



Optimized Conditions of Model Processing for Ready-to-eat Style *Galbi-jjim* Prepared by *Sous-vide* and Cook-chill System

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Abstract

To develop ready-to-eat (RTE) style Korean traditional *Galbi-jjim*, the optimal conditions for *sous-vide* cooking and cook-chill preparation and the sensory properties of the cooked products were investigated. During heating, the meat core temperatures reached 85°C within 30 min and 45 min when a water bath and combination oven were used, respectively. Chilling to 3°C within 45 min was conducted to meet the standards for microbiological safety set by the UK Department of Health and Social Security (DHSS) Guideline. *Galbi-jjim* that was vacuum-cooked in a water bath was much more tender than that of *Galbi-jjim* prepared using the cook-chill method, but had no difference in any reheating methods. The average sensory scores of juiciness and the overall acceptance of *Galbi-jjim* were significantly higher when water bath cooking was used, and there were no differences in reheating methods. In conclusion, the serial methods of *sous-vide* processing and rapid chilling can be applied to produce RTE traditional *Galbi-jjim*, and this can be conducted while meeting the standards specified in safety guidelines.

Key words: *Galbi-jjim*, *sous-vide*, cookchill, model processing, safety guideline

Introduction

Recently, the consumption of refrigerated Ready-To-Eat (RTE) type of convenient foods has been remarkably increased worldwide due to dual career family, single mother, single people and senior households (Nyati, 2000). Min (2003) reported that Korean food was introduced to foreigners as healthy and low caloric food. According to Choi (2004) native consumption have preferred the meat ("*Galbi*") for outside the home or menu, and widely known Korean food to foreigner were indicated that "*Kimchi*" (17.5%), "*Bulgogi*" (15.6%) and "*Galbi*" (15.1%). Also, the frequency of domestic consumer's using the restaurant and buying the ready-made foods from the market has been markedly increased (Lee *et al.*, 2007). Therefore, the fresh-type ready meals have a significant market potential, and then developing the pre-cooked or ready-cooked food product is necessary.

"*Galbi-jjim*" is a representative Korean traditional food,

which the seasoned beef short ribs with kinds of vegetables are braised in the pressure cooker. Generally, many Korean traditional dishes including "*Galbi-jjim*" require time-consuming and labor-intensive processing in their preparation and cooking. Thus, simplified processing and standardized recipes should be developed, and then *sous-vide*/cookchill(SV/CC) system can be most applicable to produce the ready-to-heat type Korean traditional foods.

Sous-vide cooking system is defined as raw or partially cooked materials packed with thermostable pouch or container under vacuum condition. This processing is usually performed in the lower temperature (65-95°C) and longer cooking time needed than in the conventional processing (Food Code, 2005; Hauben, 1999; Schelleken, 1996; Vaudagna *et al.*, 2007), and then the cooked products are rapidly chilled, and stored at the temperature below 0-3°C for up to 3-5weeks before reheated for serve (Nyati, 2000; Vaudagna *et al.*, 2002). Recently, *sous-vide* cooking and cookchill system is mostly used in the catering and foodservice sectors, because of its beneficial effect on the economic, labor cost, food quality, and marketing (Creed and Reeve, 1998), and has superior sensory and nutritional quality by vacuum packing (Creed, 1998). Despite of several advantages described above, the micro-

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biological safety should be concerned to produce the highly qualified products processed by *sous-vide* and cookchill system. According to Nyati (2000) and González-Fandos (2004, 2005), there are four main factors to determine the potential microbiological hazards of *sous-vide* products are (i) intense heat treatment of lethality value and monitored time/temperature (ii) rapid and monitored chilling, below 3°C (iii) chilled storage temperature and (iv) any leaks in the pouch enable to *sous-vide*/cookchill post-thermal processing contamination with pathogens.

Over the years, many researchers have studied for developing the convenient product processed by *sous-vide* cooking and cookchill system such as meat products (Armstrong and McIlveen, 2000; Cho *et al.*, 2005; Galimpin-Johan *et al.*, 2007; Jang and Lee, 2005; Jang *et al.*, 2006; Paik *et al.*, 2006; Vaudagna *et al.*, 2002; Vaudagna *et al.*, 2007), fish products (González-Fandos *et al.*, 2004; González-Fandos *et al.*, 2005) and vegetable products (Kim *et al.*, 2001; Koo *et al.*, 2008; Song and Kim, 2007a; Song and Kim, 2007b). However, very few reports are available for minimally processed Korean traditional foods applied by *sous-vide* and cookchill system (Kim *et al.*, 2001; Koo *et al.*, 2008; Jang and Lee, 2005). In addition, less information is available on the physicochemical and sensory aspects that may be crucial in the spoilage of *sous-vide* meat-based dishes stored in refrigerated conditions.

