
Weon-Sun Shin*, Kyeong Mi Kim⁴, Jin-Hee Park⁵, and Taeim Cho
Laboratory of Food Chemistry, Department of Food and Nutrition, Hanyang University, Seoul 133-791, Korea
⁴Research Institute of Food, OURHOME, Seongnam 462-819, Korea
⁵Food R&D Lab, R&D Center, DAESANG Corp., Ichon 467-813, Korea

Abstract
The aim of this study was to evaluate the physico-chemical, sensory, and microbiological properties of ready-to-eat Korean traditional seasoned beef ribs (“galbi-jjim”) prepared by sous-vide/cookchill technology during storage at three different temperatures (4, 10, and 20°C). Beef short ribs marinated in soy sauce for 24 h at 3°C were packed with vegetables under vacuum. Vacuum-packed beef ribs mixed with vegetables were heated at 90°C for 90 min in a water bath, and then immediately chilled below 3°C within 120 min in an ice slurry. Physicochemical (pH, water activity, TBARS, L*a*b* color, and texture profile), sensory (appearance, odor, flavor, texture, and acceptance) and microbiological (Coliform, *Escherichia coli*, food-borne pathogenic bacteria) properties of the samples were determined during storage at different temperatures.

Results showed that pH, a_w, and sensory evaluation of products were not affected in any consistent way as a function of either storage duration or temperature. Coliform, *E. coli* and food-borne pathogens were not detected during storage at any temperature. However, TBARS significantly increased during storage period (p<0.05). Based on TBARS values, SV/CC “galbi-jjim” can be stored for 15 d, 12 d and 1 d at 4, 10 and 20°C, respectively.

Key words: sous-vide/cook-chill, sensory quality, microbiological safety, temperature abuse simulation

Introduction
Many Korean traditional dishes require time-consuming and intensive labor for preparation and cooking (Paik et al., 2006), whereas they have limited storage stability at normal refrigeration temperature. Consumers demand foods that are convenient, easy to prepare, high quality and preservative-free (Galimpin-Johan et al., 2007; Koo et al., 2008; Paik et al., 2006). As two-income households, working mothers, singles, and seniors have increased, the market for convenient food has grown remarkably. Consequently, the production of intermediate food or ready-to-eat meals in cold chain have become more popular compared to traditional home-cooked meal (Johnson and Resurreccion, 2009).

*Sous-vide/cook-chill (SV/CC) technology* is a cooking procedure originated in France in the mid-1970s. SV/CC system is defined as raw or par-cooked foods are vacuum-sealed in a barrier pouch or container, cooked slowly in controlled mild heating conditions, rapidly chilled, stored at refrigeration temperatures and reheated for consumption (Creed, 1998; Ghazala et al., 1995; Schellekens, 1996; SV/CC, 1991). SV/CC technology is applied to catering industries, food service sectors and ready meal-type food productions (Creed, 1998; Vaudagna et al., 2002).

Previous studies (González-Fandos et al., 2004; Schellekens, 1996) have shown that SV/CC technology is possible to extend the shelf-life from 6 to 42 d. SV/CC applied foods are generally processed using a mild heat treatment and requires a long heating time at low temperature to retain tenderness, juiciness and microbiological safety (bacterial pathogens).

As the points of the quality, SV/CC is a highly advanced technology because of convenience, better sensory quality and retention of water-soluble nutrition than conventional cooked food (Schellekens, 1996; Vaudagna et al., 2008). Nevertheless, anaerobic and temperature abuse conditions of SV/CC cooked foods can cause potential
microbiological hazards during the product circulation and at the consumer level (Schellekens, 1996; Tansey et al., 2005). In our previous report, the optimal textural and sensory conditions of SV/CC processing were investigated to develop the ready-to-eat (RTE) Korean traditional “galbi-jjim” (Kim, Park and Shin, 2009). As a result, the control temperatures of SV/CC processed “galbi-jjim” satisfied the guidelines of ACMSF (Advisory Committee on the Microbiological Safety of Food, U.K., 2004), ECFF (European Chilled Food Federation, U.K., 1996), Food code (FDA, U.S.A., 2005) and DHSS (Department of Health and Social Security, U.K., 2003).

Therefore, the objective of this study was to evaluate the physico–chemical, sensory quality and microbiological safety of the ready-to-eat (RTE) type “galbi-jjim” product at normal refrigeration temperature (4°C) and temperature-abused conditions (10°C and 20°C) (FDA, USA, 2005; ACMSF, UK, 2004) for industrial application.

