Effects of Rice Bran Inclusion on Performance and Bone Mineralization in Broiler Chicks

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Primary Audience: Nutritionists, Agronomists, Veterinarians

SUMMARY

Rice bran, a by-product of the rice industry, is available for animal feeds. However, it has not been a common part of poultry rations in Argentina. Hydrolytic and oxidative rancidity development, phytate content, enzyme inhibitor, and high fiber content are the most important antinutritive factors cited as limiting factors for its use. An experiment utilizing 1-d-old male broiler chicks was conducted to determine the responses of zootechnical and bone mineralization parameters to diets with different concentrations of rice bran. The feed conversion and tibia ash were more sensitive than weight gain to detect antinutritive factors in rice bran. High concentrations of rice bran (in excess of 20%) produced a significant reduction in body weight. Furthermore, feed conversion and bone mineralization variables were impaired by feeding 10% rice bran diets. The adverse effects of rice bran on weight gain, feed conversion, and mineralization in the current studies suggest that rice bran should be included in broiler diets at a level between 10 and 20% if strategies are not used to decrease the antinutritive activity.

Key words: rice bran, broiler, bone mineralization, antinutritive factor

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DESCRIPTION OF PROBLEM

In a 5-yr period (1995 to 2000) Argentina produced an average of 1.11 million tons of rice annually. Rice bran constitutes about 10% of the weight of rough rice; therefore, 100,000 tons annually were available to be used in animal feeds.

Rice bran has a high level of some important nutrients: it is rich in protein, lipids, vitamins B and E, and trace minerals [1, 2]. Rice bran compares favorably with other cereal brans in amino acid composition [3].

The potential for rice bran as a feedstuff has long been recognized, but rice bran has not used as a common ingredient of poultry rations in Argentina. Without any substantial basis it was used up to 12%. Hydrolytic and oxidative rancidity development, phytate content, enzyme inhibitor, and high fiber content are the most important antinutritive factors cited as limiting factors for its use [4, 5, 6]. The objective of the present study was to determine the responses of performance and bone mineralization in broiler chicks grown on different concentrations of rice bran.

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TABLE 1. Composition of diets for broiler chickens 0 to 21 d of age (values are on as-fed basis)

Ingredient	Diet 0%	Diet 10%	Diet 20%
		(%)	
Corn	62.5	53.4	45.9
Soybean meal, 44	25.0	21.7	17.2
Full fat soybean (heat treated)	2.1	4.5	3.5
Meat meal, 50	6.5	6.5	6.5
Corn gluten meal, 60	2.5	2.5	5.0
Lysine HCl, 78%	0.170	0.155	0.240
Methionine hydroxy analog	0.245	0.250	0.215
Vitamin mix[A]	0.025	0.025	0.025
Mineral mix[B]	0.050	0.050	0.050
Anticoccidial	0.050	0.050	0.050
Bacitracin, 15%	0.030	0.030	0.030
Sodium chloride	0.25	0.25	0.25
Oyster shell	0.50	0.51	0.96
Choline chloride, 75%	0.80	0.80	0.80
Sodium selenite, 1%	0.001	0.001	0.001
Rice bran	—	10.0	20.0
Nutrient			
Crude protein (%)	22.0	22.0	22.0
AME (kcal/kg)	2,999	2,999	3,004
Lysine (%)	1.20	1.20	1.20
Methionine (%)	0.57	0.57	0.56
Cystine (%)	0.34	0.34	0.34
Methionine + cystine (%)	0.90	0.91	0.90
Tryptophan (%)	0.25	0.25	0.23
Threonine (%)	0.79	0.80	0.79
Arginine (%)	1.33	1.36	1.31
Ether extract fat (%)	4.48	5.91	6.89
Crude fiber (%)	3.45	4.32	5.00
Calcium (%)	0.91	0.91	1.06
Total P (%)	0.68	0.85	1.01
Available P (%)	0.44	0.50	0.55
Calcium/available P (%)	2.01	1.82	1.93
Linoleic acid (%)	1.73	2.05	2.17

[A]Per kilogram of diet: vitamin A, 15,000 IU; vitamin D, 3,000 IU; vitamin E, 31 UI; vitamin K, 2.6 mg; vitamin B_2, 7.6 mg; pantothenic acid, 7.5 mg; niacin, 40 mg; folic acid, 1.5 mg.
[B]Parts per million: manganese, 60; zinc, 35; copper, 6; selenium, 0.15; iron 20.

