EFFECTS OF MEAT ORIGIN AND DONENESS DEGREE ON NUCLEOTIDE BREAKDOWN COMPOUND CONTENT IN COOKED BEEF STEAK

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Abstract – This study investigated the effects of meat origin and doneness degree on nucleotide breakdown compound content in cooked beef steak. The *M. longissimus dorsi* and *M. semimembranosus* from Korean Hanwoo (*Bos taurus coreanae*) and Australian cattle (*Bos indicus*) were cooked to rare, medium, or well-done. Cooked steak from Hanwoo showed higher guanosine 5´-monophosphate (GMP), inosine 5´-monophosphate (IMP), and inosine contents compared to that from Australian cattle. Doneness degree did not influence the contents of GMP, IMP, and inosine in beef steak. Therefore, these findings suggest that Korean Hanwoo beef steak includes more nucleotide breakdown compounds of umami taste than Australian beef steak.

Key Words – meat origin, doneness, nucleotide, cooked steak, Hanwoo beef.

I. INTRODUCTION

Namely, Hanwoo (*Bos taurus coreanae*), Korean native brown cattle, is the most famous as beef cattle among several Korean native breeds. In Korea, the majority of the beef production is dependent on the carcasses of Hanwoo that accounted for 89.7% of the domestic beef carcasses (1). Hanwoo meat is much more expensive than other domestic and foreign-produced beef. Now, the market price of the medium-marbled Hanwoo loin (quality grade: 1) is about US $6.33 per 100 g, whereas Australian loin costs about US $1.44 per 100 g (based on US $1 = 1,124.33 Korean won in Apr 2015). Nevertheless, most Korean people want to purchase the beef from Hanwoo because they have absolute confidence in its deliciousness. Hwang, Park, Cho, Kim & Lee (2) reported that Hanwoo beef had greater flavour intensity compared to imported beef, i.e., Wagyu and Angus meat. In the sensory test by other researchers (3), Hanwoo beef received higher ratings of overall acceptability than Australian cattle meat.

Cattle meat has a variety of flavour precursors, e.g., sugars, ribonucleotides, proteins, fatty acids, and thiamine, that influence the sensory satisfaction of cooked meat (4). These are broken down into low molecular weight products by enzymatic reaction *post-mortem*. The breakdown process of ribonucleotides develops several taste-related compounds including hypoxanthine (Hx), adenosine 5´-monophosphate, inosine 5´-monophosphate (IMP), inosine, and guanosine 5´-monophosphate (GMP) (5). The IMP, inosine, and GMP contribute to umami while the Hx gives the taste of the bitterness (6).

Doneness degree affects the beef flavour. Glascock (7) demonstrated that beef steak cooked to 80°C of internal temperature (IT) had stronger umami compared to that cooked to 58°C of IT. This may be because the degree of doneness has an impact on flavour precursors in cooked beef. Cho et al. (8) described that there were different in some free amino acids between the raw beef from Hanwoo and Australian cattle. However, the comparison study of nucleotide-related compounds between cooked meat from Hanwoo and Australian cattle is still not reported.

In this study, we conducted to compare the nucleotide breakdown compound content among Hanwoo and Australian beef steaks cooked to the three degrees of doneness, i.e., rare, medium, and well-done.

II. MATERIALS AND METHODS

A. Raw materials

Fresh ribeyes and top rounds from the left carcasses (quality grade: 1) of 10 Korean Hanwoo (*Bos taurus coreanae*) steers were purchased from

a local food mart. Chilled-boneless Australian beef (10 ribeyes and 10 inside rounds) were bought from a meat packer. Prior to slaughter, Australian cattle (*Bos indicus*) was fed on a grain for 100 d.

B. Cooking

After trimming, the *M. longissimus dorsi* (LD) and *M. semimembranosus* (SM) were was cut into steaks and cooked in a household-electric oven (Tongyang/Magic, Jung-gu, Seoul, Korea) until the IT attained either to 50°C (rare), 70°C (medium), or 90°C (well-done). Cooked samples were cooled on an ice bath at 2°C for 120 min.

