Effects of F-values on the Quality and Shelf-life of *Samgyetang* Packed in a Multilayer Plastic Tray during Storage at 25℃

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***Abstract*— The effects of F-value level (4.0 and 7.0) on the quality of *Samgyetang* soup packed in a multilayer plastic tray were investigated during storage at 25℃ for 6 months. Over the storage period, pH and springiness values of samples were reduced, while TBARs, VBN, carbonyl contents, viscosity and hardness values increased. Samples treated with an F-value of 4.0 showed generally better quality characteristics than those with an F-value of 7.0 during storage. The sensory scores showed that retorted *Samgyetang* soups treated under F values both of 4.0 and 7.0 could maintain marketable quality for a minimum of 6 months.**

Key words— quality, shelf-life, *Samgyetang*, F-value, tray

I. INTRODUCTION

Samgyetang is a traditional, healthy and nourishing chicken soup containing ginseng roots, most often eaten in the summer in Korea. The chicken is stuffed with glutinous rice, garlic, jujube, chestnut and ginseng root, and cooked in broth. Traditional *Samgyetang* requires a lot of time and effort to prepare, and so tends not to suit modern lifestyles. In an effort to address this, in the early 1990s retorted *Samgyetang* was developed, packed in an aluminum laminated pouch. However, the commercial product has some drawbacks for consumption, because it can't be microwaved in the package and therefore it is inconvenient to warm-up and serve.

Commercial *Samgyetang* is usually sterilized with an F-value of approximately F-10.0 to enable its distribution for at least 18 months at room temperature, which could result in significant quality deterioration. Because the chickens used to make *Samgyetang* are relatively young, 4 to 5 week-old broilers (Yu & Jeon, 1999), severe heat treatment can cause serious sensory quality deteriorations (i.e. crumbling of the bones and softening or denaturation of meat texture). Prolonged sterilization of chicken model food packed in a retort pouch was observed to increase levels of volatile components including furan, 2-heptanone, 2-penyl, and ketone, which could affect the sensory qualities (Choi, Chung, Kong, & Moon, 1996). Therefore, the goal of this study was to develop a retorted *Samgyetang* soup packed in a multilayer plastic tray, which offers better quality and more convenience in terms of preparation. With a view to commercial distribution, optimum sterilizing conditions for this product and its potential shelf-life during storage at room temperature were also determined.

II. MATERIALS AND METHODS

For the broth, 5 chickens (Korean mini-broiler type chicks bred for 30 to 35 days and weighing between 350 g and 450 g) were boiled for 3 hrs in 10 liters of water after adding 300 g of spices and seasonings. 150 g of deboned breast and thigh meats, and 100 g of other ingredients including ginseng, garlic, chestnut, glutinous rice and jujube were placed in a multilayer plastic tray (CPP/EVOH/CPP 720/96/720 ㎛, oxygen permeability: 0.2 cc/dm^2·day·atm), and 200 mL of hot chicken broth (at approximately 85℃) was poured over them. The tray was covered with a top film (PET/PA/PE 12/15/50 ㎛, oxygen permeability: 0.6 cc/dm^2·day·atm) and heat-sealed using a sealer (Emerdica, Sam-Il, Korea). Packaged samples were then sterilized in a retort (PRS-06-1, Kyoung-han, Korea) under the F-value conditions of F-4.0 and F-7.0 respectively. The F-value during the sterilization process was monitored by means of an F-value measurement program (Nitsch & Vukovic, 2002).

The sterilized *Samgyetangs* were then stored for 6 months in a 25℃ incubator (BI-1000, Jeio Tech., Korea) and were tested periodically at one month intervals. All physico-chemical measurements were made with the chicken meat samples in the pack except for viscosity for which the gruel was measured. pH was measured using a pH meter (SG2-ELK, Mettler Toledo Co., Ltd., Switzerland). Changes in the TBARS (thiobarbituric acid reactive substances) were measured to assess lipid oxidation according to the method of Witte, Krause, and Baile (1970). VBN (volatile basic nitrogen) was measured to determine proteolytic degradation using the microdiffusion method of Conway (1958). Carbonyl contents were determined to assess protein oxidation by the method of Oliver, Ahn, Moerman, Goldstein, and Stadman (1987). Viscosity was measured with a Viscometer (DV-Ⅱ, Brookfield Engineering, USA) fitted with LV spindle No. 6. Hardness and springiness were measured

using a rheometer (Compac-100Ⅱ, Sun Scientific Co., Ltd., Japan) fitted with adaptor No. 34. Oxygen concentration in the headspace of the tray was monitored using gas chromatography (7890A, Agilent Technologies, Germany). The conditions for gas analysis are shown in Table 1. Hunter L^* (lightness), a^* (redness) and b^* (yellowness) values were determined on the surface of the chicken breast meat using a color difference meter (CR-300, Minolta Co., Japan). The *Samgyetang* samples were evaluated for outer appearance, color, texture and flavor using a 9-point hedonic scale, by a trained, 8-10 member panel of faculty members and students from Gangneung-Wonju University. Data were analyzed using the SPSS (Ver. 14.0) statistical package. Duncan's multiple range test was also applied to compare means and significance which was established at $P<0.05$.