MATERIALS AND METHODS

Three hundred fifty, 1-d-old male broiler chicks [7] were housed in electrically heated, raised wire-floored batteries. Broilers were provided feed ad libitum and were maintained on a 24-h lighting schedule. Ten replicate pens, each containing 7 chicks, were assigned at random to 5 treatments.

Traits Measured

Individual pen bird weight and feed consumption were recorded weekly. On d 21, 3 chicks from each pen were selected at random and euthanized by cervical dislocation, and right tibias were removed. On d 40, 1 bird from each pen with a body weight comparable to the pen average weight was selected. These birds were slaughtered, and the right tibias and middle toes were removed. The tibias were boiled for 2 min, after the surrounding meat and cartilaginous caps were removed, and the length was measured. The bones were dried in a forced-air oven for 24 h at 105°C and weighed. Tibias from 3 of the broilers from each pen were pooled. All tibias were ether extracted for 12 h extraction before ashing in a muffle furnace at 480°C for 16 h. The toes were severed between third and second metatarsal bone, without removing either nail or skin and were

TABLE 2. Composition of diets for broiler chickens 22 to 40 d of age (values are on as-fed basis)

Ingredient	Diet 0%	Diet 10%	Diet 20%	Diet 30%	Diet 40%
	(%)				
Corn	63.2	54.2	45.2	36.2	27.0
Soybean meal, 44	16.0	12.6	9.2	5.8	2.5
Full fat soybean (heat treated)	10.4	12.8	15.2	17.6	20.1
Meat meal, 50	6.5	6.5	6.5	6.5	6.5
Corn gluten meal 60	2.5	2.5	2.5	2.5	2.5
Lysine HCl, 78%	0.1	0.085	0.065	0.05	0.035
Methionine hidroxy analog	0.22	0.215	0.22	0.22	0.22
Vitamin mix[A]	0.025	0.025	0.025	0.025	0.025
Mineral mix[B]	0.050	0.050	0.050	0.050	0.050
Anticoccidial	0.050	0.050	0.050	0.050	0.050
Bacitracin, 15%	0.03	0.03	0.03	0.03	0.30
Sodium chloride	0.25	0.25	0.25	0.25	0.25
Dicalcium phosphate	0.025	—	—	—	—
Oyster shell	0.45	0.48	0.50	0.5	0.5
Yellow pigment	0.045	0.055	0.050	0.065	0.085
Choline chloride, 75%	0.16	0.16	0.16	0.16	0.16
Sodium selenite, 1%	0.001	0.001	0.001	0.001	0.001
Rice bran	—	10.0	20.0	30.0	40.0
Nutrient					
Crude protein (%)	21.0	21.0	21.0	21.0	21.0
AME (kcal/kg)	3,100	3,100	3,100	3,099	3,098
Lysine (%)	1.10	1.10	1.10	1.10	1.10
Methionine (%)	0.54	0.53	0.54	0.54	0.54
Cystine (%)	0.32	0.31	0.32	0.31	0.31
Methionine + cystine (%)	0.85	0.85	0.85	0.85	0.85
Tryptophan (%)	0.24	0.24	0.23	0.23	0.23
Threonine (%)	0.77	0.78	0.79	0.80	0.81
Arginine (%)	1.29	1.31	1.34	1.36	1.39
Ether extract fat (%)	5.71	7.14	8.56	9.99	11.43
Crude fiber (%)	3.20	4.11	4.96	5.83	6.69
Calcium (%)	0.89	0.90	0.91	0.91	0.91
Total P (%)	0.69	0.85	1.02	1.18	1.34
Available P (%)	0.45	0.50	0.56	0.61	0.67
Calcium/available P (%)	1.98	1.80	1.63	1.49	1.36
Linoleic acid (%)	2.37	2.70	3.02	3.34	3.66

[A]Per kilogram of diet: vitamin A, 15,000 IU; vitamin D, 3,000 IU; vitamin E, 31 IU; vitamin K, 2.6 mg; vitamin B_2, 7.6 mg; pantothenic acid, 7.5 mg; niacin, 40 mg; folic acid, 1.5 mg.
[B]Parts per million: manganese, 60; zinc, 35; copper, 6; selenium, 0.15; iron 20.

cleaned with water, dried, and ashed. Toe and tibia ashes were expressed as a percentage of dry bone weight.

