STUDIES ON THERMIC EFFECTS OF CHICKEN

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***Abstract*— The purpose of this study was to elucidate the mechanism of chicken-induced thermogenesis and the components that induce thermogenesis. After intake of experimental diets containing fractionized chicken, the body temperatures of rats fed diets containing lean chicken, namely fat-insoluble components, were higher than those of rats fed other diets. In addition, serum thyroid hormone was positively correlated with body temperature, and lipid metabolism tended to be facilitated by the intake of lean chicken. These results suggested that the thermic effect of chicken is due to an increase of thyroid hormone and the facilitation of lipid metabolism by the intake of fat-insoluble components in chicken.**

***Index Terms*—body temperature, thermic effect, thyroid hormone, lipid metabolism, chicken.**

I. INTRODUCTION

Energy is expended by our body when we consume (bite, chew and swallow) and process (digest, transport, metabolize and store) food. This process is known as diet-induced thermogenesis (DIT), specific dynamic action (SDA) or thermic effect of food (TEF). Chinese medicinal herbs in Traditional Chinese Medicine (TCM) are classified according to "the four natures": cold, cool, warm and hot. Many foods, including meat, have also been classified according to the four natures. Sheep meat, chicken, dog meat and some meats, have been classified as “warm”, and it has been empirically believed that such meats have a higher thermic effect than that of other meats. We previously reported that sheep meat has a high thermic effect ("Fujii, Nishimura and Wakamatsu. (2009)"). Thus, chicken may also have a high thermic effect. The results of our preliminary study showed that body temperature was elevated in rats by intake of chicken. Chicken is good for digestion and has many physiologically active substances ("Cornet and Bousset. (1999)" and "Ikeda, Nishijima, Kiso, Ono, and Moritani. (2001)"), but it is not known what contribute to the thermic effect of chicken. Thermogenesis is also controlled by some hormones including adrenaline, noradrenaline, corticosteroid and thyroid hormone. Capsaicin in red pepper and gingerol in ginger stimulate sympathetic nerves in which adrenaline and noradrenaline are transmitters, resulting in thermogenesis ("Diepvens, Westerterp, and Westerterp-Plantenga. (2007)" and "Liu, and Simon. (1996)"). However, it is not clear whether hormones are involved in thermogenesis by eating chicken.

Therefore, the aim of this study was to elucidate components contributing to the thermic effect of chicken and the mechanism by which body temperature is elevated by measuring levels of hormones related to thermic effect.

II. MATERIALS AND METHODS

Chicken (legs) was purchased from a domestic market. Fractionation of chicken was performed as follows. First, minced chicken was freeze-dried (freeze-dried chicken : FDC). Then defatted chicken (DFC) was prepared from FDC with hexane, and chicken fat (CF) was extracted from adipose tissue and skin of chicken with hexane.

Five-week-old male Wistar rats were obtained from Japan Laboratory Animals Inc. (Tokyo, Japan). The animals were housed individually with a 12-h light-dark cycle (lights on from 1000 to 2200) in an isolated room at a controlled temperature (22-24°C) and humidity (40-60%).

Before starting the experiment, all animals were acclimated to a control diet (Ctrl) for one week. Based on AIN-93G, experimental diets (C, F, and D) were prepared by using FDC, CF, and DFC as shown in Table 1. After fasting for 18 h, the experimental diets were given to animals for 2 h. The body temperature of each animal under anesthesia was measured in a room with controlled temperature (33°C) after 2 h of feeding. At the same time, thermal images were obtained with a TVS-200 thermography system (Japan Avionics Inc.) and then blood was collected. The levels of adrenaline and noradrenaline in plasma and the levels of thyroid hormone (triiodothyronine and thyroxine), adrenocorticotropic hormone (ACTH), glucose, triglyceride (TG), non-esterified fatty acid (NEFA) and 3-hydroxybutyric acid (3-HBA) in serum were measured. The experimental plan of this study was approved by the Laboratory Animal Care Committee of Hokkaido University.

III. RESULTS AND DISCUSSION

The body weights and the amounts of feed intake are shown in Table 2. There was no significant difference between the four groups.

After intake of the experimental diets, the body temperature of animals were measured and thermal images of the bodies were obtained. The body temperatures of animals fed C and D diets were higher than those of animals fed Ctrl and F diets (Fig. 1). Thermogenesis of animals fed C and D diets was also observed all over the bodies including the distal parts of all four limbs in the thermal images (Fig. 2). Both C and D diets included lean meat of chicken with no fat. Therefore, lean chicken, namely fat-insoluble components in chicken, may contribute to the thermic effect of chicken. In addition, remarkable thermogenesis was not observed on the interscapular brown adipose tissue, which plays a major role of thermogenesis in rat, suggesting that thermogenesis of animals fed C and D diets was not a specific action in brown adipose tissue.