The objective of this study is to develop the optimal recipe for RTE-type “Galbi-jjim” by using *sous-vide* and cookchill method and to evaluate the textural and sensory qualities of “Galbi-jjim”.

Materials and Methods

Materials

Short beef ribs (5 cm-length) were purchased from a local market (Seoul, Korea) and stored in the freezer at -20°C freezer until use. The soy sauce, sugar, pepper and vegetables for seasoning and marinating the beef short ribs (“Galbi”) were from a local market and stored at 3°C until use.

Formulation and preparation of Galbi-jjim

The “Galbi-jjim” was prepared as described in Fig. 1. Briefly, the short beef ribs were sunk in the cold water to remove the blood, and then two hundreds fifty grams of the short beef ribs were boiled in 750 mL of hot water for 10, 20, 40 and 60 min in order to tenderize the meat texture and to eliminate the off-flavor. The boiled beef ribs were marinated in 253 g of the Galbi-jjim sauce (Table 1)

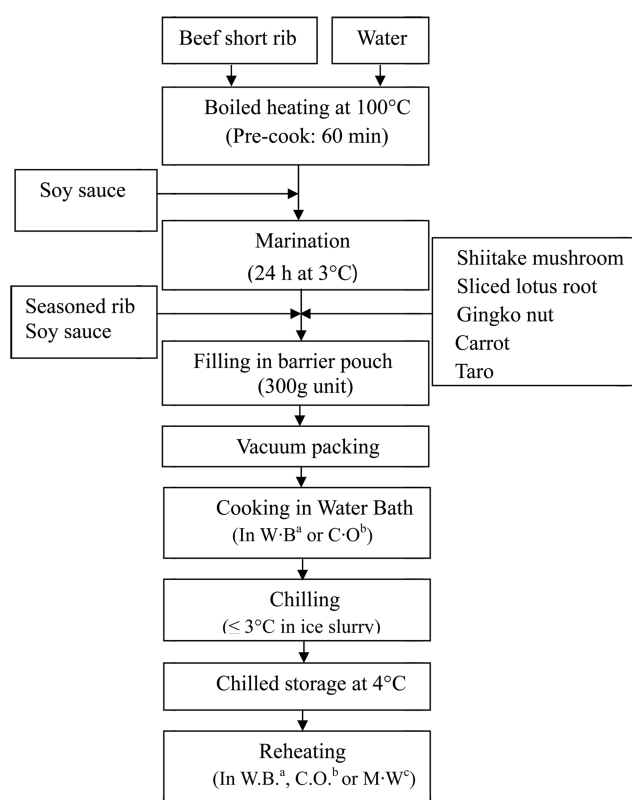


Fig. 1. Schematic process of *sous-vide* and cookchill for Korean traditional Galbi-jjim. W.B.: water-bath, C.O.: combination oven, M.W.: microwave oven.

Table 1. Formulation of Galbi-jjim sauce

Seasoning soy sauce (Raw material)	Contents (%)
Soy sauce	24.24
Water	24.24
Corn syrup	20.47
Sugar	13.27
Distilled liquor (soju)	10.77
Grounded pear	3.38
Grounded green onion	1.82
Grounded garlic	1.08
Grounded ginger	0.13
Sesame	0.20
Sesame oil	0.20
Black pepper	0.20
Total	100.00

at 3°C for 24 hr. As a control, the seasoned beef short ribs were mixed with moderately blanched vegetables such as cube-cut carrot, ginkgo nut, peeled taro, shiitake mushroom and sliced lotus root, and these were individually packed in an aluminum foil sheet, and then cooked in a conventional pressure cooker for 45 min.

Sous-vide and cookchill condition

For *sous-vide* cooking, three hundred grams of mari-

Table 2. Control temperature and guidelines for *sous-vide* cooking

Process	Internal temperature ¹⁾	Guidelines ²⁾
Cooking	85°C for 52 min	UK ACMSF ^a UK ECFF ^b
Chilling	≤ 3°C within 120 min	UK DHSS ^c
Chilled	≤ 5°C	Food code, FDA ^d
Reheating	75°C ≤ within 30 min	UK DHSS ^c
Sensory Evaluation	63°C within 15 min	UK DHSS ^c

¹⁾ Safety of food recommended center temperature and time.