At the end of the experiment (40 d), 2 broilers with body weights comparable to the average pen weight of control and birds on 40% rice bran treatments were killed. Stomachs, intestine, pancreas, and liver with gallbladder were removed, washed, and weighed. Mortality was determined daily. Feed intake and conversion were adjusted for mortality.

Dietary Treatments

Diets were formulated on a total amino acid basis to meet or exceed all NRC [8] nutrient recommendations. All diets were isocaloric, isonitrogenous, and isoaminoacidic (Tables 1 and 2). Diets were given as a starter, from 0 to 21 d of age, and as a grower, from 22 to 40 d of age. Starter diets were crumbled, and other diets were pelleted. Rice bran was collected from a commercial mill 24 h before mixing the diets (Table 3).

TABLE 3. Proximate analysis and energy of rice bran used in the experimental diets[A]

Rice bran	Dry matter (%)	Ash (%)	Crude fiber (%)	Ether extract (%)	Crude protein (%)	Gross energy (kcal/kg)	TME (kcal/kg)
Starter	88.7	8.5	8.3	14.3	15.4	5,028	3,591
Grower	88.6	7.7	7.4	13.4	13.8	4,986	3,769

[A]All values are on dry-matter basis.

Five treatments were used: control corn-soybean diet (0 to 40 d), diet with 10% rice bran (0 to 40 d), diet with 20% rice bran (0 to 40 d), diet with 20% rice bran (0 to 21 d) and 30% rice bran (22 to 40 d), and diet with 20% rice bran (0 to 21 d) and 40% rice bran (22 to 40 d).

Diets were analyzed for DM, N, ash, crude fiber, and ether extract according to the procedure of the AOAC [9]. Metabolizable energy values were calculated according to the method of Sibbald, [10, 11] (Table 4). Free fatty acids (FFA) and peroxide value of diets were determined at the beginning of the experiment [9] and the termination of each period [12] (Table 5). Data were analyzed by ANOVA procedure using the SAS package [13]. Pen was used as the experimental unit. Means different at the 5% level of probability were separated by using Duncan's multiple range test. All percentage data were converted to arc sin square root transformation prior to analysis.

RESULTS AND DISCUSSION

FFA and Rancidity

The FFA content of the oil in rice bran diets increased in the course of time; however, the rancidity (peroxide value) was low throughout the experiment. The excellent resistance of rice bran oil to oxidation is thought to be due not only to the tocopherol content but also to the ester of ferulic acid [14].

Mortality

Broiler chicks grew normally, and mortality was not related to dietary treatments. Mortality was 1.14% from 0 to 21 d and 15% from 22 d to the end of the experiment.

Broiler Performance

Weight gains were clearly affected by dietary treatment. At 21 d of age, the diets with rice bran had significantly poorer growth than the control diet. However, 1 wk later, birds fed the 10 and 20% rice bran diets had weight gains similar to control, whereas levels higher than 20% rice bran inclusion produced less growth than control birds. At the end of the experiment, the 30 and 40% rice bran diets significantly reduced weight gains (3.6 and 8%, respectively, Table 6).

Birds fed the control diet consumed significantly more feed than birds fed diets with rice bran until 21 d of age. From 28 d of age to the end of the experiment, differences in feed intake were reduced and became similar for all treatments at 40 d of age (Table 7). The

TABLE 4. Proximate analysis and true metabolizable energy of diets[A]

Diet	Dry matter (%)	Ash (%)	Crude fiber (%)	Ether extract (%)	Crude protein (%)	TME (kcal/kg)
Starter 0%	87.9	5.9	2.7	2.4	24.2	3,784
Starter 10%	87.9	5.9	3.0	2.7	24.1	3,820
Starter 20%	88.4	6.8	3.7	4.7	23.3	3,807
Grower 0%	86.4	5.7	3.1	3.2	22.1	3,966
Grower 10%	86.7	7.0	2.8	3.5	22.6	3,872
Grower 20%	86.9	7.0	3.1	4.6	22.2	3,863
Grower 30%	87.2	7.5	3.6	5.3	22.8	3,874
Grower 40%	87.3	7.9	3.3	6.9	22.5	3,724

[A]All values are on a dry-matter basis.