C. Nucleotide breakdown compound extraction

Meat nucleotide breakdown compounds were extracted with the process reported previously by Tikk et al. (9). Sample was mixed with 0.6 M perchloric acid at 2,600 g for 1 min using an Ultra-Turrax (T25 Basic, Ika Werke GmbH & Co., KG, Staufen, Baden-Württenberg, Germany) and centrifuged at 2°C and 5,000 g (Avanti J-E Centrifuge, Beckman Coulter, Inc., USA) for 10 min, and then filtered with a Whatman filter paper No. 1. The filtrate was neutralized with 0.8 M KOH and 0.2 M $KHCO_3$ and centrifuged at 2°C and 5,000 g for 5 min to remove potassium chlorate ($KClO_4$). Final supernatant was filtered with a 0.20 μm syringe filter for analysis using an ultra-performance liquid chromatography (UPLC).

D. Ultra-performance liquid chromatography analysis

The Hx, GMP, IMP, and inosine contents of meat extract were analyzed using an UPLC (Waters Corporation, Milford, Massachusetts, USA) equipped with an Acquity BEH C18 column (2.1 mm × 100 mm × 1.7 μm, Waters Corporation, USA). Triethylamine (150 mM, pH 6.0) and acetonitrile (100%, UPLC grade) were applied as mobile phase A and B, respectively. Injected meat sample (1 μl) was eluted at a flow rate of 0.4 ml/min according to the following gradient: 0 - 1.3 min, 100% A/0% B; 1.3 - 6.0 min, 100% to 94% A/0% to 6% B; 6.0 - 6.5 min, 94% to 100% A/6% to 0% B; 6.5 - 7.5 min, 100% A/0% B. The temperature of the column was maintained at 35°C. Ultraviolet detection was run at 260 nm. The area of the resulted chromatographic peak was quantified as mmol each nucleotide per kg wet sample.

E. Statistical analysis

Data were statistically analyzed by SPSS (10) program. As fixed factors, the effects of meat origin, doneness degree, and their interaction (meat origin × doneness degree) on variables were evaluated by two-way analysis of variance using the general linear model. Duncan's multiple range test was implemented to compare the significant differences among means of treatments at $P < 0.05$.

III. RESULTS AND DISCUSSION

The effects of meat origin, doneness degree, and their interaction on nucleotide breakdown compound content in cooked beef steak from the LD were presented in Table 1. There were the remarkable ($P < 0.001$) effect of meat origin on Hx, GMP, IMP, and inosine contents. Doneness degree did not have a significant ($P > 0.05$) effect on the contents of all nucleotide breakdown compounds. The interaction of meat origin and doneness degree significantly ($P < 0.05$) affected inosine content. The effects of meat origin and doneness degree on nucleotide breakdown compound content in cooked beef LD steak were shown in Table 2. Regardless of doneness degree, cooked LD steak from Korean Hanwoo had higher ($P < 0.05$) the contents of GMP, IMP, and inosine compared to that from Australian cattle. But Hx content was lower ($P < 0.05$) in Hanwoo LD steak than in Australian LD steak. In both cooked LD steaks from Hanwoo and Australian cattle, no significant differences were observed in the contents of all nucleotide breakdown compounds among rare, medium, and well-done.

In cooked beef SM steak, meat origin had a striking impact on Hx ($P < 0.001$), GMP ($P < 0.001$), IMP ($P < 0.001$), and inosine ($P < 0.05$) contents (Table 3). However, the effects of doneness degree and interaction of meat origin and doneness degree were not found. Hanwoo beef SM steak exhibited higher ($P < 0.05$) GMP and IMP contents than Australian beef SM steak (Table 4). On the other hand, cooked SM steak from Hanwoo had lower ($P < 0.05$) Hx content compared to that from Australian cattle. Inosine content was not different among Hanwoo and Australian SM steaks cooked to all doneness degrees. Our results

are consistent with the findings of Park, Lee & Chung (11) who reported that raw beef from Korean Hanwoo had higher IMP and lower Hx contents than that from Australian cattle. Furthermore, similarly, Akinwunmi, Thompson & Ramsey (12) described that doneness degree did not have a strong impact on the concentration of meat component such as cholesterol.