²⁾ Guidelines of *sous-vide*/cookchill system.

^a Advisory Committee on the Microbiological Safety of Food (2004).

^b European Chilled Food Federation (2001).

^c Department of Health and Social Security (2003).

^d Food and Drug Administration (2005).

nated-beef short ribs with blanched vegetables were vacuum-packed in 18 cm × 28 cm multilayered film pouches (Samhosa Co., Seoul, Korea) using a vacuum packer (Samhosa Co., Seoul, Korea) under 760 mm Hg pressure. Vacuum-packed pouches were heated at 90°C for 90 min or 160 min in water-bath (JS Research Inc., Gongju, Korea) or combination oven (DBM Co., Seoul, Korea), respectively. The heating conditions for microbiologically safe *sous-vide* cooking in this study were guide-lined by European Chilled Food Federation (2001) and Advisory Committee on the Microbiological Safety of Food (2004) (Table 2): for heat treatment of equivalent to the 90°C for 10 min (a z value of 7°C) process are 52 min at 85°C or 270 min at 80°C (2001) and equivalent to the 90°C for 10 min (a z value of 9°C) process are 36 min at 85°C, 129

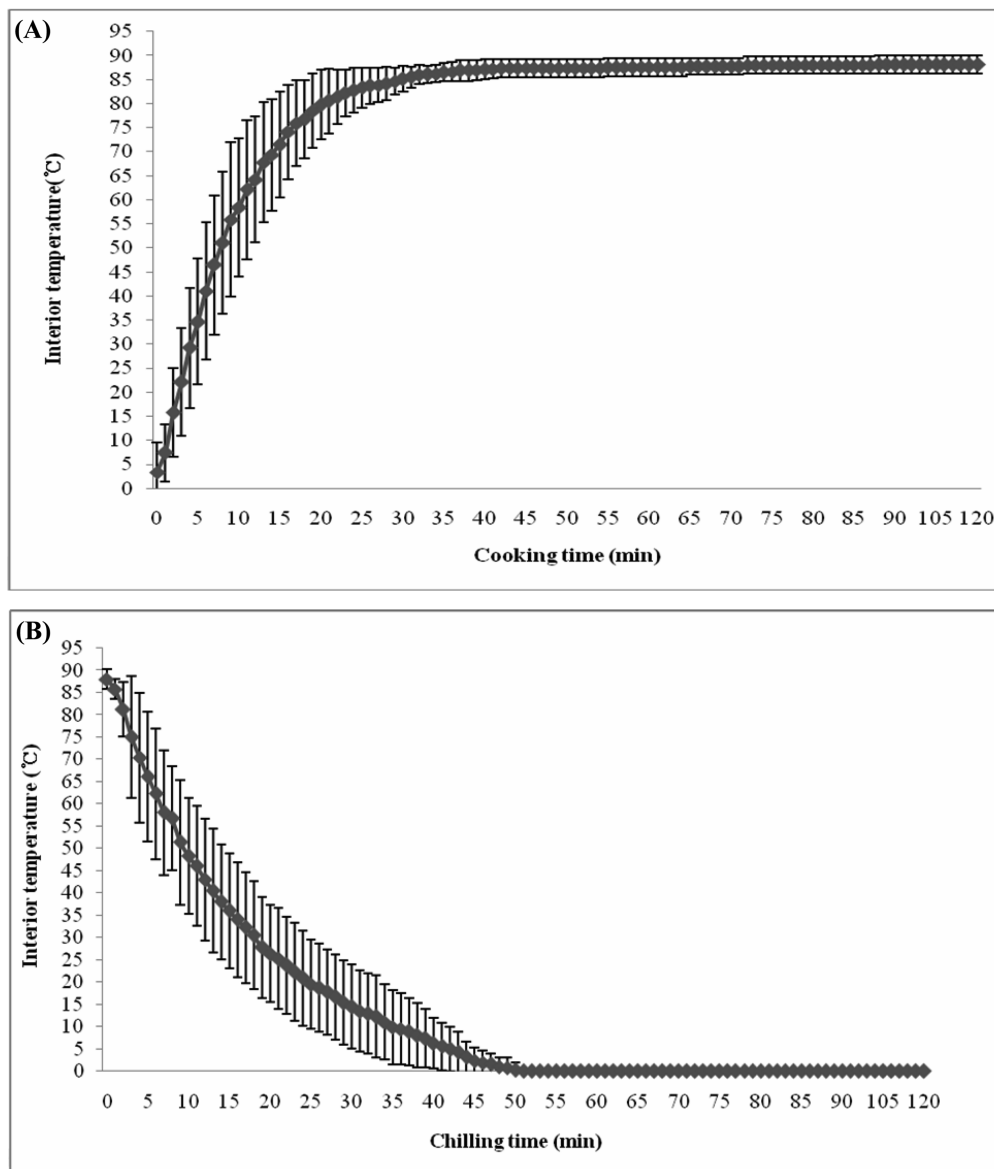


Fig. 2. (A)(B) Core temperature curves of Galbi-jjim during cooking and chilling.

min at 80°C, 464 min at 75°C or 1,675 min at 70°C (2004). The core temperatures of each piece of meat (4.93.13 cm) were measured by using a portable thermometer (K&B Inc., Incheon, Korea) during cooking. After cooking, *sous-vide* processed *Galbi-jjims* were immediately immersed in ice water below 3°C. The chilling condition is followed by the recommendation of the Department of Health and Social Security Guidelines (2003). Chilled samples were stored at 3°C until reheating for sensory evaluation and further analysis.

Texture profile analysis

Texture profile analysis (TPA) was measured using a texture analyzer TA.XT 2i/25 (Stable Micro system, London, UK) at ambient temperature. For the measurements, the vacuum packed samples were warmed in a water bath at 75°C to reach an internal temperature of 72°C, as measured by a portable thermometer. The warmed samples were cut into 1.5 cm × 41.5 cm × 1.5 cm in size and compressed perpendicular to the meat samples with a P/50 cylindrical probe. The testing conditions were: pre-test speed 3.0 mm/s, test speed 1.0 mm/s, post-test speed 1.0 mm/s, strain 80%, time 2.00 sec and force 5.00 g.