TABLE 5. Free fatty acids (FFA) and initial peroxide value (IPV) of oil extracted from rice brans and feeds on different days

Sample	FFA[A] (%)	IPV (mEq/kg)
Rice bran of starter	4.7	1.21
Rice bran of grower	8.4	1.0
Day 1		
Starter 0%	4.8	1.24
Starter 10%	6.8	0.54
Starter 20%	11.5	0.49
Day 21		
Starter 0%	8.7	0.63
Starter 10%	16.7	0.55
Starter 20%	25.8	1.82
Day 40		
Grower 0%	5.8	0.20
Grower 30%	22.8	1.0
Grower 40%	29.8	1.37

[A]FFA = oleic acid percentage.

high FFA levels in rice bran diets did not affect feed intake. The oxidative rancidity values were very low throughout the experiment.

Feed utilization was not affected by dietary treatments to 21 d of age. Beginning at 35 d of age, feed conversion was higher for birds fed the 40% diet, and at 40 d was higher for the 20, 30, and 40% diets. Birds receiving the 10% diet had the lowest feed conversion starting at 28 d of age (Table 8).

Mineralization Parameters

Tibia weights were significantly lower in the treatments with rice bran than control treatment at 21 d of age. At 40 d of age, only the treatment with 40% rice bran was significantly lower than control (Tables 9 and 10).

Tibia weights, when expressed as a percentage of live body weights, were not significantly affected by dietary treatment. This lack of difference can possibly be explained by differences in growth rate. The tibia length was not significantly different among the treatments at 21 or 40 d of age.

The percentage tibia ash of chicks at 21 d of age was not different ($P < 0.05$) among the treatments At 40 d of age, however, the level of rice bran inclusion did affect bone mineralization. Only birds fed a 10% rice bran diet had mineralization similar to birds fed the control diet. The short duration of the experiment possibly reduced the chances of a large mineral deficiency.

Although the toe and tibia ash percentages were correlated (R = 0.397; $P < 0.05$) the R-value is relatively low. Accordingly, the percentage of toe ash was not meaningfully affected by the level of rice bran in the diets (Table 10). The tibia ash seemed to be more sensitive to changes in dietary treatment than toe ash. Analogous findings have also been reported in previous trials [15].

TABLE 6. Body weight (g) of broilers from 21 to 40 d of age

Treatment	21 d	28 d	35 d	40 d
A (control)	749[a]	1,243[a]	1,744[ab]	2,067[a]
B (10%)	722[b]	1,257[a]	1,763[a]	2,076[a]
C (20%)	717[b]	1,226[ab]	1,728[ab]	2,025[ab]
D (30%)	—	1,216[ab]	1,687[bc]	1,992[b]
E (40%)	—	1,192[b]	1,631[c]	1,911[c]

[a–c]Means within the same column with no common superscripts differ significantly ($P < 0.05$).

TABLE 7. Feed intake (g) of broilers from 21 to 40 d of age

Treatment	21 d	28 d	35 d	40 d
A (control)	1,145[a]	2,037[a]	3,072[a]	3,796[a]
B (10%)	1,088[b]	1,924[b]	2,930[b]	3,679[a]
C (20%)	1,109[b]	2,013[ab]	3,082[a]	3,840[a]
D (30%)	—	1,969[ab]	2,990[ab]	3,805[a]
E (40%)	—	1,979[ab]	3,023[ab]	3,831[a]

[a,b]Means within the same column with no common superscripts differ significantly ($P < 0.05$).

TABLE 8. Feed conversion ratio of broilers from 21 to 40 d of age

Treatment	21 d	28 d	35 d	40 d
A (control)	1.53[a]	1.64[a]	1.77[b]	1.84[c]
B (10%)	1.51[a]	1.53[b]	1.66[c]	1.77[d]
C (20%)	1.55[a]	1.64[a]	1.78[b]	1.90[b]
D (30%)	—	1.62[a]	1.78[b]	1.91[b]
E (40%)	—	1.66[a]	1.85[a]	2.0[a]

[a–d]Means within the same column with no common superscripts differ significantly ($P < 0.05$).

