MATERIAL ANALYSIS OF RETORT POUCHES USED FOR *SAMGYETANG* AND THEIR STABILITY AGAINST PHYSICAL DAMAGE DURING DISTRIBUTION

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Abstract – The material composition and thickness in the layers of retort pouches and the physical strength used for packaging *Samgyetang* were examined. All of the retort pouches examined were composed of polyethylene terephthalate/aluminum/ nylon/cast polypropylene (PET/Al/Ny/CPP). The total thickness of retort pouches ranged between 135.9 and 142.2 ㎛. According to the results obtained with face drop and edge drop tests, and compression test, no significant differences in physical strength were observed between the two different film types, e.g, PET/Al/Ny/CPP in 12/9/15/80 ㎛ (sample A) and 16/9/15/70 ㎛ (sample B).

Key Words–Package, Physical strength, *Samgyetang*

I. INTRODUCTION

Samgyetang is a traditional Korean ginseng chicken soup which has gained popularity and demand as a healthy and rejuvenating food in the Asian countries, especially in the summer and for the weak and the elderly. For manufacturing *Samgyetang*, ginseng root, garlic, jujube, chestnut, and glutinous rice are stuffed into the abdominal cavity of a whole young chicken and cooked together with abundant broth. However, the preparation of *Samgyetang* at home isn't suited to our modern life style, because it is very time consuming and requires great effort. Therefore, in the early 1990s in Korea, retorted *Samgyetang* was developed commercially, packaged in an aluminum laminated pouch.

Retort pouches have been used since 1958 in the USA as a substitute for metal cans to package ready-to-eat military meals [1]. Retort pouches are expected to have absolute barrier properties against gas and water vapor, and thermal resistance under the high temperature and pressure, usually in the range between 110-130℃. They also have to be physically strong enough to preserve their integrity against stress and strain, to avoid bursting, maintain compression and resist puncturing, and preserve the adhesive properties of the heat sealed layer etc. However, defects in and damage to retort pouches have been reported during manufacture and distribution, compromising their integrity and causing serious concern about the quality of the packaged product and the safety implications for consumers of foods packaged this way.

In particular, *Samgyetang* products are subject to high external pressure since they contain a lot of broth in the package, and also to internal pressure of up to 3 atm during the retorting process. Moreover, the heat sealing capability of the retort pouch is known to be weakened by approximately 8% after the retorting process [2]. The choice of appropriate composition and material for manufacturing retort pouches is therefore important in maintaining the commodity value of *Samgyetang* and ensuring consumer safety. In this study, we have carried out experiments to analyze the composition of commercial retort pouches in the Korean market and to test the physical strength of two different material and thickness options with the purpose of finding the optimum packaging design for *Samgyetang* products.

II. MATERIALS AND METHODS

Nine kinds of retort pouches used for *Samgyetang* from four different manufacturers in Korea were obtained directly from the manufacturers. Pouch samples were sliced into approximately 0.5 x 1cm sized-pieces, and the material composition of each was analyzed using differential scanning colorimetry (DSC) (TA 2000/MDSC 2910, TA Instruments, USA). The temperature of DSC was increased up to 300℃ at a rate of 10℃/min in 3 steps, and then decreased to room temperature. The thickness of each sample of pouch material was measured using an optical microscope (DM RXA2, Leica, Germany) with a zoom rate of 400, and it was then frozen at −120℃ in liquid nitrogen, and sliced to a thickness of 3 ㎛ using a microtome diamond knife (Ultracut UCT, Austria). The sample was illuminated with polarized light and the thickness of each layer was measured. The film type in each layer of the pouch was identified by measuring its spectrum using a Fourier Transform Infrared Spectroscope (FT-IR) (1760-X Perkin Elmer, UK) and matching it with the IR reference charts.

To test the physical strength of the retort pouches, *Samgyetang* products weighing approximately 800 g were packaged in retort pouches constructed from two different film types: A) polyethylene terephthalate (PET) 12 ㎛ + aluminum (AL) 9 ㎛ + nylon (Ny) 15 ㎛ + cast polypropylene (CPP) 80 ㎛, and B) PET 16 ㎛+ AL 9 ㎛ + NY 15 ㎛ + CPP 70 ㎛. The CPP film used in A (CPP-I) was one that is specially made for retorted products, by blending rubber compounds to increase its heat resistance and to reduce the orange peel defect, commercially branded as 'CPR III' made by Philmax Co. (Korea). The CPP film used in B (CPP-II) is a general component for retort pouches whose brand name is 'CPR II' made by Philmax Co. (Korea). Physical strength was measured in terms of drop tests, bursting strength, and compression tests. Drop tests involved face drops and edge drops. A box containing 12 packaged products was dropped from a height of 1.2 m. The box was a double faced corrugated fiberboard measuring 430 x 390 x 230 (L x W x H) with a specification of KA210/3K180/KA210. The number of burst and damaged packages was counted. Face drop tests were conducted 10 times and edge drop test 5 times, respectively. Bursting strength (expressed as kgf/㎠) was measured using a digital seal tester (KST-2D, KS Tech., Korea) to identify the point when the pouch burst from air being continuously blown into the package, Compression strength (expressed as kgf) was measured using a digital compression tester (KST-2D, KS Tech., Korea) at the point when the pouch bursts by compressing the pouch.

