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Original article

The evaluation of metabolizable energy in traditional Korean food for protein sources

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ABSTRACT

Background: The validity of energy data in the composition table of Korean food has been in question due to possible differences in its chemical composition from that of western food. Traditional Korean food involves a diverse range of food ingredients so there has been considerable doubt regarding the accuracy of the energy level derived from chemical analysis and energy conversion factors.
Methods: This study was undertaken to determine the metabolizable energy of Korean food by animal testing. Cooked foods (12 items) were freeze-dried and fed to Sprague–Dawley rats with body weight 200–300 g to measure apparent metabolizable energy values for 4 days after 3 days of preliminary adaptation to the diets.
Results: When the apparent metabolizable energy values of Korean foods measured in this study were compared with energy values calculated by various conversion parameters such as those of Atwater, Rubner, Sochun, and the Food and Agriculture Organization, there were big differences indicating that the energy values calculated using the other conversion factors are hardly acceptable for many food items.
Conclusion: The various food ingredients involved in the cooking process of traditional Korean food lead to differences between the energy level attained from chemical analysis and from actual animal testing.

1. Introduction

As can be seen by epidemiological research that a westernized diet of high fat, high calories can lead to lifestyle or adult diseases such as obesity, there is a rising need to choose the right kind of food in daily life for a healthy diet. It is largely thanks to traditional Korean food (*hansik*) that lifestyle-dependent diseases are relatively less prevalent in Korea. Traditional Korean cuisine encompasses a wide range of food choices using an array of ingredients and various recipes, and is assessed to be nutritionally superior to western food, especially when it comes to preventing obesity [1]. In particular, a traditional Korean meal consists of staple foods of mainly carbohydrates and side dishes of mainly protein and vegetables so it has the advantage of containing many ingredients that benefit human health [2].

When it comes to food composition, the component with direct relation to obesity is the food calorie, which refers to the sources of energy that are needed for the human body to carry out various life activities such as growth or physical activity. The human body can only be supplied with calories through the consumption of food. This can be a double-edged sword because, depending on the amount of consumed calories, it can either maintain a healthy or unhealthy life. In the past, the main purpose of food consumption was to attain calories for life activities. However, with the advancement of scientific civilization, there is ever less physical activity while the amount of calories consumed is becoming more excessive than needed for conducting physical activity, consequentially leading to lifestyle diseases. Therefore, it is imperative for health reasons that we understand the energy values of food and apply the knowledge to our daily dietary habits. This is why the first thing to do when making a diet plan is to calculate the energy content of the diet based on the person's energy value requirements and reflect other nutrients in the diet plan based on this number.

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In this sense, the actual calorie or energy value of *hansik* may greatly diverge from energy value derived using the existing calorie calculating method of using ingredient components [3]. In past studies, it was found that the difference between metabolizable energy value of food and the calculated one was around 40% at most, and in the case of *hansik* which includes fiber-rich and various ingredients in particular, there is a pronounced gap between the actual energy value and the one from calculations [4]. In *hansik*, which contains much dietary fiber, the calorie level of the food itself can show a difference, but when consumed with rice, this can lower the calorie count utilized in the body from rice which is high in carbohydrates [4,5]. It was found that for these reasons, the caloric value of *hansik* using the current calorie estimation system may be overvalued. In particular, when the caloric values of high-carbohydrate barley rice, brown rice, *gimbap*, and *bibimbap* were measured, the metabolizable energy of these foods were 8.7%, 13.3%, 4.5%, and 17.2%, respectively, lower than those calculated from the existing method. These study findings proved that the calorie count using the calculation method is overestimating the calorie level of *hansik* [4].

This highlights the need to move away from the current western calorie estimation method and develop a new and more suitable method of measuring calories when it comes to *hansik*. Systematic studies on the metabolizable energy in food were conducted by Rubner in Germany and Atwater in the USA [6,7]. Atwater arrived at many findings from digestibility tests based on early studies of Rubner. Using these findings, he proposed the concept of *available coefficient* [8]. The concept of energy in food developed from gross energy to metabolizable energy by Rubner [6]. In particular, Rubner found that the gross energy of food is not all utilized by the human body, and the food's metabolizable energy actually used by the body was defined as the difference by deducting the energy excreted as waste from gross energy [6,7].