TABLE 9. Mineralization parameter of tibia at 21 d of age

Treatment	Tibia weight (g)	Tibia weight[A] (%)	Tibia length (cm)	Tibia ash[B] (%)
A (control)	2.66[a]	0.33[a]	6.79[a]	44.5[a]
B (10%)	2.49[b]	0.33[a]	6.77[a]	42.8[a]
C (20%)	2.50[b]	0.33[a]	6.72[a]	43.0[a]

[a,b]Means within the same column with no common superscripts differ significantly ($P < 0.05$).
[A]Percentage of live body weight.
[B]Percentage of dry bone weight.

TABLE 10. Mineralization parameter of tibia and toe at 40 d of age

Treatment	Tibia weight (g)	Tibia weight[A] (%)	Tibia length (cm)	Tibia ash (%)	Toe ash[B] (%)
A (control)	8.37[ab]	0.39[a]	11.01[ab]	47.2[a]	12.62[ab]
B (10%)	8.70[a]	0.40[a]	11.27[a]	46.2[ab]	12.87[a]
C (20%)	8.44[ab]	0.40[a]	11.14[ab]	45.0[b]	13.05[a]
D (30%)	7.73[bc]	0.39[a]	10.88[b]	45.1[b]	13.28[a]
E (40%)	7.45[c]	0.38[a]	10.95[b]	44.3[b]	11.85[b]

[a–c]Means within the same column with no common superscripts differ significantly ($P < 0.05$).
[A]Percentage of live body weight.
[B]Percentage of dry bone weight.

TABLE 11. Intestine, pancreas, liver, and stomach weight (%) of broilers at 40 d of age

Treatment	Intestine	Pancreas	Liver	Stomach
A (control)	3.173[b]	0.224[b]	2.87[a]	1.96[a]
E (40%)	3.973[a]	0.263[a]	2.85[a]	2.01[a]

[a,b]Means within the same column with no common superscripts differ significantly; test of Duncan ($P < 0.05$).

In general, percentage tibia ash was reduced at higher rice bran levels. This finding indicates that the actual available phosphorus of the diets was lower than was estimated. Available phosphorus value from rice bran used was 30% of total rice bran phosphorus. Although the phosphorus availability ranges from 30 to 40% from plant sources, Belyea et al. [16] determined, in young poults, only 9% availability of phosphorus from rice bran. Phytate and fiber can interfere with mineral digestibility and retention; however, the relative importance of these 2 factors in the nutrition of nonruminant animals is an ongoing debate [17].

Organs

Pancreas and intestine weights of birds fed the control diet were significantly lighter than those of birds fed the 40% rice bran diet (Table 11). Higher pancreas and intestine weights could be due to the presence of trypsin inhibitor activity and high dietary fiber level in rice bran, respectively.

The hypertrophy of the pancreas caused by rice bran is somewhat similar to the trypsin inhibitor effect of soybeans. This agrees with the report of Kratzer et al. [18] in which autoclaving of rice bran for 15 min caused a significant reduction in the weight of the pancreas. Similarly, Kratzer and Payne [19] showed the presence of another growth inhibitor in rice bran in addition to the trypsin inhibitor.

Jørgensen et al. [20] showed that elevated levels of fiber increased the size of the digestive system. The length of intestine and particularly the length and weight of the cecum increased with fiber level. Liver and stomach weights were not affected by rice bran inclusion.

CONCLUSIONS AND APPLICATIONS

1. Concentrations of rice bran in excess of 20% in the diet produced significant reductions of body weight. Furthermore, feed conversion and tibia ash were impaired with diets containing more than 10% of rice bran. The feed conversion and tibia ash were more sensitive than weight gain for detecting antinutritive factors in rice bran.
2. Broilers fed a diet with 40% rice bran had higher pancreas and intestine weights than controls, suggesting the presence of other antinutritive factors in addition to phytate. The adverse effects of rice bran on weight gain, feed conversion, and mineralization found here suggest that rice bran should be included in broiler diets at levels between 10 and 20% if strategies are not used to decrease the antinutritive activity.

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