III. RESULTS AND DISCUSSION

1. Analysis of the composition of packaging used for *Samgyetang*

As shown in Table 1 and Figures 1-3, all of the retort pouches examined were confirmed to be composed of PET, Al, Ny, and CPP films. Figure 1 shows typical FT-IR chromatograms of three major layers of film A in which the upper, the middle and the lower chromatogram represent PET, Ny and CPP, respectively. Figure 2 shows the layer composition and thickness of retort pouch A as analyzed by the microscope. The average layer composition and thickness of the 9 retort pouches used for this experiment are summarized in Table 1.

Table 1 Layer composition and thickness of retort pouches used for *Samgyetang* (Unit:㎛)

Sample	Layer								
	PET	Adhesive (PE)	AL	Adhesive (PE)	Nylon	Adhesive (PE)	CPP	PE	Total
A	13,5	5,8	9,3	4	15,7	3,5	84,5	0	136,3
B	17,6	7	10	3,9	17,1	5	81,6	0	142,2
C	17,7	5	10	4,5	15,5	4,5	82,2	0	139,4
D	17	5,6	8,9	4,2	15,7	5,2	79,3	0	135,9
E	18,3	5,6	7,3	2,8	16,6	4,3	79,5	20,9	155,3
F	13,6	7,1	8,9	3,7	16,2	5,8	87,9	0	143,2
G	29,3	8	12,9	2,7	18,6	4,8	75,1	0	151,4
H	20	9	9,5	5	17,6	3,6	102,9	0	167,6
I	19,8	6,7	10,7	4,7	17,3	5,3	106,3	0	170,8
Aver.±s.d.	18,5	6,6	9,7	3,9	16,7	4,7	86,6	2,3	149,1

The thickness of the pouches ranged between 135.9 and 170.8 ㎛ with an average of 149.1 ㎛. The average thickness of PET, adhesive, Al, adhesive, Ny, adhesive, and CPP of the 9 retort pouches analyzed in this experiment was in the range of 18.5, 6.6, 9.7, 3.9, 16.7, 4.7, 86.6, 2.3 and 149.1 ㎛, respectively. However, it should be considered that the thickness of the film layer could vary, depending on the spot where the measurement is made, because in manufacture the depth of deposited film is not absolutely consistent.

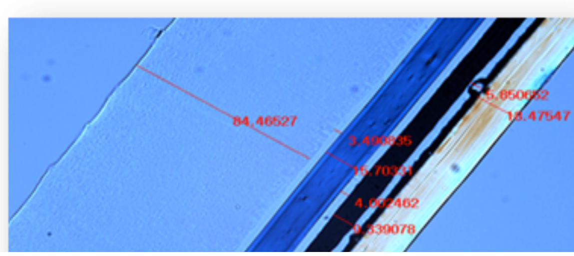


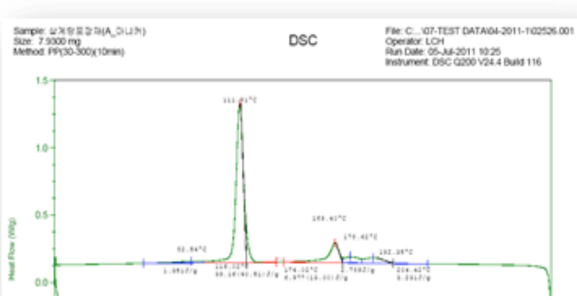
Figure 1. Typical FT-IR analysis of a retort pouch (Film A) used for packaging *Samgyetang*

Figure 2. Typical microscopic analysis of layer composition of a retort pouch (Film A) used for packaging *Samgyetang*

Furthermore, it was confirmed that the printing was done on the reverse side of the PET layer. It was identified that polyolefin was used as an adhesive resin between the film layers by extrusion lamination method. The CPP film in the sealing layer was a single layer using block copolymer PP to impart higher heat resistance and impact strength. Table 2 and Figure 3 show the melting temperature and co-crystallization temperatures of retort pouches used for *Samgyetang* measured by DSC. These were in the range of 118.67–119.72, 160.46–160.71, 202.80–209.21, and 234.94–238.62℃ for PE, PP, Ny and PET. In the PET film, a co-crytallization was confirmed for all of the pouches investigated. The temperature of co-crystallization was lower for C and D pouches, than A and B pouches.

