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# Thermic Effects of Protein from Animal and Plant Sources on Postprandial Energy Expenditures in Healthy Female Adults

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**Abstract.** Recently there are many efforts to increase thermic effect of food (TEF) by changing nutrient sources, which may be relevant for weight loss program. The aim of this study was to compare the thermic effects of different protein sources, animal and plant protein diet, on postprandial energy expenditures (PEE). Seven healthy female university students (mean age 22.3±0.5 yrs) participated in two isoenergetic diet ingestions. Animal and plant protein diet were represented by breast chicken and tofu meal, respectively. Each meal provided 15% of individual energy need, which were composed of 22/18/60 % as protein/fat/carbohydrates. Resting energy expenditure were measured in pre- and post-prandial state (every 30-min during 4 hours) using an indirect calorimetry. There were no significant differences in PEE between chicken and tofu meal. PEE of chicken meal group increased more rapidly (peak at 30 min) than those of tofu meal (peak at 120 min). However, PEE of tofu meal decreased relatively faster after peak time. Total thermogenesis of animal protein diet was 16.8 kcal/4h, higher than plant protein diet's (13.7 kcal/4h), but not significantly different. 8.68% of energy intake in animal protein diet and 6.94% in plant protein diet were oxidized as thermic effects for the digestion and absorption of the diets. Further studies that using higher energy content and protein composition in test meals should be continued to find the adequate protein source for increasing TEF.

**Keywords:** Thermic effect of food, Protein, Diet, Indirect calorimetry, Female adult

## 1. Introduction

Obesity has become one of the primary health concerns in the world since its prevalence increased dramatically. The increase in prevalence of the associated comorbidities such as diabetes, heart disease, hypothyroidism, and fat metabolism disorders, is a significant burden of health care system worldwide [1]. Decrease in energy output and increase in energy intake are two main causes of the development of obesity [2]. The thermic effect of food (TEF) is one among the contributors to energy output, besides energy used for basal metabolism, physical activity, and non-exercise activity thermogenesis (NEAT) [3]. TEF is the increase in energy expenditure above resting, which required for digestion and absorption of ingested food. It is the major form of thermogenesis in humans, accounting for 5% to 15% of the total daily energy expenditure [4].

A number of findings suggest that the TEF of separate nutrients is higher for protein than other macronutrients [5]. It has been speculated that different protein sources may affect TEF differently [6], but only very limited data from human studies on this topic is available. Considering the possible effects of protein source, the present study aimed to compare the thermic effects of animal and plant protein diet, on postprandial energy expenditures (PEE).

## 2. Subjects and Methods

### 2.1. Subjects

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Seven healthy female university students participated in the study. Characteristics of the subjects are shown in Table 1. Subjects were recruited by Department of Food and Nutrition Gangneung Wonju National University (GWNU). The inclusion criteria were if they informed no more than moderate physical activity and were not suffering from chronic disease including diabetes, heart disease, hypothyroidism, and fat metabolism disorders. They were asked not to change their regular lifestyle and physical activity levels during test days.

Table 1. Characteristics of subjects

| Healthy female adults (n=7) | | | |
|---|---|---|---|
| Age (years) | 22.3 | ± | 0.5 |
| Height (cm) | 162.7 | ± | 5.6 |
| Weight (kg) | 51.5 | ± | 9 |
| Body mass index (kg/m$^2$) | 19.3 | ± | 2.2 |
| Waist-hip ratio | 0.76 | ± | 0 |
| Fat mass (kg) | 13.9 | ± | 4 |
| Fat mass (%) | 26.6 | ± | 5 |
| Muscle mass (kg) | 20.6 | ± | 3.7 |

Tabel 2. Composition of the intervention diets

| | Chicken | Tofu | Diff |
|---|---|---|---|
| Energy intake | 15% RMR | 15% RMR | NS [1)] |
| % energy as macronutrient | | | |
| Carbohydrate | 59.90% | 60.80% | NS |
| Protein | 22.20% | 21.70% | NS |
| Fat | 17.90% | 17.50% | NS |

1) Not Significant

## 2.2. Study Design

After an overnight of 8 hours fasting and minimal amount of activity, the anthropometry and resting energy expenditure were measured. They ingested one of the two diets (chicken or tofu protein) prior to 4 hours postprandial energy expenditures measurement. Each subject returned to the laboratory once, for a total of two tests. Written informed consent was obtained from all subjects. This study was approved by Gangneung Wonju National University prior to implementation.