Materials and Methods

Preparation of sous-vide “galbi-jjim”

Beef short ribs for sous-vide/cookchill were purchased from a local market (Seoul, Korea) and cut into 4.9x3.1x3 cm pieces. The SV/CC “galbi-jjim” was processed as shown in Fig. 1. Briefly, the beef short ribs were submerged in cold water for 2 h to remove blood and cooked in boiling water for 60 min. The pre-cooked beef short ribs were marinated in seasoning sauce for 24 h at 3°C before vacuum packing. Beef short ribs and vegetables (carrots, gingko nuts, taro, and shiitake mushrooms) were vacuum-packaged in nylon/PE/LLDPE pouch (Samhosa Co., Ltd., Seoul, Korea) using a vacuum sealing machine (SH-100/SMV-206T, Samhosa Co., Ltd., Seoul, Korea) under 760 mm Hg pressure. The products were cooked at 90°C for 90 min in a water-bath with a meat core temperature of 85°C/60 min and immediately chilled in an ice slurry jacket until the internal temperature reached ≤3°C within 1 h.

The pasteurization and chilling method was followed to UK ACMSF (2004), UK ECFF (1996), FDA (2005) and UK DHSS (2003) guidelines. Chilled products were stored at 4°C and 10°C were analyzed after 1, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33 and 36 d, and those at 20°C were analyzed after 1, 3, 6, 9, 12 and 15 d.

The water activity (a_w) was determined by the Conway Unit Method (Sibata Scientific Technology Ltd., Tokyo, Japan). Three gram of potassium dichromate (regent A) and potassium mitrate (reagent B) was pur into the outside cell, separately. A sample (1 g) was placed in an aluminum weighing case and the lid, and closed to stand in a thermostat at 25 (±0.5)°C for 2 (±0.5) hours. The water activity (a_w) value was calculated according to the following equations:

\[ a_w = \frac{B \times X - A \times Y}{X - Y} \]

A: a_w value of regent (wet) A
B: a_w value of regent (wet) B
X: increase or decrease of weight with A
Y: increase or decrease of weight with A

The pH measurements (Vaudagna et al., 2008) were performed with a pH meter (Model M530 Pinnacle, Corning, USA). A sample (5 g) was mixed with distilled water (25 mL) for 30 sec using a blender (HMF-505, Han Electric Inc., Bucheon, Korea) and filtered through Whatman filter paper No. 2 (Advantec No. 2/TY2, Toyo, Japan).

TBARS was determined by a modification of the previous methods (Choi et al., 2002; Witte et al., 1970). The

<table>
<thead>
<tr>
<th>Optimization of seasoning sauce</th>
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<tbody>
<tr>
<td>Pre-boiled (100°C/60 min)</td>
</tr>
<tr>
<td>Short ribs marinated (3°C/24 h)</td>
</tr>
<tr>
<td>Vegetables</td>
</tr>
<tr>
<td>Vacuum packaged</td>
</tr>
<tr>
<td>Cooked (90°C/90 min)</td>
</tr>
<tr>
<td>Chilled (≤3°C/60 min)</td>
</tr>
<tr>
<td>Stored (4, 10 and 20°C/36 days)</td>
</tr>
<tr>
<td>Reheated (120°C/30 min)</td>
</tr>
</tbody>
</table>

Fig. 1. The sous-vide/cookchill process of Korean traditional galbi-jjim.
refrigerated sample (5 g) was mixed with 12.5 mL of 20% trichloroacetic acid in 2 M phosphoric acid and homogenized with 10 mL of distilled water for about 40 seconds in a blender (HMF-505, Hanil Electric Inc., Bucheon, Korea). The distilled water was added until the volume reached to 25 mL, centrifuged at 1500 rpm for 15 min using a centrifuge (VS-21SMTi, High Speed Refrigerated Centrifuge, Vision, Seoul, Korea), and filtered (No. 1, Whatman International Ltd., Maidstone, UK). The filtered solution (2 mL) was mixed with 2 mL of fresh 0.005 M 2-thiobarbituric acid solution (TBA) and left for 15 h at room temperature for reaction. The absorbance was measured at 530 nm with a spectrophotometer (Ultraspex® 2100 pro, Biochrom, UK), and the TBARS value was calculated according to the following equations:

\[ \text{TBARS (mg malonaldehyde/kg sample)} = \frac{\text{Absorbance at 530 nm}}{5.2} \]

The meat color was measured both on the surface and in a cross section of cut meat into half with a color meter (Minolta CR-400, Minolta Co., Ltd., Japan). Color was recorded with the Hunter L* value (darkness to lightness), a* value (greenness to redness) and b* value (blueness to yellowness) scale and the instrument was calibrated using a white standard tile prior to use. The calibration value was 96.03 at L* value, 0.16 at a* value and 2.07 at b* value. Triplicate readings per product were performed.