Table 2 Melting temperature (Tm) and co-crystallization temperature (Tcc) of retort pouches used for packaging *Samgyetang* [Unit: ℃]

Sample	Layer								
	PET	Adhesive (PE)	AL	Adhesive (PE)	Nylon	Adhesive (PE)	CPP	PE	Total
A	13.5	5.8	9.3	4	15.7	3.5	84.5	0	136.3
B	17.6	7	10	3.9	17.1	5	81.6	0	142.2
C	17.7	5	10	4.5	15.5	4.5	82.2	0	139.4
D	17	5.6	8.9	4.2	15.7	5.2	79.3	0	135.9
E	18.3	5.6	7.3	2.8	16.6	4.3	79.5	20.9	155.3
F	13.6	7.1	8.9	3.7	16.2	5.8	87.9	0	143.2
G	29.3	8	12.9	2.7	18.6	4.8	75.1	0	151.4
H	20	9	9.5	5	17.6	3.6	102.9	0	167.6
I	19.8	6.7	10.7	4.7	17.3	5.3	106.3	0	170.8
Aver.±s.d.	18.5	6.6	9.7	3.9	16.7	4.7	86.6	2.3	149.1



2. Physical strength of retort pouches

The physical strength of sample B was compared to that of sample A, to assess the plausibility of substitution, as sample B has been used in a *Samgyetang* factory with a view to saving on packaging costs. The thickness of PET layer was reduced from 16 to 12 ㎛, whereas the CPP layer increased from 70 to 80 ㎛, and the material type was changed from 'CPR II' to 'CPR III'. Table 3 shows the results of face drop tests for A and B samples. Seven A sample pouches were burst or damaged and five B pouches by face dropping, and two and three respectively in the edge drop test, as shown in Table 4. These results implied no apparent difference in the number of burst and damaged samples between the two samples, even though the point of burst time and the number of burst samples in each test didn't coincide. However, it was noted that the sample B packages were mainly damaged on the side, whereas the sample A packages were mainly damaged on the bottom. In terms of box damage, no consistent tendency was observed between two treatments.

Table 3 Numbers of burst retort pouches by face drop tests

Sample	Plastic Layer	Drop No.										
		1	2	3	4	5	6	7	8	9	10	Total
A	PET 12 + AL 9 + NY 15 + CPRⅢ 80	0	0	0	0	2	2	2	0	1	0	7
B	PET 16 + AL 9 + NY 15 + CPRⅡ 70	0	2	0	0	1	0	0	1	0	1	5

Table 4 Numbers of burst retort pouches by edge drop tests

Sample	Plastic Layer	Drop No.					
		1	2	3	4	5	Total
A	PET 12 + AL 9 + NY 15 + CPRⅢ 80	0	0	0	1	1	2
B	PET 16 + AL 9 + NY 15 + CPRⅡ 70	1	0	0	1	1	3

The bursting strength test is used to measure the physical property of a package to resist the internal pressure which is induced by the expansion of water vapor during the heating process. As shown in Table 5, the bursting strength of samples A and B were 1.18 kgf/㎠ and 1.24 kgf/cm^2, respectively. The compression test measures the strength to resist any external impact or pressure on the package during distribution. As Table 5 shows, the compression strengths of pouches A and B were 147.7 kgf and 148.8 kgf, respectively. Generally, the bursting and compression strength of sample B pouches were slightly higher than the sample A pouches, however the difference was not significant.

Table 5 Comparison of bursting strength and compression strength between two different retort pouches

Sample	Plastic Layer	Bursting strength (kgf/㎠)	Compression strength (kgf)
A	PET 12 + AL 9 + NY 15 + CPRⅢ 80	1.18	147.7
B	PET 16 + AL 9 + NY 15 + CPR Ⅱ 70	1.24	148.8

IV. CONCLUSION

Film composition and thickness of retort pouches used for *Samgyetang* could be successfully identified by instrumental analyses. By doing this, routine inspection and quality control of packages is possible in the factory to identify the cause of any package defects and the effect of package composition and thickness on the physical preservation of the quality of *Samgyetang* during distribution. Furthermore, the bursting and compression strength of the pouches is likely to be related not only to the thickness of the PET layer but also to the thickness and type of the CPP layer.

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