EFFECT OF DUCK MEAT CONSUMPTION ON BASAL METABOLIC RATE OF SPRAGUE-DAWLEY RATS

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***Abstract*—the purpose of this study was to investigate effects of duck meat consumption on basal metabolic rate (BMR) of Sprague-Dawley rats compared with a soybean protein diet. Two different diets were prepared, i.e. duck meat diet (33.8% protein, 7.03% fat, 15.40 kJ/g, dry matter) and control diet (33.8% protein, 7.03% fat, 15.40 kJ/g, dry matter). Oxygen consumption rate and rectal temperatures were determined in rats over the period of 30 days, while serum free triiodothyronine (FT3), triiodothryonine (T3), free thyroxine (FT4), thyroxine (T4) and thyroid stimulating hormone (TSH) levels were also measured. Results showed that both diet groups had similar trends in changes of those parameters. However, the duck meat diet group had significantly lower oxygen consumpution rates after day14 at each measurement, lower serum FT4 levels on day15 (P=0.053) and day30 (P<0.001), and lower serum T4 level on day15 (P=0.058). In addition, although there was no significant difference in rectal temperature between the two groups, duck meat diet group had a lower rectal temperature at each measurement from day0 to day30. These findings suggested that duck meat consumption, compared with soybean protein, decreased the BMR. Moreover, duck meat consumption decreased the function of thyroid by inhibiting the dissociation of T4 into FT4. This may explain the reason for the lower oxygen consumpution rate in duck meat diet group.**

***Index Terms*—basal metabolic rate, duck meat, oxygen consumption rate, thyroid hormone**

I. INTRODUCTION

Meat is a basic food resource in the diet, particularly in the developed countries (Delgado, 2003;Rosegrant, Gerpacio, 1999;Speedy, 2003). In general, meat is usually divided into two broad categories, red meat or white meat (McAfee et al., 2010; Song, Manson, Buring & Liu, 2004; Williamson, Foster, Stanner & Buttriss, 2005). However in China, in addition to simply red or white meat typed, meat has been further categorized by its perceived effect on inherent satisfaction following consumption, For example, in the central and southern regions of China people like to eat duck meat during the warmer months of summer rather than at other times of the year because they believe it confers a beneficial wellbeing effect. Conversely, other meats such as sheep meat confer different other perceived beneficial effects during cooler periods.. In other Asian countries, including Korea, Japan and Southeast Asia, similar practices have been followed for thousands of years, but there is no adequate scientific explanation for the belief. In order to address this issue we put forward a hypothesis that these observations result through altering the BMR by hormonal action. Here, we propose that when eaten, duck meat lowers the BMR, thus confering an altered state of wellbeing.. Therefore, the objective of this work was to investigate the effects of duck meat consumption on the BMR of rats compared with injestion of an energy-equivalent soya protein diet. As hormones are essential for the control and regulation of cellular activity we have investigated these dietary effects on the secretion of thyroid hormone (TH), comprising, FT3, FT4, T3, and T4 (Silva, 2001), These hormones are considered the prime controllers for the regulation of metabolic functions and thermogenesis in mammals and birds (Danforth & Burger, 1984; Silva, 1995; McNabb, 2000). The outcome of this study may shed some light on the impact of duck meat on the basal metabolism of the human body.

II. MATERIALS AND METHODS

A. Animals and diets

A total of 50 male Sprague-Dawley (SD) rats weighing 80 – 100 g were obtained from the Zhejiang laboratory animal center (Zhejiang, China). All animals were handled in accordance with the guidelines of the Principle of Laboratory Animal Care (NIH Publication No. 85–23, revised 1985).

Rats were given free access to control diet and water for 5 d before the start of dietary adaptations, and kept in a constant temperature (20 ± 1 °C) and humidity (60 ± 10 %) environment with a 12-h light/dark cycle. Ten rats were selected randomly and killed by decapitation at the start of experiment (day 0). The remainder were then randomly allocated to receive duck meat diet or control diet (Table1). On day 15, half the rats in each group were killed by decapitation, and the remainder were killed on day 30.