Hardness of the beef short rib was tested using a TA.XT 2i/25 texture analyzer (Stable Micro system, London, UK) during the storage period at room temperature. Beef short ribs were cut into 1.5×1.5×1.5 cm cubes. The panelists evaluated the reheated Park’s galbi-jjim using a 15 point structured scale and the scales used for the sensory evaluation were the following: meat color (1 = very light to 15 = very dark), ingredient color (1 = extremely invisible to 15 = extremely visible), oxidized odor (extremely weak to 15 = extremely strong), off-flavor, off-taste, meat juiciness, saliness (1 = extremely weak to 15 = extremely strong) and overall acceptance (1 = dislike extremely to 15 = like extremely).

**Microbiological analysis**

To determine the microbial quality of stored products, 25 g of sample were aseptically weighed and homogenized in a stomacher (BagMixer®400, Interscience, France) for 2 min with 225 mL of 0.1% peptone water (Difco, Detroit, MI, USA). Decimal serial dilutions in 0.1% peptone water were used for quantification. Cell counts of Escherichia coli and coliform were determined on Petri-film™ E. coli/Coliform Count Plate (PEC) (3M, St. Paul, USA). All the samples were analyzed in triplicate.

Other pathogenic bacteria (Shigella spp., E. coli O157: H7, Staphylococcus aureus, Bacillus cereus, Vibrio parahaemolyticus, Listeria monocytogenes, Yersinia enterocolitica, Salmonella spp.) were detected using PCR assay (Powerchek™ Multiplex-Pathogen Detection kit, Kogene, Seoul, Korea). For the PCR of the enriched sample, 1 mL of enrichment culture was collected after 24 h of incubation. The subsample was centrifuged at 12,000 rpm for 5 min by using microcentrifuge (Micro 17R, Hanil Science Machinery Ind., Co., Ltd., Seoul, Korea). The supernatant was frozen at -20°C. One µL of positive control 1 (E. coli O157:H7, Bacillus cereus, Listeria monocytogenes, Salmonella spp.) or control 2 (Shigella spp., Staphylococcus aureus, Vibrio parahaemolyticus, Yersinia enterocolitica) DNA template was mixed with 9 µL of sterile distilled water and 10 µL of sterile distilled water was used as a negative control instead of a DNA template. Positive control, negative control and sample DNA template were added to 15 µL of primer master mix and amplified by PCR (MyCycler™ Personal thermal cycler, Bio-Rad, CA, USA). Amplification conditions were: 5 min at 94°C, 40 cycles.
Quality Evaluation of Sous-vide Processed Galbi-jjim

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of 30 s at 94°C, 30 s at 60°C and 30 s at 72°C and a final extension of 5 min at 94°C. PCR products were electro-
phoresed through 2% agarose (SeaKem® LE agarose,
Lonza, USA) gel in a TBE buffer (AccuGENE, Lonza,
USA).

Statistical analysis
One-Way Analysis of variance data was done using
SPSS for Windows 13.0 (SPSS Institute, Chicago, IL,
USA) with a factor for storage days. The intensity sen-
sory anaysis was determined Multivariate Analysis of
Variance (MANOVA). Means±SD was calculated by
Duncan’s Multiple Range Test at p<0.05.

Results and Discussion

pH and water activity (a_w)
Water activity was not changed as the storage time and
temperature increased (Fig. 2).

Fig. 3 shows the pH of products measured during stor-
age. The pH values of samples stored at any temperatures
were not significantly (p<0.05) different time increased.
This result was similar to other reports for SV/CC cooked
meat-based products (Galimpin-Johan et al., 2007; Jang
and Lee, 2005).