Next, we measured the levels of hormones (adrenaline, noradrenaline, triiodothyronine, thyroxine, and ACTH) and metabolism components (glucose, TG, NEFA and 3-HBA) in plasma or serum. There was no significant difference in the levels between the four groups (data not shown). However, thyroxine showed a significant positive correlation with body temperature between individuals, and the coefficient of correlation tended to be high between groups (Table 3). These results suggested that intake of lean chicken facilitated the secretion of thyroid hormone, resulting in elevation of body temperature. It has been reported that amino acid composition influences the secretion of bile acids ("Liaset (2009)") and that bile acids facilitate the activation of thyroid hormone ("Watanabe (2006)"). Therefore, we need to investigate the involvement of bile acids in the thermic effect of chicken. On the other hand, adrenaline and noradrenaline tended to be negatively correlated with body temperature between individuals and between groups. These results suggested that, unlike capsaicin and gingerol ("Diepvens, Westerterp, and Westerterp-Plantenga. (2007)" and "Liu and Simon. (1996)"), the thermic effect of chicken is not due to sympathetic nerve stimulation. In additon, ACTH tended to be positively correlated with body temperature between groups. Therefore, we need to investigate the involvement of ACTH in the thermic effect of chicken. Blood glucose contents tended to be correlated negatively with body temperature between groups, suggesting that sugar metabolism might be facilitated by the intake of fat-insoluble components in chicken. However, since we measured only one component of sugar metabolism, the involvement of sugar metabolism in the thermic effect of chicken needs to be investigated. TG contents tended to be negatively correlated with body temperature between the four groups, and NEFA and 3-HBA contents tendend to be correlated positively between the four groups. In high temperature groups fed C and D diets, TG might be degraded into metabolites, namely NEFA and 3-HBA, and consequently body temperature might be elevated. Therefore, these results suggested that the intake of fat-insoluble components in chicken facilitated lipid metabolism.

IV. CONCLUSION

Intake of lean chicken, namely fat-insoluble components, induced an elevation of body temperature and there was no specific action in brown adipose tissue. The thermic effect of chicken seems to be due not to sympathetic nerve stimulation as in the case of capsaicin or gingerol but to the facilitation of thyroid gland stimulation and lipid metabolism.

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Table 1 Sources of protein and fat in experimental diets

Group	Protein	Fat
Ctrl	Casein	Corn oil
C	FDC	CF
F	Casein	CF
D	DFC	Corn oil

Each experimental diet contained 20% protein and 7% fat and was formulated on the basis of AIN-93G. FDC : freeze-dried chicken, DFC : defatted chicken from FDC, CF : chicken fat.

Table 2 Body weights and amounts food intake

Group	Body weight (g)	Amount of feeding (g)
Ctrl	168.0±12.2	6.36±0.55
C	175.4±14.1	5.93±0.83
F	169.9±8.04	6.10±0.75
D	178.2±10.0	6.06±0.89l

Data are shown as means ± SE (n=7).

