LONG-TERM FEEDING DIET BASED ON RICE FEED PRODUCED DOMESTICALLY AFFECTS MEAT QUANTITY AND QUALITY OF CHICKEN

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***Abstract*—In Japan, 76% of feed for poultry breeding is imported from foreign countries. Especially, Japan highly depends on foreign coutries for corn, which is fed to chicken at the level of 70% of feed. Hence, improvement of Japanese self sufficiency in feed production is important for food security. On the other hand, Maintenance and conservation of rice fields, which has been declining in Japan, are important for preservation of the environment surrounding the rice fields and its traditional technologies. In this study, we evaluated meat quantity and quality by comparing chickens fed a diet based on rice feed with those fed a diet based on imported corn feed. Layers were fed rice-based diet, which replaces corn with rice feed in commercial diet, from 120 to 490 days of age. As compared with hens fed commercial corn-based diets, final live weight, and total muscle and fat of carcass, gizzard and liver weight were significantly higher in rice-fed birds ($p<0.05$). As to meat quality, the shear-force values of the *M. pectoralis superficialis* and gizzard of chicken fed diet based on rice feed were significantly lower ($p<0.05$), respectively. The *M. pectoralis superficialis* contained significantly more threonine (179%, $p<0.001$) and less tyrosine (47%, $p<0.05$). Fatty acid composition and water holding capacity by pressure were not significantly different between treatments. In this study, we concluded that domestically produced rice feed is a suitable alternative to imported corn feed for chicken production; moreover, rice feed could improve meat quantity and quality.**

***Index Terms*—chicken, rice feed, meat production**

I. INTRODUCTION

In Japan, animal products from poultry, such as chicken and eggs, are an important protein source for humans. In Japan, 76% of feed for poultry breeding is imported from foreign countries; this includes corn, which comprises 70% of the typical chicken feed diet. Hence, management of many farms in Japan is influenced by international grain markets, and improvement of Japanese self sufficiency in feed production is important for food security, especially to prevent infectious diseases and to increase farm management stability.

On the other hand, although rice is the main staple food in Japan, many rice fields are abandoned because farmers cannot compete with cheaper imported foods. Maintenance and conservation of rice fields are important not only for the production of meal, but also for preservation of the environment surrounding the rice fields and its traditional technologies.

Therefore, the production of rice for livestock has recently become a subject of study. There are several reports on the effect on the growth rate of chickens of feeding a diet based on rice feed for a short period (8−21 days) (Gonzalez-Alvarado, Jimenez-Moreno, Lazaro & Mateos, 2007; Shelton, Mavromichalis, Payne, Southern & Baker, 2003). However, there are few reports on the effects on meat quantity and quality from feeding such a diet for a long period.

The purpose of our study was to evaluate meat quantity and quality by comparing chickens fed a diet based on rice feed with those fed a diet based on imported corn feed. We also assessed the potential of a diet based on rice feed as an alternative to imported corn feed in chicken production. We compared the carcass composition, meat tenderness and juiciness, amino acid level and fatty acid composition between layer hens fed a diet based on rice and those fed corn feed for 370 days.

II. MATERIALS AND METHODS

At 120 days of age, 12 layer hens (Momiji, GOTO incubate plant, Inc., Gifu, Japan) were randomly allocated to two groups. The control group (group C: n=6) were fed a commercial diet containing 70% corn. The rice group (group R: n=6) were fed an experimental diet containing domestically produced rice (mizuhochikara) feed instead of corn. The hens were reared for 370 days, during which time they laid eggs; and they were slaughtered at 490 days of age.

After slaughter, the muscle, fat (subcutaneous, visceral, and intermuscular fat), gizzard, liver, and ovary were dissected from the carcasses and weighed. The *Musculus pectoralis superficialis*, *M. pectoralis profundus*, and *M. iliotibialis lateralis* were individually excised and weighed. The shear-force value of the *M. pectoralis superficialis*, *M. iliotibialis lateralis* and gizzard were measured with a Chatillon GR82011317 (GR Electric Manufacturing Co., Kansas, USA). Frozen cross-sections were obtained from the *M. pectoralis superficialis* and stained with histochemical methods for myosin ATPase activity after alkaline (pH 10.5) preincubation and NADH-TR activity (Brooke & Kaiser, 1970). Type IIA and IIB myofibers were identified and the myofiber diameters were measured. The amount of amino acid and fatty acid composition were also measured, and the water holding capacity of the *M. pectoralis superficialis* was analyzed by pressure (Japan Certification Services, Inc., Tokyo, Japan).

III. RESULTS AND DISCUSSION

A. Estimation of rice feed

Crude nutritional values for the domestically produced rice feed and commercially corn feed are shown in Table 1. According to the Japanese feeding standard for poultry, a diet based on the rice feed that was used in this experiment satisfies the demands for metabolizable energy (2.80 Mcal/kg) and crude protein (15.5 %) in layer hens. Hence, a diet based on rice feed could replace a diet based on imported corn feed.

Table 1. Chemical composition of experimental diet and commercial diet.

Item	group R[1] (n= 6)	group C[2] (n= 6)
Metabolizable Energy Kcal/kg	2813.274	2816.217
Total Digestible Nutrients %	57.424	67.776
Crude Protein %	16.399	16.414
Ether Extract %	8.517	4.153
Crude Fiber %	10.725	2.735
Nitrogen Free Extracts %	38.871	53.856

[1]Group R indicates layer hens that were fed the diet based on rice feed.
[2]Group C indicates layer hens that were fed the diet based on corn feed.

