treatment processing technology that extends shelf life by minimizing food-borne pathogens and spoilage microorganisms while maintaining the fresh quality of products. Physical methods such as heating, drying, and freezing, and chemical methods such as the addition of food preservatives have been traditionally used for the improvement of food preservation. However, heat process has unavoidable quality decrease such as nutrient destroy, change in texture and color, and loss of fragrant composites due to heat treatment. Accordingly, non-thermal process and antiseptic packaging technology have been actively explored. High pressure processing is considered as a technology with the highest application potential among non-thermal processing technologies, and has been the most commonly used in reality. High pressure processing, which is also known as high pressure processing (HPP), high hydrostatic pressure (HHP) processing, or ultra-high pressure (UHP) processing, is defined as a technology in which liquid or solid foods are treated with a hydrostatic pressure of 100-900MPa under packaged or unpackaged condition [1, Park].

Superheated steam processing, a quick-cooking method that has been applied to manufacture products such as flake, puffing, and granular products, is a material transfer-based food processing technology that performs effective physical treatments for the formation of small-sized micropores inside grains in order to achieve gelatinization after thermal hydration caused by fast moisture movement. In addition, compared to the conventional sterilization by irradiation or chemicals, which is harmful to the body. High pressure, superheated steam processing is considered as a useful food processing technology by providing safety without the occurrence of residual toxic materials that are regulated by the law. The most

significant advantages of this technology is that this technology is rapid and economic as it can not only control cooking level at a wide degree via physical treatment and osmosis, but also process products by controlling cooking time at a range of ≤5 minutes [2, Lee *et al.*].

Accordingly, this study was conducted to investigate the effect of SHS and HPP applied to manufacturing process on the improvement of Bulgogi product quality and shelf life extension.

II. MATERIALS AND METHODS

Sample preparation

The Bulgogi treated 4 cooking methods like as conventional cooking (S1), conventional cooking and HPP (S2), SHS (S3), SHS and HPP (S4).

General properties, color, texture

The sample was used physicochemical analysis after grinded and cold storage. The moisture content, crude ash, crude fat and crude protein were measured 105□ oven drying method (AOAC), 550□ dry ashing method, Soxhlet method, kjeltec system (kjeltec auto sampler system 8440 analyzer, Foss Tecator, sweden). The meat color was measured with color meter (spectrophotometer CM-2500d, konica minolta, Japan). The calibration value was L=69.08, a=-0.78, b=14.39.

Texture measurements in the form of texture profile analysis were performed at room temperature with a texture analyzer (TA-XT2, stable Micro systems Ltd. UK). Sample was cut into 2 × 2 × 0.5 cm and measurements were conducted by aluminum cylinder probe with 2.5cm in diameter (pretest:3.0mm/s, test:1.0mm/s, post:1.0mm/s. Shear force was conducted by warner-bratzler blade (pretest:2.0mm/s, test:5.0mm/s, post: 5.0mm/sec).

Preference test

The preference test was carried out by 20 panelists from KFRI (*Gyeonggi*, Korea). The sample was placed on white lidded container with three-digit numbers after into 25~30g Bulgogi. The panelists evaluated the prepared Bulgogi using a 9 point scale and the scales used for the preference test were the following: appearance, aroma, taste, overall preference (1 = dislike extremely to 9= like extremely), off-flavor, saltiness, sweetness, juiciness, texture (1= extremely weak to 9= extremely strong).

Inhibitory effect by microbiological test

The sample was cut into 5 × 5 × 0.6 cm, and then deposited in sterilized water diluted to have $1x10^2$-$1x10^3$ bacteria for 15 minutes. Subsequently, the sample was cooked according to the established condition of superheated steam cooking in order to investigate the inhibitory effect on microbial growth. In this experiment, bacteria such as *Listeria monocytogenes* (ATCC 19112), *Staphylococcus aureus* (ATCC 12598), *Salmonella typhimurium* (ATCC 13311), *Escherichia coli* O157:H7 (ATCC 43890) were used. After treated according to the condition of superheated steam cooking, the bacteria were cultured in the Plate Counting Agar (Difco, Franklin Lakes, NJ, USA) at 37□ for 24 h, followed by counting the bacterial cell number.