TBARS
TBARS values of galbi-jjims were measured at the
interval of 3 d during storage at three different tempera-
tures are shown in Fig. 4. In several studies, TBARS
value of meat increased during storage (Witte et al.,
1970) and lipid oxidation in cooked meats stored at an
improper temperature during storage increased (Igene and
Pearson, 1979). Fanco (2002) has reported that TBARS
value is usually below 0.46 mg MDA/kg in raw meat and
Turner (1954) has shown that the lipid oxidation value of
decayed food was 1.2 mg MDA/kg. Also, several research-
ers (Chang and Chen, 1998; Moon et al., 2006) have
reported that TBARS value of Korean seasoned meat was
high due to some ingredients derived from Korean tradi-
tional ingredients such as soy sauce, garlic and ginger. In
this study, the TBARS values of Galbi-jjim stored at 4°C
significantly increased (p<0.00001). The initial TBARS
value was 0.62 mg MDA/kg and then was over 1 mg
MDA/kg after 15 d. After 36 d of storage, the TBARS
value of Galbi-jjim reached 4.13 mg MDA/kg. TBARS
values of galbi-jjim stored at 10°C significantly changed over time ($p<0.00001$). The values increased until 30 d, but rapidly decreased from 3.65 mg MDA/kg to 0.33 mg MDA/kg after 33 d. This result has been in good agreement with Gokalp et al. (1983) and Laleye et al. (1984), which TBARS values increased due to the formation of malondialdehyde (MDA) at initial storage, but decreased by combining with amino acid or carbonyl compounds in the meat product after a certain period. When galbi-jjims were improperly abused at 20°C, TBARS value reached to 1.06 mg MDA/kg after 3 d, suggesting that malondialdehyde more rapidly reacted at 20°C than at 4°C and 10°C. Thus, this result shown that TBARS value mainly depends on both storage temperature and time.

### Hardness

The hardness of galbi-jjim stored at different temperatures was measured with time course. Statistically, the storage time did not influence on the change in hardness of galbi-jjim samples at any temperatures ($p>0.05$). Although, the measurements in hardness of galbi-jjim samples stored at different temperatures were repeated more than 10 times, the precise and homogeneous data among the samples were not obtained as shown in Fig. 5. Therefore, we conferred that meat used for galbi-jjim preparation caused to produce uneven and statistically insignificant data.

### Color

The surface colors of the meat samples were shown in Table 1(A). $L^*$ (lightness) and $a^*$ (redness) value of beef short rib slowly increased with storage days at 4°C. At 10°C, the $L^*$ values were not changed for 18 d, but significantly increased from 22 d (27.26) to 32 d (38.08) ($p<0.05$). And, $L^*$ value of galbi-jjims stored at 20°C was not significantly changed ($p>0.05$) but $a^*$ values markedly ($p<0.05$) increased during storage period. However, Fu et al. (1992) reported that $L^*$ and $a^*$ values were decreased by producing peptides and amino acids because of the

#### Table 1(A). Change in surface colors of Galbi-jjim by sous-vide/cook/chill system during storage

<table>
<thead>
<tr>
<th>Surface color</th>
<th>Storage d</th>
<th>1 d</th>
<th>4 d</th>
<th>8 d</th>
<th>11 d</th>
<th>15 d</th>
<th>18 d</th>
<th>22 d</th>
<th>25 d</th>
<th>29 d</th>
<th>32 d</th>
<th>36 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>L* 4°C</td>
<td>28.37±2.66</td>
<td>30.70±0.76</td>
<td>34.18±5.29</td>
<td>31.71±4.55</td>
<td>34.03±1.64</td>
<td>31.76±3.69</td>
<td>32.27±1.25</td>
<td>34.86±3.31</td>
<td>30.64±5.40</td>
<td>29.38±2.98</td>
<td>34.33±1.14</td>
<td></td>
</tr>
<tr>
<td>10°C</td>
<td>32.13±2.92</td>
<td>31.90±0.62</td>
<td>31.93±3.36</td>
<td>29.78±3.65</td>
<td>31.65±3.70</td>
<td>30.46±2.24</td>
<td>27.26±4.98</td>
<td>29.72±2.62</td>
<td>32.91±1.78</td>
<td>38.08±0.34</td>
<td>34.80±1.58</td>
<td></td>
</tr>
<tr>
<td>20°C</td>
<td>29.82±3.19</td>
<td>29.77±2.44</td>
<td>32.11±0.78</td>
<td>30.99±2.16</td>
<td>30.68±1.18</td>
<td>29.82±1.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a* 4°C</td>
<td>4.67±1.18</td>
<td>6.63±0.38</td>
<td>5.53±1.48</td>
<td>4.54±0.61</td>
<td>3.47±0.31</td>
<td>5.95±0.85</td>
<td>5.68±0.11</td>
<td>6.24±1.05</td>
<td>6.01±0.44</td>
<td>6.35±0.91</td>
<td>6.99±0.29</td>
<td></td>
</tr>
<tr>
<td>10°C</td>
<td>4.69±2.27</td>
<td>4.41±0.64</td>
<td>4.92±0.67</td>
<td>5.88±1.03</td>
<td>4.67±1.50</td>
<td>5.10±0.67</td>
<td>6.21±1.46</td>
<td>5.82±0.55</td>
<td>6.08±0.56</td>
<td>5.96±0.60</td>
<td>5.17±1.12</td>
<td></td>
</tr>
<tr>
<td>20°C</td>
<td>6.53±0.90</td>
<td>6.11±0.62</td>
<td>8.58±0.99</td>
<td>8.26±1.11</td>
<td>8.50±1.78</td>
<td>6.53±1.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Data are mean ± SD.