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III. RESULTS AND DISCUSSION

Table 2 depicts the pH, TBARS, VBN and carbonyl content changes of retorted *Samgyetang* soup in a tray relative to sterilization conditions and period of storage. Initial pH values of the treatments of F-value 4.0 (F-4) and 7.0 (F-7) were 6.24 and 6.23, and steadily decreased to 5.90 and 5.88 respectively after 6 months. Initially, TBARs values of the F-4 and F-7 samples were 0.11 and 0.13 mg MA/kg, respectively, but they increased to 1.32 and 1.42 mg MA/kg after 6 months. As the storage period extended, TBARS values increased due to the fat being decomposed by lipolytic enzymes, forming carbonyl compounds, alcohols, ketones and aldehydes (Demeyer, Hooze, & Meadom, 1974). The initial carbonyl content of the F-4 samples (9.7 nmoles/mg proteins) was significantly lower than those of the F-7 samples (11.9 nmoles/mg proteins) (P <0.05). Carbonyl contents showed a tendency to increase over the storage period, with a particularly sharp increase observed between months 1 and 2. At the end of storage period, the carbonyl contents of F-4 and F-7 samples were measured as 21.3 and 28.9 nmoles/mg proteins, respectively. At the outset, VBN values of F-4 and F-7 were 2.6 mg% and 3.9 mg%, respectively. As the storage period extended, VBN values increased gradually and those of the F-4 samples were significantly lower than the F-7 samples over the storage period (P <0.05). A similar observation was reported with retorted fish products, in which VBN values and carbonyl contents increased with higher F-values (Oh, Sung, Choi, & Lee, 1991).

Table 3 shows the changes in the viscosity, hardness, springiness and oxygen concentration values of retorted *Samgyetang* soup according to sterilization conditions and storage time. Over the storage period, the viscosity values of both treatments increased steadily; those of the F-4 samples tending to be insignificantly lower than the F-7 samples (P >0.05). The increase of viscosity with the extension of storage can be explained by the retrogradation process of rice starch which is a reassociation of gelatinized starch from amorphous state to more ordered or crystalline state (Adebowale & Lawal, 2003).

With extended storage time, the hardness of chicken meat in the *Samgyetang* soup steadily increased, especially sharply in the 1st month. At the outset, F-4 showed significantly higher springiness values than F-7 (P<0.05). Initial oxygen concentrations in the headspace of the packages of F-4 and F-7 samples were 1.3% and 1.8%, respectively, which did not change significantly during the whole storage time (P <0.05). The F-4 samples showed significantly lower oxygen concentration than the F-7 samples up to the 4-month stage (P <0.05). While these concentrations may be negligible, oxidation of fats and proteins can nevertheless occur progressively after long storage under this circumstance, indicating the need for further work to develop options for reducing the residual oxygen contents in packaging headspace to assist in maintaining the quality of *Samgyetang* soup.

As shown in Table 4, Hunter L^*, a^* and b^* values were not significantly affected by F-values. In terms of the sensory characteristics of retorted *Samgyetang* during storage, the appearance, color, texture and flavor scores of the F-4 samples were generally higher than those of the F-7 samples. Nevertheless, the products treated under F-value conditions of 4.0 and 7.0 both maintained their quality until month 6, when the sensory characteristics were assessed below 5.0, losing the product's market value.

IV. CONCLUSION

Samgyetang soup requires optimum sterilization conditions in order to minimize any potential impact on its quality, and guarantee safety from microbial hazards. Even though this study was conducted at pilot-scale, the results indicate that *Samgyetang* samples treated with an F-value of 4.0 can be preserved for at least 6 months. At the same time they sustain better qualities than those with an F-value of 7.0 in terms of VBN, TBARS, carbonyl content, oxygen concentration in the package's headspace, and sensory attributes during storage. However, a commercial mass production process would have to include a strict, standardized quality control system in the production line to guarantee microbiological safety.

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REFERENCES

Adebowale, K. O., & Lawal, O. S. (2003). Microstructure, physicochemical properties and retrogradation behavior of Mucuna bean (Mucuna pruriens) starch on heat moisture treatments. *Food Hydrocolloids*, 17, 265-272.

