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«Research Note»

Effects of Dietary Brown Rice and Sake Lees on the Growth Performance and Color of Meat in Broiler Chicks

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In this study, we examined whether brown rice and sake lees (domestic feed ingredients) could replace corn and soybean meal (major imported feed ingredients) in broiler chick feed. In Experiment 1, 21-day-old broiler chicks were assigned to two groups and fed a corn-soybean- or a brown rice-soybean-based diet for three weeks (3 birds × 4 replicates/group). Dietary brown rice significantly improved body weight gain and feed conversion ratio. Brown rice feeding also significantly increased L* (lightness) in the thigh and significantly decreased a* (redness) and b* (yellowness) in the thigh and b* in the fat. In Experiment 2, 21-day-old broiler chicks were assigned to three groups and fed either a corn-soybean-based diet for 3 weeks, a corn-soybean-based diet for the first 2 weeks followed by a brown rice sake lees-based diet for the last week, or a brown rice sake lees-based diet for 3 weeks (3 birds × 4 replicates/group). Replacement of the imported feed ingredients significantly improved the feed conversion ratio. The a* values for the breast, thigh, and fat, and the b* values for the thigh and fat were significantly decreased by rice and sake lees feeding for 3 weeks. The a* values for the breasts and fat were significantly decreased by rice and sake lees feeding for 1 week. These results suggest that brown rice and sake lees can be used as replacements for imported feed ingredients such as corn and soybean meal in broiler chicks without detrimental effects on growth performance. These domestic feed ingredients may benefit local production and consumption of poultry in Japan.

Key words: chicken, color, hulled rice, maize, unpolished rice

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Introduction

Feed production and transport account for approximately 70% of the global warming potential associated with poultry systems[1]. Japan imported more than 15 million tons of corn and 3 million tons of soybeans from overseas in 2021[2]. Therefore, the replacement of dietary corn and soybean meal, the major components of poultry diets, with domestic feed ingredients is an important objective in the poultry industry in Japan.

Rice is a promising candidate for replacing corn in feed. For example, brown rice may provide more benefits than those from corn in broiler chicks from 7 to 21[3] or 10 to 24[4] days of age. Nanto *et al.*[5] reported no significant differences in body, breast muscle, or leg weights between broilers fed corn-and brown rice-based diets up to 28 days of age. Gonzalez *et al.*[6] found no significant differences in body weight between broilers fed corn- and rice-based diets up to 21 days of age. These results suggest that replacing corn with rice in broiler diets does not adversely affect meat production in chicks, at least during the early stages of development. However, the effects of rice feeding on broiler chicks during a later period, such as 21 to 42 days of age, have not been investigated, even though feed consumption in the later period is greater than that in the earlier period.

Soybean meal is a major source of protein in poultry feed. Therefore, a high-protein feed ingredient is required to replace soybean meal. Sake lees powder, obtained by brewing liquefied rice, consists of over 40% protein and yeast components[7]. Nucleotide-rich yeast extract improves the feed conversion ratio without affecting feed intake[8]. Dietary β-glucan, a component of the yeast cell wall, improves the villus height:crypt depth ratio and thickens mucosa in broiler chicks[9]. Enzymatically treated yeast enhances nutrient utilization and augments intestinal development in broiler chickens[10]. Therefore, it is possible that dietary sake lees improves the growth performance of broiler chicks. The effective use of sake lees as a replacement for soy-

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bean meal in broiler chicken feed will thus substantively contribute to the prevention of global warming.

In the present study, we evaluated the possible use of brown rice and sake lees as replacements for imported feed ingredients for broiler chicks. Our results clearly showed that these domestic ingredients can be used as feed replacements without any serious detrimental effects on the growth performance of broiler chicks.

Materials and Methods

Animals and diet

This study was approved by the Institutional Animal Care and Use Committee and performed according to the Kobe University Animal Experimentation Regulations (2021-0404-R1 and 2022-06-01-R2).

In Experiment 1, one-day-old male broiler chicks (Ross 308) were purchased from a local hatchery (Yamamoto Co., Ltd., Kyoto, Japan). Water and food were provided *ad libitum* throughout the experiment. The chicks were maintained in electric battery cages for 20 d. At 21 days of age, 24 chicks were distributed between two groups: a control group fed a corn-based diet and a brown rice group fed a brown rice-based diet, in which all corn was replaced by brown rice (Table S1). The average body weight of each group was equivalent (887 ± 64 g and 887 ± 63 g, respectively). Chicks were moved to a cage with dimensions of 60 × 90 × 32 cm (three birds per cage × four replicates per group) and reared for 21 days. Water and food were provided *ad libitum* throughout the experimental period. At the end of the experiment, the birds were fasted for 10 h, weighed, and euthanized under carbon dioxide anesthesia. The breast and legs were removed (without skin), weighed, and refrigerated for 48 h for aging. Subsequently, the color of the breast and legs was measured as described below.