B. Meat quantity

Average live weight, and total muscle and fat of carcass, gizzard and liver weight were significantly higher in group R than in group C ($p<0.05$, respectively, Table 2). Visceral fat weight was also higher in group R than in group C. These results suggest that the rice feed could promote body growth and adipogenesis more than did the corn feed.

Table 2. Carcass yields of chicken fed a rice feed or imported corn based diet from 120 to 490 days of age.

Item	group R (n= 6)	group C (n= 6)
live weight (g/bird)	**2232 ± 100.1***	**1929 ± 39.9**
muscle (g/bird)	**618.5 ± 29.75***	**573.4 ± 21.11**
M. pectoralis superficialis (g/bird)	78.36 ± 8.290	71.64 ± 5.037
M. pectoralis profundus (g/bird)	28.17 ± 1.849	27.34 ± 1.673
M. iliotibialis lateralis (g/bird)	14.18 ± 0.944	14.84 ± 1.383
fat (g/bird)	**313.9 ± 85.60***	**199.4 ± 37.99**
subcutaneous fat (g/bird)	107.87 ± 16.39	76.57 ± 13.37
visceral fat (g/bird)	189.7 ± 55.90*	111.7 ± 15.12
intermuscular fat (g/bird)	16.35 ± 4.349	11.12 ± 1.460
gizzard (g/bird)	**54.02 ± 5.306***	**40.42 ± 3.286**
liver (g/bird)	**41.94 ± 4.501***	**36.33 ± 4.106**
ovary (g/bird)	**200.6 ± 21.06**	**175.7 ± 22.27**

Data represent means±SD for each 6 birds. *Mean value was significantly different between group R and C ($p< 0.05$).

C. Meat quality

The shear-force value is an index of tenderness. The shear-force values for the *M. pectoralis superficialis* and gizzard were significantly lower in group R than in group C ($p<0.05$, respectively, Figure 1). Meat tenderness is related to myofiber composition, myofiber diameter, and the amount of connective tissue (Liu, Nishimura & Takahashi (1996)). Tenderness of the *M. Pectoralis superficialis* differed between groups; however, all myofibers were type IIB and the mean myofiber diameter did not differ significantly between groups (group C: 51±7 μm, group R: 53±8 μm).

The amount of amino acid and fatty acid composition affect the tastiness of the meat. We investigated the composition of analyzed amino acid and fatty acid in the *M. Pectoralis superficialis.* The *M. Pectoralis superficialis* contained significantly more threonine (179% of group C, $p<0.001$) and less tyrosine in group R than in group C (47% of group C, $p<0.05$). Threonine makes the meat taste sweet, whereas tyrosine has no effect on taste. Therefore, meat quality, which is related to tenderness and taste, was greater in chickens fed the diet based on rice feed than those fed the diet based on corn feed. On the other hand, fatty acid composition (saturated fatty acid, monounsaturated fatty acid, and polyunsaturated fatty acid) did not differ significantly between group R and group C (Figure 2); in addition, water holding capacity by pressure, which is related to meat juiciness, was not significantly different between group R (39.9%) and group C (38.6%).

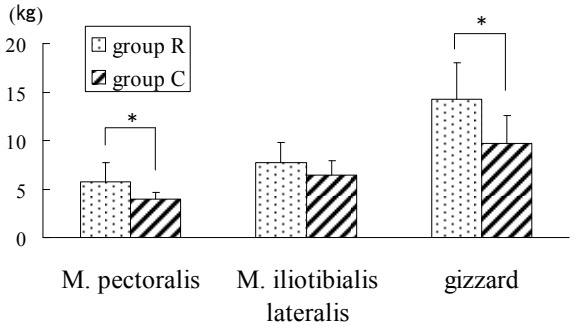

Figure 1. Comparison of the shear-force values for the *M. pectoralis*, *M. iliotibialis lateralis*, and gizzard. Data represent means±SD for each 6 birds.
The samples from group R and C are represented by dot bars and crosshatched bars, respectively.
*Mean value was significantly different between group R and C ($p< 0.05$).

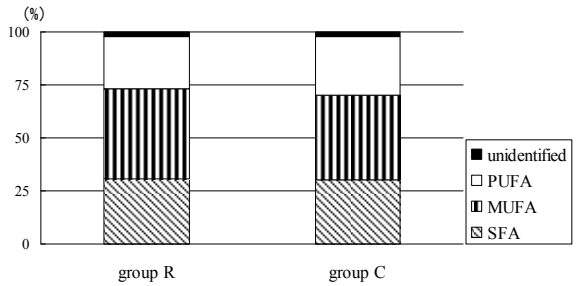

Figure 2. Comparison of fatty acid composition for the *M. pectoralis superficialis*.

IV. CONCLUSION

This study showed that feeding chickens a diet containing rice feed instead of corn improved meat quantity and quality. Feeding a diet containing rice feed promoted muscle growth, visceral fat deposition, and tenderness of the breast and gizzard. Meat tenderness was not a result from myofiber composition and diameter; therefore, further studies are needed to investigate other factors that affect tenderness. These results indicate that domestically produced rice feed is a suitable alternative to imported corn feed for chicken production; moreover, rice feed could improve meat quantity and quality.

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