III. RESULTS AND DISCUSSION

General properties, color, texture

Water content, Crude protein, crude fat and crude ash was analyzed respectively 45.94-53.41%, 19.44-21.74%, 15.95-19.72%, 1.01-2.17% and showed significant difference by samples ($p<0.05$, $p<0.01$, $p<0.001$). SHS processing of sample showed that increasing water content, decreasing crude protein, fat, ash. The sample which processed SHS and HPP (S4) was increased crude fat.
(Table1)

Table 1 General component of Bulgogl samples

	Water (%)	Crude protein (%)	Crude fat (%)	Crude ash (%)
S1[1)]	50.96± 0.32[b]	21.74± 0.56[b]	16.69± 0.62[ab]	2.17± 0.28[b]
S2	45.94± 0.06[a]	19.44± 0.02[a]	17.13± 0.46[b]	1.54± 0.01[ab]
S3	53.34± 0.52[c]	19.61± 0.03[a]	15.95± 0.09[a]	1.84± 0.35[b]
S4	53.41± 0.40[c]	19.44± 0.02[a]	19.72± 0.18[c]	1.01± 0.03[a]
F-value	187.668***	32.206**	33.628**	9.441*

1) S1,Conventional cooking; S2,Conventional cooking and HPP;S3,SHS;S4, SHS and HPP
*: p<0.05, **: p< 0.01, ***: p< 0.001
a-c values with different lowercase superscripts in the same column are significantly differently by ANOVA with Duncan's multiple range test.

The L value was shown to have increased after HPP and SHS, which was statistically significant among the samples (p<0.05). A value was shown to have decreased, and no significant difference in the b value among the samples**.** Meat color is influenced by the oxidization status of iron in myoglobin and the denaturation of myofibrillar proteins. [3, Carlez *et al*., 4, Ko *et al*.] Jung *et al*. [5] reported that a value increased by applying pressure until 350MPa, and thereafter, a value decreased as the pressure increased. The aforementioned results were consistent with the result of this study. Gray-brown meat color, which is formed due to the increased L value and decreased a value, is considered one of problems that occur during HPP. No difference in the meat color was found after cooking even if the meat color was changed due to HPP [5, Jung *et al.*, 6, Kim *et al.*]. However, Ko *et al*. [4] reported that meat color change was minimized via the shortening of pressure application time.
(Table 2)

Table 2 color value of Bulgogi samples
1) Refer to table 1

	L	a	b
S1[1)]	48.83±1.53[a]	4.61±0.41	13.55±0.87
S2	51.76±1.39[b]	4.54±0.28	13.28±0.88
S3	51.92±1.44[b]	4.38±0.32	13.77±1.50
S4	53.84±1.19[b]	3.98±0.06	13.14±0.65
F-value	6.605*	2.719	0.227

*: p< 0.05
a-b Means± SD with different lowercase superscripts in the same column are significantly by ANOVA with Duncan's multiple range test

The hardness was shown to be the lowest in the conventional cooking processed Bulgogi (S1), but the highest in the SHS processed Bulgogi (S3), which showed that the hardness increased by SHS and HPP (p<0.001). The springiness was shown to have decreased underwent SHS and HPP processing. The cohesiveness was shown to be the highest in the SHS and HPP processed Bulgogi (S4), but the difference in the cohesiveness was insignificant among the samples. The gumminess, chewiness, and shear force were shown to be the highest in the SHS and HPP processed Bulgogi (S4), and a significant difference in the gumminess and shear force was found among the samples (p<0.001, p<0.01).