Sensory evaluation

For the sensory analysis, the packs of *Galbi-jjim* samples were reheated by using a thermometrically controlled water bath or microwave oven. Reheating condition was followed by the recommendation of Department of Health and Social Security Guidelines (2004). After reheating, the samples were placed on the ceramic plates with lid which was pre-warmed at 80°C in an oven for 10min, and immediately served to the panels.

The sensory evaluations were divided into two sections: at the first section, the trained panels evaluated the optimal condition of pre-cooking time (0, 20, 40 and 60 min before marinating). And then, at the second section, the trained 36 panels evaluated the sensory qualities of *Galbi-jjim* initially prepared by either waterbath or combination oven and reheated by either waterbath or microwave oven. In addition, the consumer preference test was conducted for the attributes of appearance, odor, flavor, texture and acceptability. These attributes were scored using a point scale ranging from 9 (like extremely) to 1 (dislike extremely).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) and Duncan's multiple range test ($p < 0.05$) to determine

significant effects and differences among the experimental treatments. Statistical software version 12.0 (SPSS Institute, Chicago, IL, USA) was used for the analysis.

Results and Discussion

Heating and cooling conditions for the sous-vide cooking *Galbi-jjim*

In this study, the heat treatment condition for microbiological control was subjected to temperature process control of ECFE ($P_{85}^{7.0} = 52$ min) (2001) and ACMFS ($P_{85}^{9.0} = 36$ min) (2004). Changes in an interior temperature were recorded with a portable needle-type thermometer during cooking and chilling. In the process of heating, The meat core temperatures reached at 85°C within 30 min in water bath, whereas within 45 min in combination oven. Thus, in order to satisfy the international standard for microbiological control, the heat treatment was performed at 90°C in water-bath for 90 min and in combination oven for 120 minutes (Fig. 2A). For chilling, the meat core temperatures reached at $\leq 3^\circ\text{C}$ within 45 min in ice slurry (Fig. 2B). In this study, chilling time was followed by specified requirement of DHSS (2003) in case of joint of meat product.