## 2.3. Test Meal

The 2 interventions consisted of diets with different isoenergetic compositions and varied in protein source. Animal protein diet was represented by breast chicken meal and plant protein diet was represented by tofu meal. Both of them were cooked and served with rice and kimchi as Korean breakfast style. Each meal provided 15% of each individual energy need, which was determined by weight, height, and age. **Table 2** describes portion of meal, which composed nearly of 60%, 22%, and 18% energy as carbohydrate, protein, and fat, respectively. This diet composition followed standard menu in Korean population [7]. Meals were prepared at Culinary Laboratory Department of Food and Nutrition GWNU. Food ingredients were weighed to the nearest 0.1 g. Analysis of the macronutrient of the meal was performed using the computerized nutrient composition program Computer Aided Nutritional Analysis Program Version 3.0 (CAN Pro 3.0).

## 2.4. Laboratory Measurement

Anthropometric measurements were carried out by the same investigator. The data included body weight, height, and body composition. Body weight and body composition (fat mass and muscle mass) were measured using the bioelectrical impedance analysis (Inbody720, Biospace Corp., Korea). Weight was obtained with the subject in light clothing and adjusted to the nearest 0.1 kg. Height was measured without shoes and socks and adjusted to the nearest 0.1 cm.

Resting energy expenditure (REE) and postprandial energy expenditure were conducted with indirect calorimetry of a TrueOne 2400 metabolic cart (Model QMC, ParvoMedics Corp., USA), which recorded the amount of $O_2$ consumed and $CO_2$ produced. The ventilated hood system was automatically recalibrated every five minutes during measurement.

Upon arrival to the laboratory, subjects were asked to relax for 10 minutes before measurement. The REE was measured for 15 minutes before consumption of each meal. The 4-h PEE were measured every 30

minutes. No additional foods were permitted for the following 4 hours, during TEF measurement. For all measurements, subjects remained in a supine position in an adjustable bed with their head placed under a transparent ventilated hood connected to monitor by tube. In order to keep in drowsiness, documentary video was provided that can be quietly watched by subjects.

### 2.5. Statistical Analysis

Data were analyzed using the Statistical Analysis System (version 9.2, SAS Institute Inc, Cary, NC). Paired t-test was used to compare postprandial energy expenditure between chicken and tofu meal. This analysis was also used to compare preprandial and postprandial energy expenditure in both meals. Area under curve (AUC) analysis were applied to calculate how much the total amount of TEF during 4 hours measurement.

## 3. Result and Discussion

All subjects completed all 2 interventions, and energy expenditure increased significantly after meal consumption during 4 hours measurement in both animal and plant protein diets (**Table 3**). However the preprandial and postprandial energy expenditure were similar between two diet interventions. The increased energy expenditure associated with the consumption of a meal. The degree to which metabolism increases after meal consumption is strongly related to the energy content [5]. In this study, the energy content of the meal was 15% of the subject's daily energy need. It can be the answer why only small value of energy expenditure increased in postprandial state, which were 61.6~141.5 kcal/day and 48.2~119.6 kcal/day for chicken and tofu meal, respectively (data not shown).

Table 3: Preprandial and postprandial energy expenditure of subjects (unit: )

| | Chicken meal (animal based) | Tofu meal (plant based) | *Difference* (chicken-tofu) |
|---|---|---|---|
| Preprandial state | 1251 ± 225 | 1250 ± 200.1 | *0.7*$^{NS}$ |
| Postprandial state | | | |
| 30 min | 1392.6 ± 266.2**[1)] | 1355 ± 234.5* | *37.9*$^{NS}$ |
| 60 min | 1376.1 ± 228.5** | 1361 ± 246.9* | *15.0*$^{NS}$ |
| 90 min | 1352.9 ± 241.2* | 1351 ± 242.4* | *2.4*$^{NS}$ |
| 120 min | 1371.4 ± 257.5** | 1370 ± 218.6** | *1.3*$^{NS}$ |
| 150 min | 1327.5 ± 258* | 1312 ± 235* | *15.5*$^{NS}$ |
| 180 min | 1331.4 ± 254.4** | 1304 ± 212.5* | *26.6*$^{NS}$ |
| 210 min | 1348.6 ± 266.4* | 1324 ± 233.4* | *24.9*$^{NS}$ |
| 240 min | 1321.7 ± 231.2** | 1299 ± 1298.6* | *14.1*$^{NS}$ |

*: $p< 0.05$; **: $p< 0.01$

1) Significantly different by Paired t-test between preprandial and postprandial state

2) Not significant between chicken and tofu meal

The thermic effect of both meals, which was the increased energy expenditure, are expressed in Figure 1. Chicken meal reached the peak as soon after ingestion (at 30 min). The peak of tofu meal was reached more late (at 120 min). TEF after chicken meal typically laid above those after tofu meal ingestion during 4 hours measurement. Exploration using Area Under Curve (AUC) analysis demonstrated that total thermogenesis of animal protein diet was 16.8 kcal, higher (not significant) than 13.7 kcal of tofu meal's (Figure 2). This result was probably due to lower composition of protein in the meal as standard menu. Similarly with present study, Tan et al [8] observed that during 8 hours stay in respiratory chamber, total PEE was slightly higher in participants who were served meals containing meat as the main protein source than those who received soy protein meals, but not significant. Other study reported that the animal protein diet produced a greater increase in total PEE than plant protein diet, which suggest different source of meals may invoke different

thermogenesis response [9]. They used pork and tofu as animal and plant protein based diet in higher composition (29%), whereas in this present study composition of protein was only 22%.