*Different letters are significantly different ($p<0.05$) by Duncan’s test.

#### Table 1(B). Change in inner colors of Galbi-jjim by sous-vide/cook/chill system during storage

<table>
<thead>
<tr>
<th>Inner color</th>
<th>Storage d</th>
<th>1 d</th>
<th>4 d</th>
<th>8 d</th>
<th>11 d</th>
<th>15 d</th>
<th>18 d</th>
<th>22 d</th>
<th>25 d</th>
<th>29 d</th>
<th>32 d</th>
<th>36 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>L* 4°C</td>
<td>32.11±2.66</td>
<td>34.68±0.76</td>
<td>34.34±3.29</td>
<td>34.69±4.59</td>
<td>34.78±1.64</td>
<td>34.03±3.69</td>
<td>36.88±1.25</td>
<td>35.74±3.31</td>
<td>33.31±5.40</td>
<td>34.23±2.98</td>
<td>33.96±1.14</td>
<td></td>
</tr>
<tr>
<td>10°C</td>
<td>38.27±2.92</td>
<td>35.06±0.62</td>
<td>33.03±3.36</td>
<td>35.34±3.65</td>
<td>25.47±3.76</td>
<td>33.21±2.24</td>
<td>33.59±4.97</td>
<td>29.13±2.62</td>
<td>37.17±1.78</td>
<td>41.51±0.34</td>
<td>32.97±1.59</td>
<td></td>
</tr>
<tr>
<td>20°C</td>
<td>36.19±3.58</td>
<td>35.64±2.84</td>
<td>37.72±2.56</td>
<td>35.76±2.64</td>
<td>34.45±1.17</td>
<td>36.19±1.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a* 4°C</td>
<td>6.74±1.18</td>
<td>7.12±0.38</td>
<td>8.18±1.48</td>
<td>7.22±0.61</td>
<td>8.32±0.31</td>
<td>7.71±0.85</td>
<td>7.64±0.11</td>
<td>6.99±1.05</td>
<td>7.01±0.44</td>
<td>7.90±0.91</td>
<td>8.29±0.29</td>
<td></td>
</tr>
<tr>
<td>10°C</td>
<td>8.55±2.27</td>
<td>7.15±0.64</td>
<td>8.16±0.67</td>
<td>6.98±1.03</td>
<td>7.91±1.50</td>
<td>6.21±0.67</td>
<td>7.55±1.46</td>
<td>8.08±0.55</td>
<td>7.75±0.57</td>
<td>7.45±0.60</td>
<td>8.32±1.12</td>
<td></td>
</tr>
<tr>
<td>20°C</td>
<td>7.38±1.15</td>
<td>7.61±0.56</td>
<td>8.34±1.18</td>
<td>7.89±0.34</td>
<td>8.22±1.31</td>
<td>7.38±2.23</td>
<td></td>
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</tr>
</tbody>
</table>

Data are mean ± standard deviation.

*Different letters are significantly different ($p<0.05$) by Duncan’s test.
degradation of proteins during aging. The b’ values (yellowness) of galbi-jjim stored at 4°C for 4 d were significantly higher than 1 d, but decreased during storage (Data not shown).

