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Research report

Effect of duck meat consumption on thyroid hormone concentrations and energy metabolism of Sprague–Dawley rats ☆

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ABSTRACT

The two diets, a duck meat diet (DMD) and a control casein diet (CD) were isocaloric (15.9 kJ/g dry matters), and contained 18.3% protein, 7.4% fat, 60.0% carbohydrate. The selenium contents in casein, duck meat powder, CD and DMD were 0.061, 0.549, 0.123 and 0.225 mg/kg. Rats in the DMD group had higher serum selenium concentrations ($p < 0.05$) and liver 5′-deiodinase activities ($p < 0.05$). As a result, duck meat consumption increased serum tri-iodothryonine (T3) concentrations ($p < 0.05$) and decreased serum thyroxine (T4) concentrations ($p < 0.05$). The lower serum T4 concentrations ($p < 0.05$) were also supported by the lower total content of tyrosine and phenylalanine in duck meat powder compared to casein (7.72 vs 10.13). Compared to casein, duck meat powder had higher total content of glutamic acid, leucine, aspartic acid, serine, and alanine (44.68 vs 49.21), which led to higher serum TBG concentrations ($p < 0.05$) in the DMD group. Hence, the DMD group had lower serum free T4 (FT4) concentrations ($p < 0.05$), and lower serum free T3 (FT3) concentrations on day 14 ($p < 0.05$), which significantly decreased the energy expenditure of rats in the DMD group, with lower liver Na,K-ATPase and Ca-ATPase activities ($p < 0.05$), lower OCRs and rectal temperature, especially on day 13 ($p < 0.05$), higher body weight ($p < 0.05$), and body-weight gain ($p < 0.05$). We concluded that duck meat consumption decreased the energy metabolism of rats by multiple-step regulation of THs.

Introduction

Meat is rich in nutrients (Biesalski, 2005; capra, 2006) and has traditionally held a central position in Western food culture (FAO, 2004). Food culture is a very important influence on food preference (Hoogland, de Boer, & Boersema, 2005; Rozin, 1996; Rozin, Fischler, Imada, Sarubin, & Wrzesniewski, 1999). Generally, the choice of meat in Eastern food cultures is quite different from that of West. For example, duck meat is very popular in the warm times of the year in some parts of China, because consumers believe that duck meat consumption provides health benefits, such as having a cooling effect on the body (Chen & Weng, 1998; Satia et al., 2000). However, despite this is widely accepted belief there is little evidence to support this meat preference.

Some researchers have indicated that meat consumption by humans affects body weight and the concentrations of certain hormones of the body. Habito, Montalto, Leslie, and Ball (2000) found that in healthy males, the ratio of testosterone to oestradiol, and the concentrations of the sex hormone-binding globulin (SHBG) and the free androgen index were significantly different between those eating a tofu diet compared with those eating a meat diet. Our previous study found that sheep meat consumption, compared with a casein-based diet, affected the body weight and serum thyroid hormone concentrations in rats (Feng et al., 2011). It has been found that the major sources of animal proteins, as well as vegetable proteins, are associated with increases in IGF-I concentrations (Giovannucci et al., 2003). Others have reported that increasing meat consumption is significantly correlated with weight gain in rats (Belobrajdic, McIntosh, & Owens, 2003). However, little is known specially on the effects of duck meat consumption on body physiology.

THs, including FT3, FT4, T3, and T4 (Silva, 2001), are very important in regulating energy metabolism (Kim, 2008). We, therefore, hypothesize that duck meat has a special effect on energy metabolism through multiple-step regulating of THs, which can lower

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the generation of heat, consequently making our bodies more comfortable during warmer periods of the year, such as in summer.

In the following work, we investigated the effects of duck meat consumption on the body weight, body-weight gain, rectal temperature, OCRs, serum THs concentrations, liver Na,K-ATPase activity and Ca-ATPase activity of rats compared with ingestion of an isocaloric AIN-93G diet (casein protein) with a view to determining if, and how, certain foods appear to elicit different thermic effects in humans.

Methods and materials

Diets and animals

Two diets were prepared by modifying the AIN-93G diet (Reeves, Nielsen, & Fahey, 1993; Zirulnik & Giménez, 1999), i.e. duck meat diet (DMD) and control diet (CD) (AIN-93G diet) (Table 1). Both diets were prepared by Jiangsu-Xietong, Inc. (Jiangning, Nanjing, China).

Duck meat was ground and then dried in an oven at 80 ± 2 °C for 12 h, and then pulverized. The composition of the dried duck meat (93.94% solids) was 84.34% protein and 4.33% fat. The composition of the casein (86.95% solids) was 77.45% protein and 0.28% fat. As the dried duck meat contained more fat than the casein (4.33% compared with 0.28%), an amount of soybean oil was added to obtain an equivalent fat content. In addition, fiber (microcrystalline cellulose) was added to the DMD so that the dry matter of two diets was balanced.