Table 1. Effects of meat origin, doneness degree, and their interaction (meat origin × doneness degree) on variables in the cooked beef steak of *M. longissimus dorsi*

Variables[1]	*P* value[2]		
	Meat origin	Doneness degree	Interaction
Hx	***	NS	NS
GMP	***	NS	NS
IMP	***	NS	NS
Inosine	***	NS	*

[1]Hx: hypoxanthine; GMP: guanosine 5´-monophosphate; IMP: inosine 5´-monophosphate.
[2]NS: not significant ($P > 0.05$); *: $P < 0.05$; ***: $P < 0.001$.

Table 2. Effects of meat origin and doneness degree on nucleotide breakdown compound content (mmol/kg wet sample) in the cooked beef steak of *M. longissimus dorsi*

Items[1]	Korean Hanwoo beef			Australian beef			SEM[2]
	Rare	Med-ium	Well-done	Rare	Med-ium	Well-done	
Hx	2.85[b]	2.68[b]	2.66[b]	5.34[a]	5.33[a]	5.65[a]	0.145
GMP	0.052[a]	0.053[a]	0.057[a]	0.004[b]	0.004[b]	0.007[b]	0.003
IMP	2.16[a]	2.17[a]	2.35[a]	0.34[b]	0.34[b]	0.39[b]	0.109
Inosine	1.36[a]	1.32[a]	1.19[a]	0.84[b]	0.96[b]	0.98[b]	0.029

[a-b]Means in the same row with different superscripts differ significantly ($P < 0.05$).
[1]Hx: hypoxanthine; GMP: guanosine 5´-monophosphate; IMP: inosine 5´-monophosphate.
[2]Standard errors of means.

Table 3. Effects of meat origin, doneness degree, and their interaction (meat origin × doneness degree) on variables in the cooked beef steak of *M. semimembranosus*

Variables[1]	*P* value[2]		
	Meat origin	Doneness degree	Interaction
Hx	***	NS	NS
GMP	***	NS	NS
IMP	***	NS	NS
Inosine	*	NS	NS

[1]Hx: hypoxanthine; GMP: guanosine 5´-monophosphate; IMP: inosine 5´-monophosphate.
[2]NS: not significant ($P > 0.05$); *: $P < 0.05$; ***: $P < 0.001$.

Table 4. Effects of meat origin and doneness degree on nucleotide breakdown compound content (mmol/kg wet sample) in the cooked beef steak of *M. semimembranosus*

Items[1]	Korean Hanwoo beef			Australian beef			SEM[2]
	Rare	Med-ium	Well-done	Rare	Med-ium	Well-done	
Hx	3.46[b]	3.58[b]	3.99[b]	6.38[a]	6.25[a]	6.15[a]	0.150
GMP	0.048[a]	0.043[a]	0.049[a]	0.004[b]	0.009[b]	0.012[b]	0.002
IMP	2.11[a]	1.72[a]	1.97[a]	0.34[b]	0.46[b]	0.47[b]	0.096
Inosine	1.34	1.27	1.25	1.22	1.18	1.11	0.025

[a-b]Means in the same row with different superscripts differ significantly ($P < 0.05$).
[1]Hx: hypoxanthine; GMP: guanosine 5´-monophosphate; IMP: inosine 5´-monophosphate.
[2]Standard errors of means.

IV. CONCLUSION

Cooked beef steak from Korean Hanwoo contained higher umami-related nucleotide breakdown compounds, such as GMP, IMP, and inosine, compared to that from Australian cattle. However, based on wet beef weight, the amounts of nucleotide breakdown compounds were not changed by doneness degree.

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