Table 1 -Diet composition

Ingredients	Content, g/kg	
	Control diet	Duck meat diet
Soybean protein (g/kg DM)[a]	289.10	—
Duck meat [b](g/kg DM)	—	289.74
Duck fat (g/kg DM)	—	33.30
Soybean oil	46.60	
Corn [c] (g/kg DM)	435.00	437.22
Wheat bran [d] (g/kg DM)	187.82	187.53
Limestone power [e] (g/kg DM)	21.56	21.56
Calcium bicarbonate (g/kg DM)	2.94	2.94
Salt (g/kg DM)	3.27	3.27
Feed Premix[f] (g/kg DM)	5.44	5.44
Total protein (g/kg DM)	338.12	338.12
Total fat (g/kg DM)	70.31	70.32
Total carbohydrate (g/kg DM)	425.81	425.78
Metabolizable energy (kJ/g DM)	15.40	15.40

[a]DM, dry matter.

[b] Duck breast meat was ground and then dried in oven at 80 ± 2°C, and then pulverized.

[c]Corn, [d] wheat bran and [e]limestone powder meet the Chinese national standards GB/T 17890-2008, GB10368-89 and GB13078-2001, respectively.

[f]Feed Premix contained (g/1000g): 310 calcium hydrogen phosphate, 50 salt, 20 Lysine, 20 Methionine, 40 microelements, 10 Tert-butylhydroquinone, 40 calcium lactate, 50 calcium propionate, 5 xylo-oligosaccharides, 10 Vitamin Premix TF-1 (Ramikal-Werkhansmlchelsen Gmbh & Co.), 5 sweetener, 440 Corn meal.

B. Rectal temperature

Eight rats were randomly selected from each group and rectal temperature was determined using a digital rectal thermometer, taken at 4:00pm at 7-8 day intervals.

C. Oxygen consumption rate

Measurement of oxygen consumption rate in rats commenced at the start of dietary treatments and was repeated at 7-8 day intervals until end of trial. Room temperature was maintained at a constant 20 ± 1 °C.

An oxygen consumption rate measuring device was designed by our laboratory (Fig. 1) essentially as described by Perez, Eatwell & Samorajski (1980). For measurements, individual rats were put in a hermetic container (3000ml), which contained 15 g soda lime to absorb CO_2. The chamber was then clamped and recordings were started. The ink solution level rose as the O_2 was consumed by the rat. When the air volume had decreased by 5 mL (indicated by graduated tube), the time was recorded. The Oxygen consumption rate was determined as mL of O_2 per minute per kg of body weight according to formula below:

$$\text{Oxygen consumption rate} = \frac{5ml}{Time(\min) \times Weight(kg)}$$

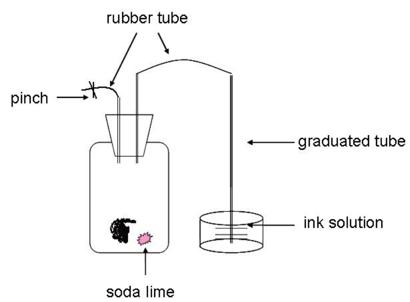


Fig. 1 Oxygen consumption rate measuring device

D. Serum TH levels

Twenty-four hours after oxygen consumption rate measured, blood was collected in 10ml tubes and centrifuged at 5,000 g for 10 min to separate out the serum. Serum thyroid hormone levels were determined using a modified method by Zhang, Blomgren, Kuhn & Cooper-Kuhn (2009). Thyroid hormone status was determined by measuring concentrations of FT3, T3, FT4 and T4 using a radioimmunoassay kit (Beijing North Institute of Biological Technology, Fengtai District, Beijing, China). The concentration of TSH was also measured.