Texture profile analysis

Texture profiles of beef short ribs pre-cooked with 0, 20, 40 and 60 min were shown in Table 3(A). The hardness, gumminess and chewiness of pre-cooked beef short ribs significantly decreased ($p < 0.05$) with extending of blanching time. These results are similar to those of Jang's (2005) report, which longer heated meat was tender than the shorter one. The textural characteristics obtained from different cooking methods such as water bath and combination oven were summarized in Table 3(B). Hardness and chewiness of *Galbi-jjims* were between 13.16 kg and 9.14 kg, and 2.73 and 3.45 in combination oven and water-bath, respectively. This suggested that short beef rib cooked under water bath was much tender than combination oven ($p > 0.05$). Table 3(C) shows the average values of textural characteristics of *Galbi-jjim* reheated with different methods. Prior to the measurement, the samples were reheated at 90°C for 30 min in water bath, at 120°C for 30 min in combination oven and at 700 W for 3 min in microwave oven. As the results, hardness, gumminess and chewiness had no notable difference among the reheating methods ($p < 0.05$). Only, springiness value of *Galbi-jjim* cooked in water bath was significantly higher than in combination oven ($p < 0.05$).

Table 3(A). The average values of the texture profile analysis of different pre-cook time

	Hardness(kg)	Springiness	Cohesiveness	Gumminess	Chewiness
0 min	9.45±3.09 ^a	0.53±0.073 ^{bc}	0.46±0.028 ^a	4.38±1.59 ^a	2.39±1.00 ^a
20 min	6.80±4.14 ^{ab}	0.65±0.83 ^a	0.50±0.04 ^a	3.53±2.37 ^{ab}	2.29±1.52 ^{ab}
40 min	4.03±1.70 ^{bc}	0.60±0.07 ^{ab}	0.38±0.06 ^b	1.61±0.88 ^{bc}	1.01±0.60 ^{bc}
60 min	2.51±1.19 ^c	0.46±0.04 ^c	0.38±0.07 ^b	0.92±0.48 ^c	0.43±0.24 ^c

Data are mean ± standard deviation.

^{abc} Different letters are significantly different ($p < 0.05$) by Duncan's test.

Table 3(B). The average values of the texture profile analysis of different cooking methods

	Hardness(kg)	Springiness	Cohesiveness	Gumminess	Chewiness
W.B.	9.14±0.34 ^a	0.64±0.10 ^a	0.45±0.03 ^a	4.27±1.96 ^a	2.73±1.31 ^a
C.O.	13.16±5.03 ^a	0.55±0.01 ^a	0.55±0.01 ^a	6.22±0.99 ^a	3.45±0.45 ^a

Data are mean ± standard deviation.

W.B. = Water-bath, C.O. = Combination oven.

^{abc} Different letters are significantly different ($p < 0.05$) by T- test.

Table 3(C). The average values of the texture profile analysis of different reheating methods

	Hardness(kg)	Springiness	Cohesiveness	Gumminess	Chewiness
W.B.	10.09±3.13	0.65±0.12 ^a	0.55±0.04	5.58±2.14	3.71±1.73
C.O.	14.38±7.00	0.52±0.07 ^b	0.54±0.06	7.80±4.13	4.17±2.55
M.W.	12.03±2.06	0.56±0.08 ^{ab}	0.56±0.07	6.85±1.90	4.12±1.45

Data are mean ± standard deviation.

W.B. = Water-bath, C.O. = Combination oven, M.W. = Microwave.

^{ab} Different letters are significantly different ($p < 0.05$) by Duncan's test.

Sensory properties of *sous-vide* processed Galbi-jjim

Pre-cooking procedure is necessary to remove the off-flavor from the raw meat and improve of texture. Accordingly, beef short ribs were treated with boiled water under different time (0, 20, 40 and 60 min). Through the first session of sensory evaluation, the optimal pre-cooking time of beef short ribs was determined (Table 4(A)). Interestingly, sensory scores in color, odor, saltiness, sweetness, chewiness and overall acceptance were high in both 20 and 60 min for pre-cooking. And, no pre-treatment for *sous-vide* processed Galbi-jjim gave the worst sensory scores in all sensory attributes ($p < 0.05$).

This can be explained that the pre-cooking time helped to decrease off-flavor of the meats and increase the palatability of final product. Regardless of this result, there could be limitation to be solved empirically. Even though the short beef ribs used for the *sous-vide* cooking were massively purchased from the same store in the same day, the original textures of the meats might be different one another due to the biased fat marbling, muscle density and uneven thickness of muscle and so on. Based on Jang's report (2005) which 20 minute pre-heating did not affect any significant quality changes in the attribute of

beef, the optimal pre-cooking time for *sous-vide* Galbi-jjim was determined 60 min in this study.