Experiment 2 was conducted as described for Experiment 1, except for the experimental diet (Table S2) and grouping. In total, 36 male broilers (21 days old) were assigned to one of three groups: a control group fed a corn soybean-based diet for 3 weeks; 1 week brown rice group fed a corn soybean-based diet for the first 2 weeks and a brown rice sake lees-based diet for the last week; and 3 weeks brown rice group fed a brown rice sake lees-based diet for 3 weeks. The average body weight of each group was equivalent (928 ± 89 g, 930 ± 92 g, and 930 ± 95 g, respectively).

Measurement of color

The color of the meat was measured using a spectrophotometer (NF 333; Nippon Denshoku Industries Co., Ltd., Tokyo, Japan) at the center of the breast, biceps femoris (thigh), and sartorius muscle fat (fat).

Statistical analysis

Data from Experiment 1 were analyzed using the Student's *t*-test with Microsoft Excel 2016 (Redmond, WA, USA). Data from Experiment 2 were analyzed using the Tukey–Kramer method with Stat View 5.0 (SAS Institute Inc., Cary, NC, USA).

Results and Discussion

The results of Experiment 1 are summarized in Table 1. The replacement of corn with brown rice significantly increased body weight and improved the feed conversion ratio in broiler chicks. Leg weight tended to increase (P = 0.056). These results suggest that rice feeding during 21 to 42 days of age does not have any detrimental effects on the growth of broiler chicks. Prior evidence suggests that dietary corn can be replaced with rice during the starter period in broiler chicks[3–6]. Together, these findings suggest that brown rice can be used as a replacement for corn throughout the feeding period in commercial broiler chicks.

Brown rice feeding significantly increased L* (lightness) in the thigh and significantly decreased a* (redness) and b* (yellowness) in the thigh and b* in the fat. Corn contains considerable amounts of carotenoid pigments, whereas rice has the lowest carotenoid content among all cereals[11]. Feeding high-carotenoid corn diets to chickens increases the yellowness of the skin, meat, croup, and base of the wings[12]. These results suggest that the differences in meat color observed in the present study were due to differences in the carotenoid pigment content of the experimental diets.

The results of Experiment 2 are summarized in Table 2. Brown rice and sake lees feeding significantly improved the feed conversion ratio and did not detrimentally affect the body, breast, or leg weight, or the feed intake. These results suggest that feeding broiler chicks brown rice and sake lees from 21 to 42 days of age may improve growth performance without affecting meat

Table 1. **Effects of brown rice feeding on the growth performance and color of meat in broiler chicks**

	Corn (control)	Brown rice
Body weight (g)	2095 ± 30	2227 ± 24 *
Body weight gain (g)	1208 ± 27	1340 ± 18 *
Feed intake (g)	2602 ± 40	2644 ± 32
Feed conversion ratio	2.19 ± 0.03	1.97 ± 0.01 **
Breast (g)	359 ± 15	360 ± 7
Legs (g)	443 ± 11	477 ± 5
Color of breast		
L*	37.3 ± 0.7	39.9 ± 0.8
a*	-1.71 ± 0.07	-2.07 ± 0.12
b*	1.05 ± 0.51	-0.04 ± 0.09
Color of thigh		
L*	37.3 ± 0.3	39.1 ± 0.4 *
a*	-1.14 ± 0.10	-1.84 ± 0.04 **
b*	-0.64 ± 0.21	-3.09 ± 0.28 **
Color of fat		
L*	55.9 ± 0.6	57.3 ± 0.7
a*	-0.74 ± 0.26	-1.49 ± 0.03
b*	10.66 ± 1.22	5.20 ± 0.17 *

Data are expressed as means ± SEM of four replicates in each group. Asterisk indicates significant with respect to control group (*, $P < 0.05$; **, $P < 0.01$).