Table 1(B) shows the change of the inner color in the SV/CC processed galbi-jjim. During storage, L’ (lightness) values and a’ (redness) values were not significantly changed at 4°C, whereas products at 10°C and 20°C were significantly changed (p<0.05). At 10°C, L’ (lightness) values of inner beef color significantly decreased for 15 d (38.27 to 25.47), but increased after 15 d and a’ (redness) values were slightly changed. At 20°C, L’ (lightness) values decreased and a’ (redness) values increased during storage.

**Sensory analysis**

The sensory qualities of sous-vide galbi-jjim were shown in Fig. 6. The values of saltiness, meat color and meat flavor were significantly changed between 0 to 3 wk (p<0.05) but, the scores of ingredient color, meat texture, oxidized odor, off-flavor and off-taste, meat juiciness and overall acceptance were not changed during storage. Oxidized odor, off-flavor, off-taste values were increased, but not significantly changed (p>0.05). The scores of meat juiciness and overall acceptance were decreased during storage, but were not significantly different (p>0.05).

**Microbiological analysis**

Microbiological analysis of the samples stored at 4°C and 10°C were performed at the interval of 3 d for 36 d. At 20°C, samples were analyzed until 15 d because of swelling of packages. Generally, a high number of coliforms and detection of E. coli in food reflects poor hygienic handling during the production process, inappropriate storage conditions and post-process contamination (Ghazala et al., 1995; Keeratipibul et al., 2009). After being stored for 1 d, coliform and E. coli were not detected in any of the samples at 4, 10 and 20°C and it was demonstrated that SV/CC “galbi-jjim” was properly produced. At 4 and 10°C, microbial growth was not observed until 36 d (Fig. 7). Also, after storage at 20°C until 15 d, coliform and E. coli were not detected, even though packs were visibly swollen. In addition, Food-borne pathogenic bacteria (Shigella spp., E. coli O157:H7, S. aureus, B. cereus, V. parahaemolyticus, L. monocytogenes, Y. enterocolitica, Salmonella spp.) were not detected during storage at any temperature. These results are in agreement with those reported by Jang and Lee (2005), who also found similar aerobic and anaerobic bacteria growth in sous-vide Korean seasoned beef at 4°C and 10°C during the storage, but, bacteria started to grow at 20°C after 9 d of storage. Also, Gonzalez-Fandos (2004) reported that other anaerobic or facultative anaerobic bacteria were found at 20°C during the storage. In general, since temperature abuses can happen during the products distribution, retail or consumer level, the storage temperature cannot guarantee microbiological safety of SV/CC products. Additional hurdles like low pH, aw, and high NaCl contents should be applied. At 4, 10 and 20°C, other pathogenic bacteria except Shigella spp. were not detected during storage periods. However, Shigella spp. was detected after 36 d at 4°C and 10°C and 1 d at 20°C. Even though raw materials were appropriately stored (-20°C in vacuum packaging) and heat treatment was applied according to ACMSF (2004) and ECFF (1996) guidelines, samples can be contaminated during production due to utensils and environmental condition such as air. To ensure microbiological safety of sous-vide products in mass production, Hazard Analysis Critical Control Point (HACCP) system should be applied (Gonzalez-Fandos et al., 2004).

**Conclusion**

Our study has shown that the proper storage of vacuum-packaged and cooked galbi-jjim at 4°C and 10°C did not lead to the hygienic and pathogenic microbiological growth during storage. Also, the qualities in the physico-chemical properties such as pH and water activity of sous-vide processed galbi-jjim were not changed during storage at 4°C and 10°C, and the sensory qualities were
not affected by storage time and temperature. However, the TBARS values of galbi-jjims stored at different temperatures significantly increased with storage time ($p<0.05$). The hardness of galbi-jjim stored at 10$^\circ$C and 20$^\circ$C were lower at refrigerating temperature (4$^\circ$C). This study suggested that sous-vide/cookchill processing can provide a microbiologically safe quality of RTE food products for a relatively long period.

**Abbreviations**

SV/CC, sous-vide and cook-chill; RTE, ready-to-eat; ACMSF, advisory committee on the microbiological safety of food; ECFF, European chilled food federation; DHSS, department of health and social security; PE, polyethylene; LLDPE, linear low density polyethylene; TBARS, thiobarbituric acid reactive substance; TBA, thiobarbituric acid; PCR, polymerase chain reaction; TBE, tris/borate/EDTA; HACCP, hazard analysis and critical control points.

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References


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