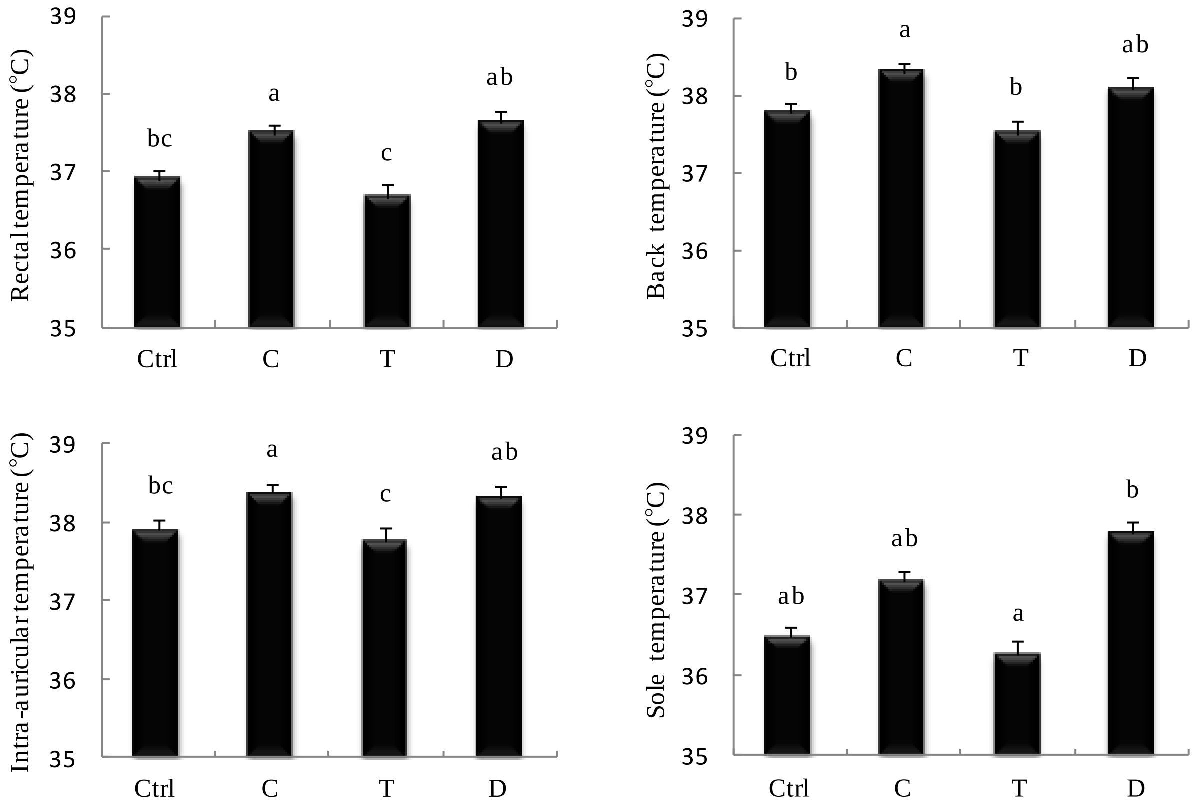

Fig. 1 Body temperatures after 2 h of intake. Values bearing different letters are significantly different (P<0.05).

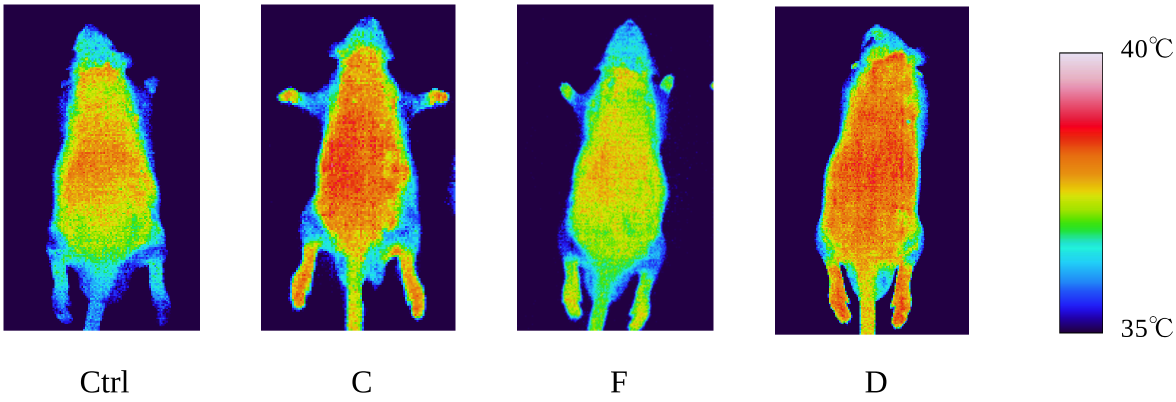

Fig. 2 Thermal images of rats after 2 h of intake.

Table 3 Coefficients of correlation of body temperatures with contents of hormones and metabolic parameters in blood after 2 h of intake

	Between groups				Between individuals			
	Rectum	Back	Intra-auricule	Sole	Rectum	Back	Intra-auricule	Sole
Triiodothyronine	-0.24	-0.23	-0.11	-0.27	-0.06	-0.02	0.08	0.07
Thyroxine	0.88	0.94	0.85	0.92	0.39*	0.42*	0.44*	0.51*
ACTH	0.79	0.87	0.75	0.88	0.34	0.31	0.32	0.25
Adrenaline	-0.51	-0.63	-0.31	-0.77	-0.04	-0.25	-0.13	-0.09
Noradrenaline	-0.07	-0.15	0.13	-0.31	-0.04	-0.04	-0.12	-0.02
Glucose	-0.88	-0.95	-0.84	-0.94	-0.18	-0.31	-0.13	-0.09
TG	-0.63	-0.56	-0.56	-0.50	-0.07	-0.07	0.00	-0.12
NEFA	0.48	0.61	0.28	0.77	0.29	0.24	0.16	0.33
3-HBA	0.77	0.64	0.89	0.43	0.22	0.16	-0.20	0.23

*: $P<0.05$