Table 2. **Effects of brown rice and sake lees feeding on the growth performance and color of meat in broiler chicks**

	Corn and soybean meal (control)	Brown rice and sake lees for 1 week	Brown rice and sake lees for 3 week
Body weight (g)	2235 ± 181	2193 ± 270	2257 ± 232
Body weight gain (g)	1356 ± 135	1264 ± 93	1326 ± 72
Feed intake (g)	2921 ± 243	2610 ± 324	2568 ± 235
Feed conversion ratio	2.17 ± 0.07 [a]	2.07 ± 0.11 [ab]	1.94 ± 0.04 [b]
Breast	392 ± 84	360 ± 78	315 ± 66
Legs	409 ± 42	393 ± 46	426 ± 24
Color of breast			
L*	40.65 ± 0.81	42.74 ± 1.72	41.78 ± 1.67
a*	-1.9 ± 0.25 [a]	-2.67 ± 0.18 [b]	-3.15 ± 0.36 [b]
b*	0.9 ± 0.96	0.44 ± 1.23	-0.54 ± 0.87
Color of thigh			
L*	38.2 ± 2.55	39.53 ± 1.24	40.44 ± 2.38
a*	-1.45 ± 0.41 [a]	-1.55 ± 0.27 [ab]	-2.1 ± 0.13 [b]
b*	-0.04 ± 0.44 [a]	-0.36 ± 0.18 [a]	-1.24 ± 0.51 [b]
Color of fat			
L*	57.08 ± 1.60	56.27 ± 1.50	57.2 ± 0.91
a*	-0.91 ± 0.20 [a]	-1.5 ± 0.20 [b]	-2.01 ± 0.40 [b]
b*	13.95 ± 2.06 [a]	12.46 ± 1.85 [a]	7.09 ± 0.79 [b]

Data are expressed as means ± SEM of four replicates in each group.
Groups with different letters are significantly different ($P < 0.05$).

yield. In terms of meat color, the a* values of the breast, thigh, and fat and b* values of the thigh and fat were significantly decreased by brown rice and sake lees feeding for 3 weeks. Therefore, the consumption of sake lees likely modifies the effect of brown rice feeding on meat color. In comparison, only the a* values of the breast and fat were significantly decreased by rice and sake lees feeding for 1 week. This result suggests that the effect of rice and sake lees feeding on meat color likely depends on the feeding period.

In Experiments 1 and 2, growth performance and meat color differed significantly between the groups. In both experiments, the soybean oil content in the brown rice and brown rice plus sake lees diets was higher than that in the control diet, to equilibrate the metabolizable energy (ME) level of each diet. Recently, Elbaz *et al.* reported that dietary oils, including soybean, corn, olive, and fish oils, significantly influenced the growth performance and color of meat in broiler chicks, although the ME level of each diet was similar between groups (3,047–3063 kcal/kg) [13]. Therefore, the different soybean oil contents in the present experimental diets may have affected the growth performance or meat color in broiler chicks.

Antibiotic-free production of poultry has become increasingly popular in recent decades in Western countries, as has addressing health problems in chickens, including enteric and systemic diseases[14]. Supplementation with post-biotics can facilitate these objectives. For example, Alagbe *et al.*[10] reported that enzymatically treated yeast attenuate the detrimental effects of a coccidia challenge. Nucleotide-rich yeast extract attenuates the detrimental effects of an Eimeria challenge[8]. Alizadeh *et al.*[15] reported that dietary supplementation with yeast cell walls stimulates systemic innate immune responses in broiler chickens following lipopolysaccharide challenge. Sake lees also contains yeast components[7]. In the present study, consumption of brown rice and sake lees during the third feeding week did not show any detrimental effects. In Japan, an antibiotic-free diet must be administered for one week before the slaughter of broiler chicks. Therefore, brown rice and sake lees diets may be suitable as antibiotic-free finisher diets for broiler chicks, although further studies are required.

The fatty acid composition differs among corn, soybeans, brown rice, and sake lees. Compared to corn oil, rice bran oil contains more oleic acid, palmitic acid, saturated fatty acids, and monounsaturated fatty acids[16]. Sake lees contain approximately 50% saturated fatty acid[17], whereas soybean oil contains approximately 16% saturated fatty acid[16]. These differences may affect the melting point of fat in meat. Because Japanese sake contains several volatile flavor components[18,19], sake lees also seems to contain flavor components. In contrast, soy protein contains off-flavor compounds[20]. Therefore, brown-rice and sake lees feeding likely enhances the palatability of chicken meat.

In conclusion, replacing dietary corn with brown rice improved the growth performance of broiler chicks. The replacement of both dietary corn and soybean meal with brown rice and sake lees improved the feed conversion ratio in broiler chicks.

These findings support the use of brown rice and sake lees as domestic feed ingredients for poultry meat production.

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Author Contributions

Koki Nishikawa and Karin Miyazaki conducted the experiments and analyzed the data; Takehiro Hirai and Kazuhisa Honda designed the experiments; Koki Nishikawa wrote the manuscript; Takaoki Saneyasu and Kazuhisa Honda edited the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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