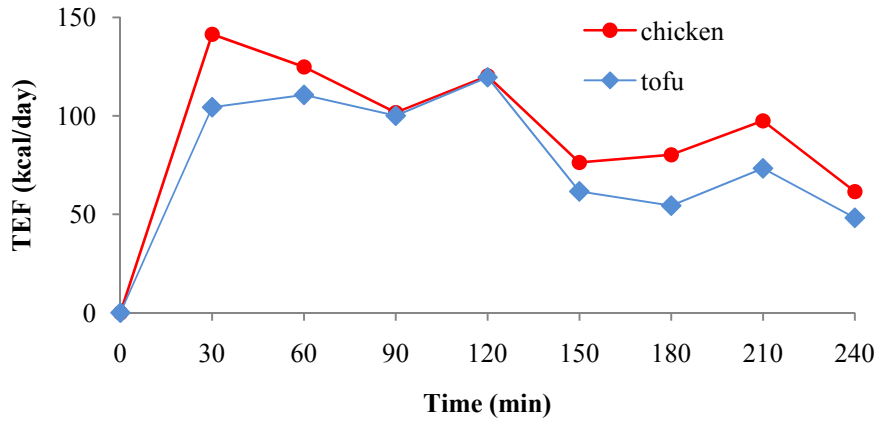


Fig. 1: TEF curve at each 30-min over 4 hours after meal

**Figure 3** describe the ratio of thermic effect both of meals and energy intake. 8.68% of energy intake in chicken diet and 6.94% in tofu diet were oxidized as thermic effect. In line with this result, Schutz et al [4] observed that 5-15% of total daily energy expenditure is typically accounted from diet induced thermogenesis. Other study also reported that among macronutrients, protein has a higher thermic effect than carbohydrate and fat [10]. The percentage of energy intake was low in this study due to the macronutrient composition followed to standard menu (not high in protein). On the other hand, the measurement of postprandial energy expenditure was only during 4 hours. The thermogenesis process may still continue after 4 hours. It can be confirmed that at last minutes the TEF of chicken and tofu meal were 61.6 kcal/day and 48.2 kcal/day, respectively.

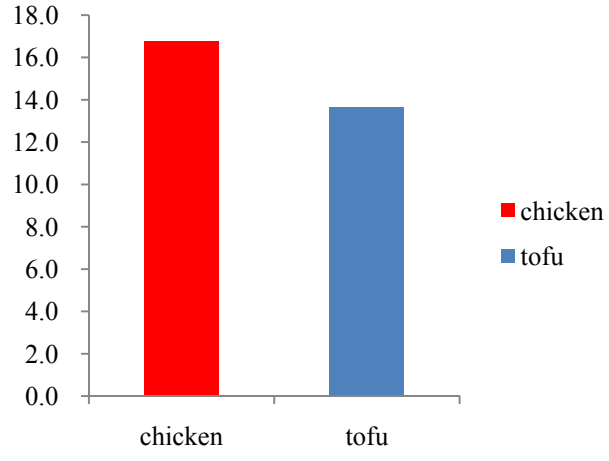


Fig. 2: Total of TEF over 4 hours postprandial

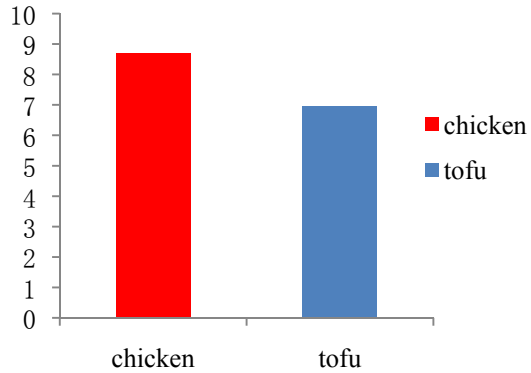


Fig. 3: Percentage of energy intake as TEF

The strength of our study is well-controlled measurements of anthropometric variable and resting metabolic rate. The limitation is we did not control for the pattern of menstruation in subjects, which may influence the metabolism. In conclusion, we suggest that in the standard composition of protein in meals, postprandial thermogenesis seems to be similar between animal and plant protein based diet. Hence, we prompt to explore the further studies related to this finding. A longer measurement period with higher calorie amount and higher protein composition in the diet can be the alternative to get valuable thermic effect, which may be relevant for weight loss program.

## 4. Acknowledgemments

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