Choi, J. B., Chung, H. Y., Kong, W. Y., & Moon, T. H. (1996). Analysis of volatile components of a chicken model food system in retortable pouches. *Food Science Biotechnology*, 28, 772-778.

Conway, E. J. (1958). Microdiffusion analysis and volumetric error. New York: The MacMillian Company.

Demeyer, D., Hooze, J., & Meadom, H. (1974). Specificity of lipolysis during dry sausage ripening. *Journal of Food Science*, 39, 293-296.

Nitsch, P., & Vukovic, I. (2002). Schnellbestimmung des F-Wertes mittels Gauß'scher Integration. *Fleischwirtschaft*, 11, 122-123.

Oh, K. S., Sung, D. H., Choi, J. D., & Lee, E. H. (1991). Changes in food components of dark, white-fleshed fishes by retort sterilization processing. *Bulletin of the Korean Fisheries Society*, 24, 123-129.

Oliver, C. N., Ahn, B., Moerman, E. J., Goldstein, S., & Stadman, E. R. (1987). Age-related changes in oxidation proteins. *Journal of Biology Chemistry*, 262, 5488-5491.

Witte, V.C., Krause, G. F., & Baile, M. E. (1970). A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. *Journal of Food Science*, 35, 352-358.

Yu, I. J., & Jeon, K. H. (1999). Effect of heating conditions and additives on bone crumble and shelf-life of retorted *Samgyetang*. *Korean Journal of Food Science Animal Resources*, 19, 19-25.

Table 1
Conditions of Gas Chromatography for gas analysis

Column	Carboxen-1000 (Supelco)
Detector	TCD, 300℃
Oven temp.	Maintained at 30℃ for 7 minutes and rise 10℃ to 300℃ / min
Carrier gas	He (35 psi, total flow 50 mL/min)
Injection	100 μℓ, 30□

Table 2
Changes in pH, TBARs, VBN and carbonyl contents of *Samgyetang* packaged in a multilayer tray and retorted under the F-values of 4.0 and 7.0 during storage at 25°C

Parameters	F- value	Storage time (month)						
		0	1	2	3	4	5	6
pH	4.0	6.24^{Aa}	6.22^{Aa}	6.20^{Aa}	6.08^{Ab}	5.97^{Abc}	5.92^{Ac}	5.90^{Acd}
	7.0	6.23^{Aa}	6.22^{Aa}	6.19^{Aa}	6.07^{Ab}	5.96^{Abc}	5.9^{Ac}	5.88^{Acd}
TBARs (mg MA/kg)	4.0	0.11^{Aef}	0.14^{Ae}	0.36^{Bd}	0.52^{Bc}	0.61^{Bbc}	0.74^{Bb}	1.32^{Ba}
	7.0	0.13^{Afg}	0.18^{Af}	0.54^{Ae}	0.64^{Ad}	0.75^{Ac}	0.92^{Ab}	1.42^{Aa}
VBN (mg%)	4.0	2.6^{Bf}	2.9^{Bef}	3.6^{Be}	8.4^{Bd}	12.8^{Bc}	16.1^{Bb}	18.7^{Ba}
	7.0	3.9^{Af}	4.1^{Aef}	4.7^{Ae}	10.4^{Ad}	15.6^{Ac}	18.8^{Aab}	20.3^{Aa}
Carbonyl contents (nmoles/mg proteins)	4.0	9.7^{Bde}	10.1^{Bd}	14.9^{Bbc}	15.3^{Bbc}	17.0^{Bb}	17.9^{Bb}	21.3^{Ba}
	7.0	11.9^{Af}	13.9^{Ae}	17.8^{Acd}	20.5^{Ac}	24.6^{Ab}	26.1^{Aab}	28.9^{Aa}

$^{A-B}$: Means with different letters between two F-values in each quality parameter at each storage time are significantly different ($P<0.05$).

[a - g]: Means with different letters with a same row of each treatment period are significantly different ($P<0.05$).