E. Statistical analysis

Data were reported as the mean ± SD. Statistical analysis was performed using one-way analysis of variance (ANOVA) with diet as a factor. The Statistical Package for the Social Sciences (SPSS 16.0) was used for all analyses.

III. RESULTS AND DISCUSSION

The BMR (and the closely related resting metabolic rate, RMR), is the amount of energy expended while at rest in a constant temperate environment. The rate of energy expenditure, as measured in terms of oxygen consumption rate (McNab, 1997; Koteja, 1987) shows the duck meat diet group (Fig. 2) was not significant different from controls on day7, but some differences were observed on day14 (P=0.069), day21 (P=0.067) and on day29 (P=0.056). The results verified our hypothesis of the study that duck meat diet, compared with soybean diet could decrease the BMR.

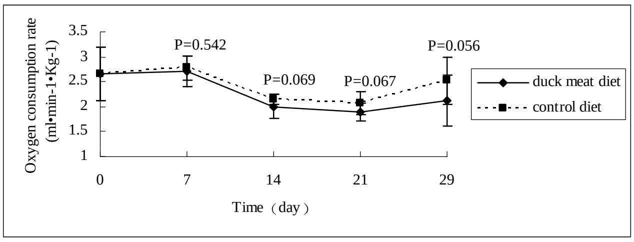


Fig. 2 Oxygen consumption rate of duck meat diet group and control diet group; n=8.

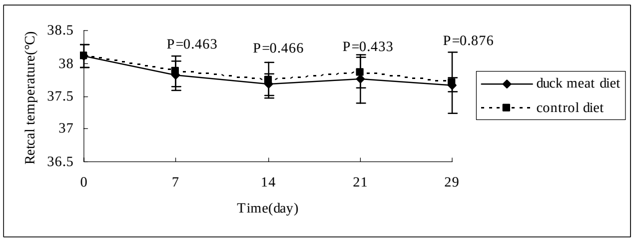
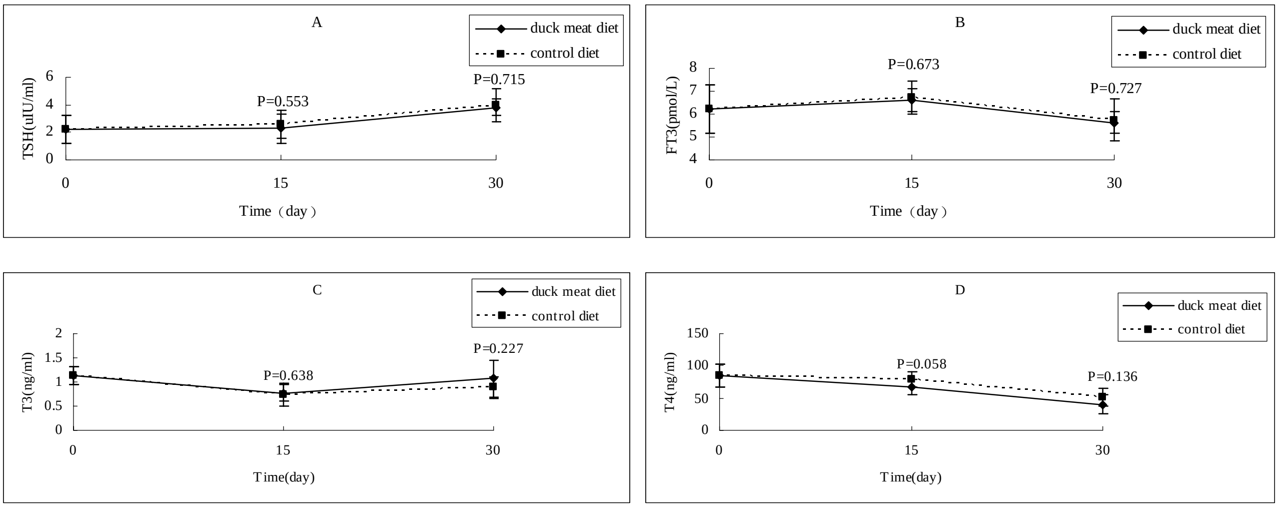


Fig. 4 Rectal temperature of duck meat diet group and control diet group; n=8.

