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Comparison of 3-Hydroxyacyl CoA Dehydrogenase Activity Between Broiler and Layer Chickens During Embryonic Development

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Abstract: The activity of 3-Hydroxyacyl CoA Dehydrogenase (3-HADH), rate limiting enzyme relating fatty acid oxidation, in broiler and layer embryos was compared, because their growth and lipid metabolism are largely different during embryogenesis. The 3-HADH activity in the liver was constant from the embryonic stage to the hatch, but the activity was significantly higher in broilers than in layers.

Key words: Chicken, embryo, 3-hydroxyacyl CoA dehydrogenase, broiler, layer, metabolism

INTRODUCTION

Broiler and layer chickens have been intensively selected for different purposes. The former has been selected for rapid growth and high meat yield and the latter for egg production. Consequently, at 6 weeks of age, the body weight of broilers is 5 times higher than that of layers (Zhao *et al*., 2004). Several factors are involved in the rapid growth of broiler chicks. For instance, higher food intake (Hocking *et al*., 1997), lower activity (Saito *et al*., 2004), lower rate of protein degradation (Saunderson and Leslie, 1988) and lower basal metabolic rate (BMR) (Kuenzel and Kuenzel, 1977) in broilers. Hocking *et al*. (1997) indicated that food intake and the rate of food consumption were double greater in broiler than in layer breeder males. In addition, BMR of broiler chicks is lower than that of layer chicks from day of hatch to 500 g of body mass (Kuenzel and Kuenzel, 1977).

Extensive experiments have investigated the physiological difference between chicken types, but these studies are usually limited from hatch to maturity. The difference in growth rate is remarkable even just after hatching (Mahagna and Nir, 1996; Masic *et al*., 1974). However, it was found recently that the embryonic growth of broilers was actually faster than that of layers (Ohta *et al*., 2004). This fact implies that genetic selection modifies physiological responses during embryonic stages and suggests that not only difference in food intake after hatch but also other factors are involved in the growth rate because the embryo within the fertilized egg is enclosed by eggshell and is hardly influenced by external factors. Therefore, to compare the growth mechanism between these 2 types at embryonic stages is important to clarify genetic factors.

Sato *et al*. (2006) reported that chicken embryos use lipids as energy resource since the respiratory quotient value was about 0.7. In addition, plasma concentrations related to lipid metabolism were different between broilers and layers during embryonic development. It is possible that lipid metabolism differs in broiler and layer embryos and this difference may lead to difference in growth rate between broilers and layers. However, knowledge about the molecular characteristics of lipid metabolism is limited. In the chicken embryo, excess of 90% of the total energy requirement is derived from fatty acid oxidation of yolk lipid (Noble and Cocchi, 1990). Therefore, energy yield by fatty acid oxidation may differ in broilers and layer embryos.

In this study, in order to approach the major difference in lipid metabolism during embryonic development between 2 types of chickens, we measured 3-Hydroxyacyl CoA Dehydrogenase (3-HADH) activity, the rate limiting enzyme related to fatty acid oxidation, in the liver and muscle.

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MATERIALS AND METHODS

Animal maintenance: Fertilized eggs were purchased from Mori hatchery in Fukuoka, Japan (broiler: Chunky) and GHEN corporation in Gifu, Japan (layer: Julia). All eggs were numbered and weighed individually prior to incubation. They were incubated at 37.6°C and a relative humidity of 58-68% and turned once every 1 h. All eggs were incubated in the same incubator. To remove chapped and broken eggs, all eggs were candled before incubation and only non-chapped and non-broken eggs were used.

All experimental procedures were performed according to the National Research Council publication, Guide for Care and Use of Laboratory Animals and the Guidance for Experiments in the Faculty of Agriculture and in the Graduate Course of Kyushu University and the Law (No. 105) and Notification (No. 6) of the Japanese Government.

Measurement of 3-HADH activity: The liver and pectoralis muscle were removed at embryonic stage of 14 (E14), E18 and post hatch (P0) and frozen on dry ice and stored at -85°C until analyzed. The 3-HADH activity was determined using the method of Bradshaw and Noyes (1975). Enzyme activities were corrected for the tissue weight. One unit of enzyme activity was defined as 1 μmoL NADPH production min^{-1} for 3-HADH.