In a study of Kim *et al.* [7] that was conducted on Post-rigor beef treated with 100-600MPa (for 15min, at 15□), the change of shear force varied depending on pressure. The shear force was reported to increase at a pressure of 400 and 500MPa due to the inactivation of cathepsin D and the increased binding force between proteins (6, Kim *et al.*). which was consistent with the result of this study in which 500MPa was applied.
(Table 3)

Table 3 Texture profile analysis of Bulgogi samples

	Hardness (Kg)	Sprigine ss	Cohesiv eness	Gummi ness	Chewin ess	Shear force (kg)
S1[1)]	12.92± 0.55[a]	0.81± 0.05	0.55± 0.04	7.13± 0.49[a]	5.76± 0.61	20.40± 1.54[a]
S2	15.79± 1.06[b]	0.74± 0.07	0.55± 0.05	8.75± 1.23[b]	6.47± 1.32	25.98± 1.18[b]
S3	17.07± 0.99[c]	0.71± 0.04	0.55± 0.02	9.35± 0.47[b]	6.67± 0.72	24.85± 7.22[ab]
S4	16.75± 0.33[bc]	0.74± 0.04	0.59± 0.03	9.80± 0.58[b]	7.24± 0.51	29.99± 0.62[b]
F-value	28.376***	3.091	0.948	11.585***	2.574	5.525**

1) Refer to table 1
**: p< 0.01, ***: p< 0.001
a-c Means± SD with different lowercase superscripts in the same column are significantly by ANOVA with Duncan's multiple range test

Preference test

In the evaluation of preference according to processing method, the preference was the highest in the SHS processed Bulgogi, and a significant difference in the saltiness, juiciness, texture, and overall preference were found

among the samples ($p<0.05$, $p<0.001$). Thus, SHS processing, which showed the highest preference, was assessed to be an appropriate cooking method.
(Fig.1)

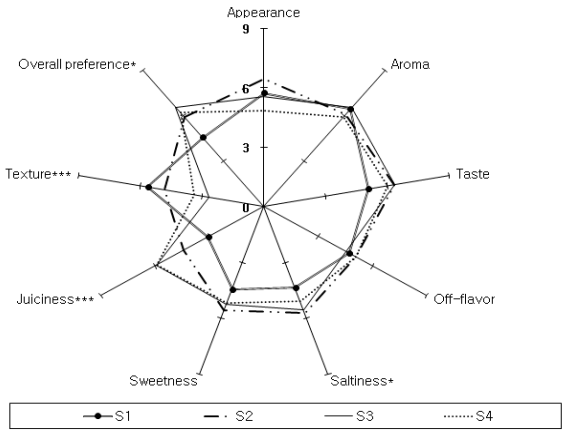

Figure 1. Preference of Bulogogi samples
S1,Conventional cooking; S2,Conventional cooking and HPP;S3,SHS;S4, SHS and HPP
*: $p< 0.05$, ***: $p< 0.001$

Inhibitory effect by microbiological test

The result of assessing the antiseptic effect after HPP showed that HPP inhibited *E-coli, Salmonella, Staphylococcus aureus, and Listeria monocytogenes*. Thus, if products undergo both SHS and HPP, their shelf life could be more extended compared to that of products that undergo the conventional cooking process.

Table 5 Inhibitory effect on HPP

	Before	After	%
E.coli	$3.25x10^3$ cfu/g	0	100%
Salmonella	$2.24x10^3$ cfu/g	0	100%
Staphylococcus aureus	$3.74x10^3$ cfu/g	0	100%
Listeria monocytogenes	$3.65x10^3$ cfu/g	0	100%

IV. CONCLUSION

In Bulgogi product applied with SHS and HPP, showed improvement of quality compared to conventional cooking method. The Bulgogi of processed SHS and HPP showed high preference and Inhibitory effect without additional sterilization. This study showed that SHS and HPP process can provide quality improvement and microbiologically safe quality of Bulgogi product.

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