It is well accepted that thyroid hormones are an important determinants of overall energy expenditure and the BMR (Kim, 2008). We therefore determined the thyroid hormones and the TSH over time. Changes in serum FT3, FT4, T3, T4 and TSH levels of both groups with time were similar (Fig.3). However, the effects of the duck meat diet on these serum parameters were differed between the individual hormones measured.



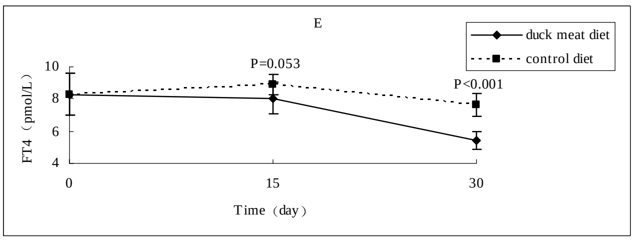


Fig. 3 Serum TSH(A), FT3(B),T3(C), T4(D) and FT4(E) levels of duck meat diet group and control diet group; n=10.

TH production in the thyroid gland is induced by TSH which is produced by the pituitary gland (Wikstr et al., 1998). It can be seen (Fig. 3A) that, compared with control feed, the duck meat diet had no effect on the serum TSH levels.

Also, no significant differences were found in serum T3 and FT3 levels between the duck meat diet group and the control diet group from day 0 to day 30 (Fig.3 B & C). Fig.3D shows the effects of the two diets on the serumT4 levels from day0 to day30. The duck meat diet group had a significantly lower serum T4 level than the control diet group on day15 (P=0.058), but no difference was found on day30 (P=0.136). This result indicated that by day 15 there was some inhibition of the thyroid to secrete the T4 but by day 30, self regulation of the body had returned the homeostatsis. Most of the thyroid hormone circulating in the blood is bound to carrier proteins. Only a very small fraction of the circulating hormone is free (unbound) and biologically active, so the amount of free T4 is what is important. In present study, the result showed (Fig. 3E) that the duck meat diet greatly decreased the thyroid function compared to the control diet, with lower serum FT4 levels, at day15 ($P=0.053$) and day30 ($P<0.001$). The result indicated that duck meat diet inhibited the dissociation of T4 from carrier proteins compared to control diet. This may explain why feeding duck meat diet resulted in a lower oxygen consumption rate. These results are consistent with previous publications (Barker & Klitgaard, 1952; Silva, 2001; Tata, Ernster, Lindberg, Arrhenius, Pedersen & Hedman, 1963) where oxygen consumption rates have been shown to be affected by TH.

Heat is an obligatory by-product of energy expenditure (Ribeiro et al., 2001) and a substantial fraction of the energy contained in food is dissipated through thermogenesis during metabolism (Silva, 1995). Thyroid hormone plays a fundamental role in thermogenesis (Lowell & Spiegelman, 2000; Ribeiro et al., 2001). Alhough, there were no significant differences in rectal temperature, the duck meat diet group had a slightly lower temperatures than that of control diet group at each measurement, with lower serum FT4 levels (Fig.4) and lower T4 levels on day 15 (Fig 3D). Barker et al. (1952) and Silva (1995) also found that higher thyroid hormone levels may enhance thermogenesis.

IV. CONCLUSION

Since the major difference between the two balanced diets was that dried duck meat had been substituted for dried soybean protein, we propose that dietary duck meat inhibits the secretion of T4 and the dissociation of T4 from carrier proteins into FT4. This may explain why the duck meat diet group exhibited a lower BMR and maybe why certain consumers prefer duck meat during warmer weather. Components responsible for these effects are not known. This work supports the contention that different food types alter the thermogenic effects on the body and modify overall satisfaction and wellbeing.

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