Fifty Sprague–Dawley male rats weighing between 90 and 110 g were obtained from the Zhejiang laboratory animal center (Hangzhou, 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). The rats were acclimated and fed with a commercial diet (Jiangsu-Xietong, Inc.) for 1 week prior to the initiation of a 2-week feeding trial. OCRs and rectal temperature of five rats were recorded on day 7 of the week before the feeding trial. On day 1 of the study, before changing the commercial diet to the trial diets, 10 rats were selected randomly and killed, with blood and liver samples being collected for analysis. The remaining rats were randomized into two dietary groups. The rats were kept in a room at a temperature of 22 ± 1 °C, with a relative humidity of 40 ± 5% and a lighting cycle of 12-h light/dark. Water and diets were provided *ad libitum*. Food intake for each rat was calculated using the initial food weight minus the food weight remaining after every 7 days. On days 7 and 14 of the study, ten rats from each group were killed, and blood and liver samples were again collected for analysis.

Table 1
Composition of diets fed to rats (g/kg).

Ingredients (g/kg diet)	CD (AIN-93G)	DMD
Casein	206.12	–
Duck meat	–	204.60
Soybean oil	65.00	56.90
Cornstarch	397.49	397.49
Dextrinized cornstarch	132.00	132.00
Sucrose	100.00	100.00
Fiber[A]	50.00	59.67
Mineral mix (AIN-93G-MX)	35.00	35.00
Vitamin mix (AIN-93-VX)	10.00	10.00
L-Cystine	3.00	3.00
Choline chloride	1.38	1.38
Tert-butylhydroquinone	0.014	0.014
Dry matter	937.31	937.32
Total protein (g/kg DM[B])	182.79	182.73
Total fat (g/kg DM)	73.96	73.97
Total carbohydrate (g/kg DM)	599.84	600.19
Metabolizable energy (kJ/g DM)	15.85	15.85

[A] Fiber, microcrystalline cellulose.
[B] DM, dry matter.

Determination of amino acids in casein, duck meat powder, CD and DMD (g/100g protein)

The amino acid compositions of casein, duck meat powder, CD and DMD were determined referring to Chen, Zhang, Wu, and Shi (2011). Briefly, 25 mg of samples was mixed with 10 mL of 6 mol/L HCl, and placed into constant temperature box for hydrolysis 24 h at 105 °C. The acid was evaporated at 65 °C, and the residue was dissolved in 20 mmol/L HCl buffer. The mixture was filtered through a 0.45 μm Millipore filter and determined by Hitachi L-8900 automatic amino acid analyzer (Hitachi High-Technologies Corporation, Japan). The amino acid composition of samples was represented as g/100 g protein.

Body weights and body-weight gains

Body weights were recorded at the beginning of the experiment, on days 7 and 14. Body-weight gains were expressed as g per day (from day 1 to day 7; from day 8 to day 14).

OCRs

Before each measurement, the animal was deprived of food for a period of 12 h. OCRs were measured as previously described (Feng et al., 2011; Perez, Eatwell, & Samorajski, 1980). Five rats were randomly selected from each group, and taken for measurement of OCRs. This was repeated on days 6 and 13 of the study.

Rectal temperature

Rectal temperatures were determined using the modified method described by Nava et al. (1997) using a digital rectal thermometer (Omega Engineering, Inc., Stamford, CT). Five rats were randomly selected. The probe of the thermometer was inserted 2.5 cm into the rectum. This was repeated on day 6 and day 13 of the study.

Serum THs concentrations

Blood (8–10 mL) was collected according to Williams, Cattley, and Borghoff (2000). After collection in 10-mL glass tubes, blood was centrifuged (Avanti J-E, Beckman Coulter Inc., Fullerton, CA, USA) at 1300g for 10 min at 4 °C to obtain the serum, which was then removed and stored at −80 °C until required. THs status was determined by measuring concentrations of FT3, T3, FT4 and T4 with radioimmunoassay kits (Beijing North Institute of Biological Technology, Fengtai District, Beijing, China). The concentration of TSH was measured using the method of Radovi et al. (2010).

Serum TBG, transthyretin (TTR) and albumin concentrations

Serum TBG concentrations were determined using radioimmunoassay kits (CIS, Gif-sur-Yvette Cedex, France). Serum TTR concentrations were determined by ELISA methods (Zeledon et al., 2006). The serum albumin concentrations were determined according to the method of Doumas, Ard Watson, and Biggs (1997). A microspectrophotometer (SpectraMax-M2e, Molecular Devices, USA) was used instead of a standard spectrophotometer with a 96 cell microplate.