Therefore, the aim of this study was to measure the caloric value of *hansik* actually utilized by the human body, and comparing this number with that from the current caloric system as to prove the error in the case of *hansik*'s caloric value and provide its accurate caloric content, thus enabling healthier dietary habits. To this end, the study suggests findings that measured the metabolizable energy contents of nine Korean foods high in protein intake along with three western foods.

2. Materials and methods

The energy content of food is currently measured using four methods: the energy conversion coefficient method; the digestibility coefficient method; human research; and animal testing [9]. For measuring the metabolizable energy, there is also the method of feeding the food concerned to laboratory rats as their entire diet or part of a mixed diet [3]. The first method for feed has the issues of the laboratory rat's preference and nutritional imbalance, so this study minimized such side effects by mixing *hansik* at a 30% ratio with the basal diet [9].

2.1. Procedure and materials

For this study, Sprague–Dawley albino rats at age 8 weeks and 215.1 ± 5.6 g in body weight were used. There were a total of 13 test groups consisting of one group of basal diet (BD) and 12 diet groups with nine *hansik* groups and three western food groups. Each test group used six rats and the test duration was 7 days with 3 days of adjusting to the test feed and 4 days of testing. For the 4 days of testing, the amount of dietary intake and excretion was precisely recorded. The rats were each kept in 30 cm × 30 cm × 30 cm cages (acrylic; Daejong Instrument Industry Co., Ltd, Seoul, Republic of Korea) and supplied with water and feed on a fixed daily schedule. The lighting in the lab facility was controlled by light bulbs, and the indoor temperature maintained at 22 ± 2°C. The rats were left to freely consume the water and feed and other factors were implements in accordance with standard specifications. This animal testing was conducted with the approval of the Animal Testing Ethics Committee of the Korean Food Research Institute (Gyeonggi-do, Republic of Korea).

2.2. Experimental foods

Using basic data research, 12 Korean food items high in protein that are preferred by Koreans and foreigners were selected and produced using the same methods of cooking for typical consumption. The *hansik* items selected were: *bulgoki*, *jeyuk bokeum*, *samkyopsal-gui*, *jang-jorim*, *myolchi-jorim*, fish-*jeon*, *kalchi-gui*, *kodeungo-gui*, *kodeungo-jorim*. The compared western food items were: steak, pork cutlet, and fried chicken (Table 1). The selected items were cooked using the method of Yoon [10] and used in the experiment.

The cooked *hansik* items were freeze-dried and pin milled to 100 meshes in standard particle size to be used as test materials. The 12 Korean food items were analyzed for water, protein, fat, fiber, and ash content using component analysis as to create the proper recommended amount for the tested rats, as shown in Table 2. To prevent water absorption and change, all feed was stored in a −70°C deep freezer (Ilsin Lab., Seoul, Korea), and was air dried for 6–8 hours before proportional mixing and use as test feed. The test feed reflected the nutrient requirements of the test rats, was created by mixing BD 70% and *hansik* 30%, and made as pellets for feeding.

The basal diet mixed corn flour and casein, and the protein content kept at the 10% range to meet the life-maintaining requirements of the laboratory rates. Other nutrients were sufficiently provided in line with the requirements of the U.S. National Research Council (Table 3).

2.3. Analysis of gross energy content of excretion and more

Every day at the same time, the measurement of dietary intake and excretion amount was taken, and the excreted waste was separately collected and used as a test sample for study. The collected feces sample was sprayed with 0.5N sulfuric acid and dried for 48 hours at 75°C, then crushed and stored at −10°C to prevent decomposition and the volatilization of nitrogen content. The collect urinary samples were each added 2 mL of 0.1N hydrochloric acid and kept at 4°C.

The gross energy content of *hansik* samples, test feed, and excretion were combusted and measured using a bomb calorimeter (Parr, Moline, IL, USA). The energy contents of test feed and feces samples were measured by weighing (0.7–0.8 g) and placing in a calorimeter chamber for combustion for estimation of gross energy. Urinal energy was measured by first measuring the weight of the calorimeter container as well as the filter paper (No. 4; Whatman, Haverhill, MA, USA) which was cut to fit the container, and placing a specific amount of the urine stored at 4°C into the filter paper using a pipet for weighing, then thoroughly drying and combusting in the bomb calorimeter. During this time, the temperature of the calorimeter was maintained at room temperature, and benzoic acid (6,307.9 cal/g; Fisher Scientific, Hampton, NH, USA) was the standard substance.

The crude protein, fat, and fiber content of the test feed and collected feces were measured in compliance with the AOAC method [11], and the used analytics tools were AutokjelTech