Generally, *sous-vide* cooking is performed in both water-bath and steam/forced convection combination oven (Philip, 2000). In this study, the water-bath and combination oven were also used for *sous-vide* processed Galbi-jjim, and subsequent sensory tests were carried out to determine the optimal cooking method for *sous-vide* processed Galbi-jjim (Table 4(B)). The average sensory scores in juiciness and overall acceptance were significantly higher in waterbath-cooked Galbi-jjims than in combination oven ($p < 0.05$). This might be due to texture associated with the thermal conductivity, where in water heat transfer is higher than in air. And, the other sensory attributes between two cooking methods were not different.

Both re-heating method and internal temperature are basically important to contribute the sensory, hygiene (Song and Kim, 2007b) and microbiological safety. Thus, in this study, *sous-vide* processed Galbi-jjim products were reheated with different methods such as reheating at 90°C for 30 min in water bath, at 120°C for 30 min in combination oven and at 700 W for 3 min microwave, and the third sensory evaluation was performed. As shown in Table 4(C), there was no significant different in sen-

Table 4(A). The average values of sensory evaluation of different pre-cook time

	Color	Odor	Salty	Sweety	Chewiness	Overall Acceptance
0 min	4.42 ^b	3.82 ^b	3.92 ^b	4.17 ^b	4.17 ^b	4.50 ^b
20 min	6.50 ^a	5.60 ^a	6.33 ^a	5.83 ^{ab}	6.33 ^a	6.67 ^a
40 min	6.25 ^a	5.18 ^{ab}	5.42 ^{ab}	5.08 ^{bc}	5.58 ^a	5.67 ^{ab}
60 min	7.08 ^a	6.70 ^a	6.33 ^a	6.50 ^a	6.50 ^a	6.25 ^a

Data are mean ± standard deviation.

^{abc} Different letters are significantly different ($p < 0.05$) by Duncan's test.

Table 4(B). The average values of sensory evaluation of different cooking methods

Cook	Color	Odor	Salty	Sweety	Chewiness	Juiciness	Overall Acceptance
W.B.	6.27±1.63	6.30±1.49	5.46±1.68	5.73±1.52	7.08±1.48	6.81±1.47 ^a	6.97±1.44 ^a
C.O.	5.97±1.54	5.76±1.81	5.70±1.76	5.32±1.63	6.43±1.63	5.78±1.51 ^b	5.65±1.62 ^b

Data are mean ± standard deviation.

W.B. = Water-bath, C.O. = Combination oven.

^{ab} Different letters are significantly different ($p < 0.05$) by T-test.

Table 4(C). The average values of sensory evaluation of different reheating methods

Reheated	Color	Odor	Juiciness	Salty	Sweety	Chewiness	Overall Acceptance
W.B.	6.33±1.37 ^a	5.81±1.82 ^a	6.42±1.89 ^a	5.81±1.51 ^a	5.92±1.34 ^a	6.42±1.48 ^a	6.33±1.72 ^a
C.O.	6.00±1.54 ^a	5.56±1.73 ^a	6.50±1.38 ^a	5.92±1.44 ^a	5.86±1.61 ^a	6.50±1.32 ^a	5.92±1.40 ^a
M.W.	5.56±1.90 ^a	5.53±1.76 ^a	5.97±1.65 ^a	5.78±1.64 ^a	5.61±1.59 ^a	6.22±1.62 ^a	5.92±1.90 ^a

Data are mean ± standard deviation.

W.B. = Water-bath, C.O. = Combination oven, M.W. = Microwave.

^{abc} Different letters are significantly different ($p < 0.05$) by Duncan's test.

sory qualities ($p > 0.05$) among the reheating methods. This is well correlated with the results of textural analysis. Several reported that reheating methods have been performed in controlled water-bath (Armstrong and McIlveen, 2000; Díaz *et al.*, 2008), microwave (González-Fandos *et al.*, 2004; González-Fandos *et al.*, 2005; Vaudagna *et al.*, 2002) and steam convection oven (Song and Kim, 2007a; Song and Kim, 2007b). Reheating temperature and time were strictly specified as requirement of DHSS (2003) as follows: the internal temperature of the products removed from the refrigerator should be reached to 75°C within 30 min. Accordingly, our study can be satisfied with international standard of *sous-vide* cooking and could be good possible application to RTE-type Korean traditional "Galbi-jjim".

Acknowledgments

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