Table 3
Changes in viscosity, hardness, springness and O_2 composition of *Samgyetang* packed in a multilayer tray and retorted under the F-values of 4.0 and 7.0 during storage at 25°C

Parameters	F- value	Storage time (month)						
		0	1	2	3	4	5	6
Viscosity (cP)	4.0	$1,051^{Ag}$	$1,649^{Af}$	$2,168^{Be}$	$2,871^{Ad}$	$3,261^{Ac}$	$3,431^{Ab}$	$4,016^{Aa}$
	7.0	$1,064^{Ag}$	$1,675^{Af}$	$2,201^{Ae}$	$2,994^{Ad}$	$3,294^{Ac}$	$3,476^{Ab}$	$4,136^{Aa}$
Hardness (g/cm^2)	4.0	$1,421^{Ac}$	$2,082^{Aab}$	$2,135^{Aa}$	$2,193^{Aa}$	$2,236^{Aa}$	$2,284^{Aa}$	$2,341^{Aa}$
	7.0	$1,499^{Ab}$	$2,214^{Aa}$	$2,268^{Aa}$	$2,284^{Aa}$	$2,291^{Aa}$	$2,327^{Aa}$	$2,401^{Aa}$
Springness (%)	4.0	92.8^{Aa}	81.2^{Ab}	78.8^{Abc}	76.4^{Ac}	75.9^{Ac}	75.2^{Acd}	69.8^{Ade}
	7.0	85.8^{Ba}	80.7^{Ab}	77.1^{Abc}	75.7^{Ac}	74.8^{Acd}	74.1^{Ae}	67.1^{Af}
Oxygen (%)	4.0	1.3^{Ba}	1.2^{Bab}	1.4^{Ba}	1.4^{Ba}	1.3^{Ba}	1.4^{ABa}	1.4^{ABa}
	7.0	1.8^{Aa}	1.8^{Aa}	1.7^{Aa}	1.8^{Aa}	1.7^{Aa}	1.6^{Aab}	1.6^{Aab}

[A-B, a - g]: Same as in Table 2.

Table 4
Changes in color of *Samgyetang* packed in a multilayer tray and retorted under the F-values of 4.0 and 7.0 during storage at 25°C

Parameters	F- value	Storage time (month)						
		0	1	2	3	4	5	6
L^*	4.0	68.2^{Aa}	69.4^{Aa}	69.8^{Aa}	69.6^{Aa}	69.7^{Aa}	69.4^{Aa}	68.4^{Aa}
	7.0	68.6^{Aa}	68.9^{Aa}	69.4^{Aa}	68.8^{Aa}	68.5^{Aa}	68.7^{Aa}	68.3^{Aa}
a^*	4.0	2.4^{Aa}	0.7^{Ab}	0.6^{Ab}	0.6^{Ab}	0.6^{Ab}	0.5^{Ab}	0.5^{Ab}
	7.0	2.2^{Aa}	0.7^{Ab}	0.5^{Ab}	0.6^{Ab}	0.5^{Ab}	0.4^{Abc}	0.5^{Ab}
b^*	4.0	22.8^{Aa}	20.7^{Ab}	20.3^{Ab}	20.5^{Ab}	20.5^{Ab}	20.4^{Ab}	20.1^{Ab}
	7.0	23.1^{Aa}	21.8^{Ab}	20.6^{Ab}	20.4^{Ab}	20.7^{Ab}	20.6^{Ab}	20.6^{Ab}

[A-B, a - g]: Same as in Table 2.

Table 5
Changes in sensory characteristics of *Samgyetang* packed in a multilayer tray and retorted under the F-values of 4.0 and 7.0 during storage at 25°C

Parameters	F- value	Storage time (month)						
		0	1	2	3	4	5	6
Appearance	4.0	9.0^{Aa}	8.7^{Ab}	7.8^{Ac}	7.3^{Ad}	6.8^{Ae}	6.6^{Af}	5.9^{Ag}
	7.0	8.9^{Aa}	8.1^{Bb}	7.4^{Bc}	6.9^{Bd}	6.6^{ABde}	6.2^{Be}	5.6^{ABfg}
Color	4.0	9.0^{Aa}	8.6^{Ab}	7.7^{Ac}	7.4^{Acd}	7.1^{Ad}	6.4^{Ae}	6.1^{Af}
	7.0	8.7^{ABa}	8.2^{Bb}	7.3^{Bc}	7.0^{Bcd}	6.4^{Be}	6.1^{ABef}	5.7^{Bg}
Texture	4.0	9.0^{Aa}	8.7^{Aab}	8.1^{Abc}	7.4^{Ad}	7.0^{Ae}	6.7^{Aef}	6.2^{Ag}
	7.0	8.6^{Ba}	8.3^{Bab}	7.5^{Bcd}	7.1^{ABd}	6.5^{Be}	6.1^{Bf}	5.8^{Bfg}
Flavour	4.0	9.0^{Aa}	8.5^{Ab}	7.5^{Ac}	7.2^{Acd}	6.8^{Ade}	6.6^{Ae}	6.0^{Af}
	7.0	8.7^{ABa}	8.1^{Bb}	7.1^{Bcd}	6.9^{ABd}	6.5^{ABe}	5.9^{Bf}	5.8^{Af}

[A-B, a - g]: Same as in Table 2.