METABOLIZABLE ENERGY EVALUATION OF THE KOREA TRADITIONAL MEAT FOODS

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Abstract – This study was conducted to evaluate metabolizable energy of the traditional Korean meat foods by using an experimental animal method. The experimental groups were 9 (6 Korean foods and 2 Western foods and basal diet (BD)). Each experimental diet was composed of 70% BD, and 30% experimental food. There were no statistically significant differences in the level of body weight change. The dietary and energy intake of the BD group were lower than those of other groups ($p<0.05$). The fecal and urinary energy loss of the BD group were lower than those of other groups ($p<0.05$). In dry basis, the food apparent metabolizable energy (AME) of samgyetang, bulgogi, samgyeopsal, jeyuk-bokkeum and fried chicken were higher than those of other groups ($p<0.05$). However, in as fed basis, the moisture of foods was responsible to the AME of the foods. The results of this study show that Korean meat foods have different energy content with cooking method and types of meat. Therefore, because Korean foods have considered high-calorie foods based on conventional calorimetry, accurate determination of actual metabolizable energy content must be evaluated by using animal experiments.

Key Words – Apparent metabolizable energy, Meat food, By-difference energy evaluation

I. INTRODUCTION

The concept of food energy has evolved from gross energy to metabolizable energy, and as suggested by Rubner, not all of the gross energy can be used by the body [1]. Metabolizable energy is defined as the difference between the gross energy and the energy excreted as feces and urine [2]. Systematic studies of metabolizable energy of food were conducted by Rubner in Germany and Atwater in the U.S. [3]. Atwater used data from digestibility experiments of proteins, fats, and carbohydrates in humans, and suggested the concept of coefficient of availability. Atwater and Bryant applied this coefficient of availability to the gross energy value of mixed diets. Based on these experiments, they established numbers known as the Atwater factor. The reported Atwater factors for proteins, fats, and carbohydrates were 16.736, 37.2376, and 16.736 kJ/g of available energy, respectively [3].

Because of the recent changes in dietary consumption among Koreans, with high calories and high fat content, nutritional imbalance has become more prevalent and incidences of chronic metabolic diseases have been increasing. Until recently, adult diseases have been relatively less prevalent in Korea than in developed countries, and this can be attributed to the consumption of traditional Korean food [4]. Traditional Korean food uses a variety of ingredients and cooking methods, which helps in maintaining a healthy body. The calculations based on the conversion coefficients do not consider the differences in digestion because of interactions between the different ingredients and changes in the availability in different cooking methods, thus, making the calculated values different from the actual energy the body obtains from such foods. Previously published studies show that the actual metabolic availability in the body and calculated calories using coefficients show a difference of up to 40%.

Therefore, in this study, we aimed to determine the actual metabolizable energy of traditional Korean foods by using an experimental animal method, to show the limitations of using calorimetry based on conversion coefficients. Further, we measured the actual bioavailable energy in Korean foods to show that traditional Korean foods are low-calorie and healthy in terms of the energy metabolism.

II. MATERIALS AND METHODS

Animals and diets

The animals were divided into 9 experimental groups: the basal diet (BD) group, 6 groups with representative Korean meat foods (samgyetang [chicken soup with glutinous rice], seolleongtang [cattle bone soup], galbitang [cattle rib meat soup], bulgogi [cattle meat with onion and soy source], samgyeopsal [roasted bacon] and jeyuk-bokkeum [bacon with hot pepper paste] and 2 groups with Western foods (fried chicken and tonkasu [fried pork cutlet]) [5].

The experimental animal used was the Sprague–Dawley rat with an average body weight of 215.1 ± 5.6 g. Each experimental group consisted of 6–8 rats. The total duration of the experiments was 7 days, including 3 days of adaptation to the diet and 4 days of collecting feces and urine. The nutritional ingredient compositions of the basal diet were listed in Table 1.

Table 1 Formulation of basal diet

Ingredient	Composition
	%
Corn starch	42.809
Casein	17.500
Glucose	13.200
Sucrose	10.000
Soy oil	5.000
Cellulose	5.000
Mineral prem[1]	4.500
Vitamin prem[2]	1.300
Cystein	0.390
Cholin, bitatarate	0.300
BHT	0.001

[1] Vitamin premix provided the following in mg/kg or IU/kg diet: thiamin HCl, 7.8; riboflavin, 7.8; calcium pantothenate, 20.8; niacin, 39; pyridoxine HCl, 9.1; folic acid, 2.6; biotin, 0.26; vitamin B12, 32.5 α-tocopherol acetate, 97.5; vitamin A palmitate, 5200; vitamin D3, 1300.

[2] Mineral premix provided the following in mg/kg diet; Ca, 6429; P, 2007, K, 4629; Na, 1310; Cl, 2020; S, 386; Mg, 652; Fe, 45; Cu, 8; Mn, 13; Zn, 38.5; Cr, 1.28; I, 0.257; Se, 0.19; F, 1.28; B, 0.64; Mo, 0.19; Si, 6.4; Ni, 0.64; Li, 0.13; V, 0.13.

This study was conducted in accordance with the NIH guideline described in the Principles of Laboratory Animal Care and approved by the Animal Ethics Committee of the Korea Food Research Institute.