Statistical analysis: Data were analyzed using a factorial 2-way Analysis of Variance (ANOVA) with respect to type and developmental stage. Statements of significance were based on $p<0.05$. Data were expressed as mean±SEM.

RESULTS AND DISCUSSION

Comparison of 3-HADH activity in the liver and muscle between broilers and layers at E14, E18 and P0 is shown in Fig. 1. The 3-HADH activity in the liver was almost constant ($F (2, 21) = 0.904$, $p>0.05$) during the developmental stage, but the activity was significantly ($F (1, 21) = 16.424$, $p<0.001$) higher in broilers than in layers. There was no significant ($F (2, 21) = 0.136$, $p>0.05$) interaction between the developmental stage and type.

The 3-HADH activity in the pectoralis muscle was negligible.

Chicken embryos mainly use lipid for energy resource (Sato *et al*., 2006). Lipid metabolism is different between 2 types of chicken embryos, i.e., broilers and layers (Sato *et al*., 2006). However, the precise mechanism, by which both types express the different lipid metabolism

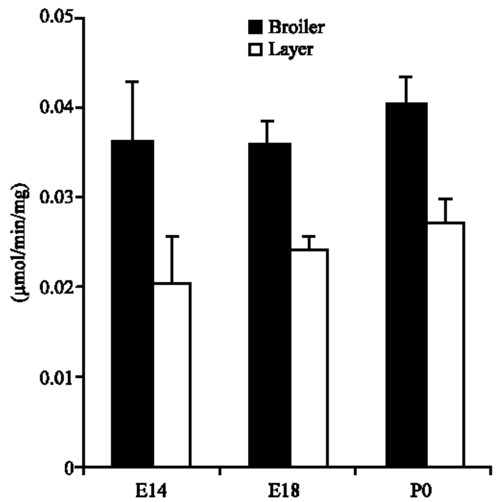

Fig. 1: Comparison of 3-hydroxyacyl CoA dehydrogenase activity (μmol/min/mg) in the liver between broilers and layers during embryonic development. Abbreviations were as follows: E14, 14 days of incubation; E18, 18 days of incubation and P0, within 1 day after hatch. The number of each group was broiler: E14, 5; E18, 5; P0, 4: layer: E14, 4; E18, 5; P0, 4. Data are expressed as mean±SEM.

has not yet been clarified. In the present study, we tried to explain the difference in the activity of 3-HADH, rate limiting enzyme related to fatty acid oxidation.

The 3-HADH activity appeared in the liver, but not in the muscle. Therefore, it is possible that energy yield during embryonic development mainly occurs in the liver, but not in the muscle. In addition, 3-HADH activity was higher in broiler than in layer embryos. This suggested that fatty acid oxidation during embryonic development might be higher in broiler than in layer embryos. More than 90% of the total energy requirement of embryos is obtained from fatty acid oxidation derived from yolk lipids (Noble and Cocchi, 1990). Because energy yield by fatty acid oxidation was higher in broiler than in layer embryos, the growth rate of broiler embryos might be faster than in layer embryos. In addition, ketone bodies have been known to serve as fuel for various extrahepatic adult mammalian tissues during starvation and experimental diabetes (Owen *et al*., 1967; Hawkins *et al*., 1971). When higher fatty acid oxidation is leaded in the liver, ketogenesis occurs. The concentration of ketone bodies in the blood of the developing chick prior to and just after hatching was higher than those found in the adult (Beis, 1985). Therefore, fatty acid oxidation in the liver is high during embryonic development. Production of ketone body might be higher in broiler than in layer embryos because fatty acid oxidation was higher in broiler than in layer embryos in the present study. In addition, it was reported that plasma concentration of ketone body, D-3-hydroxybutyrate, was lower in broiler than in layer embryos (Sato *et al*., 2006). Therefore, it was considered that because production of ketone body was higher in broiler and incorporation of ketone body to muscle was higher in broilers than in layers, the growth rate of broiler was faster than that of layers.

CONCLUSION

The activity of 3-HADH in the liver was higher in broilers than in layers during embryonic development. This difference may partly explain the difference in growth between the 2 type 2 embryos.

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