The gross energy content of the Korean food sample, experimental diet, the feces and urine were determined by completely combusting the samples in a bomb calorimeter (Parr Co., USA). The metabolizable energy of the experimental samples was measured in terms of the apparent metabolizable energy (AME) [6]. The AME was calculated using the following equations:

$$\text{AME (kJ/g)} = \frac{(\text{GEf} \times \text{X}) - \text{Yef}}{\text{Feed Intake (g)}}$$

AME: Apparent metabolizable energy (kJ/g)
GEf: the gross energy per kg of consumed diet (kJ/g)
X: amount of diet consumed
YeF: the total excreted energy (total energy of feces and urine, kJ) of the experimental rats that received the experimental diet

AME per gram test ingredient (kJ/g) =

$$\text{AME per gram basal diet} + \frac{\text{AME per gram test diet - AME per gram basal diet}}{0.3}$$

0.3: the ratio of experimental food to BD

Statistical analysis

All results of the experiments were presented as the mean with SEM, and the variance was analyzed using one-way analysis of variance, and the significance test between the averages was conducted using the Tukey test by SPSS (version 18.0.0, 2009), with $p < 0.05$ as the significance level.

III. RESULTS AND DISCUSSION

In this study, the metabolizable energy of Korean meat foods was measured using experimental animals, to determine the energy content more accurately. Currently, the energy conversion coefficients that are widely used are considered to overestimate the energy content of Korean foods, which are generally made of a variety of ingredients. The level of dietary intake, energy intakes, and fecal and urinary energy losses of each experimental group is listed in Table 2. The gross energy intake of the BD group was lower than those of the other experimental groups ($p < 0.05$).

The dietary AME and the actual AME of the foods (dry basis) were listed in Table 3. The AME of foods were ranged from 4722 to 6144 kcal/kg in dry basis. Whereas, the AME of food in wet basis were range from 589 to 3669 kcal/kg. In spite of the foods were used in this experiment were all meat, the AME of the Korean meat foods and the Western meat foods were varied with the cooking methods and recipe [6]. Therefore, because Korean foods have considered high-calorie foods based on conventional calorimetry, accurate determination of actual metabolizable energy content must be evaluated by using animal experiments.

Table 2 Dietary and energy intakes, and fecal and urinary energy loss[1]

Dietary groups		Intake: Diet (g/rat)	Intake: Energy (kcal/rat)	Energy loss: Fecal (kcal/rat)	Energy loss: Urinary (kcal/rat)
Basal diet (BD)		55.1 ± 14.1[a2]	229.8 ± 58.3[a]	24.0 ± 3.9[a]	7.1 ± 1.4[a]
BD +	Samgyetang	90.0 ± 2.2[bc]	420.3 ± 10.5[c]	33.3 ± 2.9[b]	10.4 ± 0.9[ab]
	Seolleongtang	89.5 ± 8.6[bc]	414.9 ± 39.9[c]	35.3 ± 4.3[b]	19.5 ± 2.5[c]
	Galbitang	100.8 ± 2.9[c]	458.5 ± 13.3[cd]	45.9 ± 1.5[c]	24.5 ± 1.4[d]
	Bulgogi	86.0 ± 3.9[bc]	402.5 ± 18.3[c]	37.0 ± 2.3[b]	11.3 ± 0.6[ab]
	Samgyeopsal	103.0 ± 5.3[c]	491.3 ± 25.1[d]	37.2 ± 3.6[b]	20.8 ± 3.7[c]
	Jeyuk-bokkeum	86.1 ± 4.9[bc]	409.0 ± 23.2[c]	34.2 ± 1.2[b]	9.8 ± 1.2[ab]
	Fried chicken	69.1 ± 12.3[a]	329.9 ± 58.6[b]	20.0 ± 3.0[a]	11.8 ± 2.2[ab]
	Tonkasu	86.4 ± 5.5[bc]	393.2 ± 25.2[b]	30.4 ± 1.4[b]	16.2 ± 2.6[c]

[1] Mean ±SEM, n=6-8
[2] Means in a row with superscripts without a common letter differ, p<0.05.

Table 3 Dietary AME and Food AME[1]

		Dietary AME (kcal/kg diet)	Food AME: Dry basis (kcal/kg food)	Food AME: Wet basis (kcal/kg food)
Basal diet (BD)		3489.5 ± 67.8[a2]		
BD +	Samgyetang	4182.1 ± 19.5[b]	5859.1 ± 65.7[c]	1049.9 ± 11.8[c]
	Seolleongtang	4024.0 ± 26.8[b]	5385.5 ± 91.2[b]	921.4 ± 10.3[b]
	Galbitang	3849.2 ± 29.0[ab]	4722.7 ± 97.2[a]	589.4 ± 12.1[a]
	Bulgogi	4115.6 ± 26.6[b]	5976.4 ± 88.6[c]	1909.0 ± 30.3[d]
	Samgyeopsal	4213.7 ± 40.0[b]	5972.2 ± 134.9[c]	3669.9 ± 82.9[f]
	Jeyuk-bokkeum	4232.2 ± 47.3[b]	6144.0 ± 162.5[c]	2075.4 ± 54.9[d]
	Fried chicken	4288.4 ± 41.2[b]	6243.6 ± 139.2[c]	3097.5 ± 69.1[e]
	Tonkasu	4012.2 ± 15.9[b]	5317.4 ± 53.7[b]	3121.3 ± 31.5[e]

[1] Mean ±SEM, n=6-8
[2] Means in a row with superscripts without a common letter differ, p<0.05.

IV. CONCLUSION

In our study, because the AME of the Korean traditional meat foods were varied with cooking and recipe, the animal experiment were more effective and accurate than the calculation method with Atwater coefficient factors.

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