

Wet Feeding Mitigates the Adverse Effects of High Dietary Rice Bran Levels on Growth Performance and Nitrogen Retention of Broiler Chickens

Research Article

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ABSTRACT

The objective of this study was to evaluate whether the adverse effects of high dietary rice bran (RB) inclusion levels on the feed intake, performance, bone status and nitrogen (N) retention of broilers could be mitigated by wet feeding. Giving a completely randomized design experiment in 2 × 2 factorial arrangement, seventy two broiler chickens, managed in 24 floor pens received one of the two experimental diets (having 20 or 40% RB) either in dry or wet form from day 21 to 42 using a completely randomized design experiment in a 2 × 2 factorial arrangement of treatments. Wet feeds were prepared every day by mixing the respective air dry feed with tap water (1:1 w/w). Growth performance, visceral organ weights, N retention and tibia ash percentages were determined. At both dietary RB levels, birds given wet feed ate significantly more feed dry matter than those fed dry form of the respective feeds. The increase of RB level from 20 to 40% significantly reduced the feed intake, weight gain and N retention while increasing the digestive tract weight when the diet was of dry form. Those adverse effects were mitigated when the 40% RB diet was offered in wet form. It is concluded that wet feeding mitigates the adverse effects of high RB inclusion levels on broiler diets

KEY WORDS performance, poultry, wet feeding.

INTRODUCTION

Rice bran (RB), a by-product of the rice milling industry, is composed of pericarp, aleurone and sub-aleurone layers, parts of the germ and a small portion of the starchy endosperm (Hargrove, 1994). RB constitutes about 10% of the weight of rough rice (Hu *et al.* 1996) and thus milling of 645 million tonnes of global paddy production (Sharif, 2009) yields 64.5 million tonnes of bran. The *in vitro* nutritive value of RB is superior to or at least comparable with other cereals and their by products (Warren and Farrell, 1990). Particularly in the areas where rice is grown, RB is a readily available and relatively cheap feed ingredient for

poultry feed formulations. Atapattu (2005) calculated that under Sri Lankan conditions, the unit costs of many nutrients and energy coming from RB are lower than those of other cereals and their by products. Oladunjoye and Ojebiyi (2010) found that the cost of broiler feeding can be substantially reduced if higher levels of RB could be used in their diets.

However, the *in vivo* nutritive value of RB is greatly reduced due to the presence of some anti-nutrients such as phytate (Puminn, 2003), fibre (Warren and Farrell, 1990; Martin *et al.* 1998), anti-proteolytic substances (Kratzer and Payne, 1977; Deolankar and Singh, 1979) and lipase (Ramezanzadeh *et al.* 1999).

A number of studies (Warren and Farrell, 1990; Farrell, 1994; Madrigal *et al.* 1995; Martin *et al.* 1998; Farrell and Martin, 1998; Oladunjoye and Ojebiyi, 2010) have clearly shown that more than 20% RB in diets reduced the performance and the mineral status of poultry while increasing the excretion of minerals and nitrogen. Dietary manipulations such as supplementation of diets with phytase (Martin *et al.* 1998), fibre degrading enzymes (Pourrezal and Clasen, 2001; Deniz *et al.* 2007), enzyme mixtures (Martin *et al.* 1998; Malathi and Devegowda, 2001), organic acids such as citric acid (CA) alone or in combination with phytase (Bolling *et al.* 2000; Bolling *et al.* 2001; Afsharmanesh and Pourreza, 2005) have been found to be effective in mitigating the adverse effects of those anti-nutrients. However, with respect to RB, all these studies have been done with diets having relatively low levels ($\leq 20\%$) of RB. A number of studies carried out by different authors (El Gamri *et al.* 2005; Piyarathna *et al.* 2009; Atapattu and Prathath, 2010), using higher inclusion levels of up to 40% of RB in broiler diets, have failed to prevent performance being negatively affected.

Wet feeding has been found to increase growth and, in particular cases, feed efficiency (Yalda and Forbes, 1995; Yalda and Forbes, 1996; Yasar and Forbes, 1999; Yasar and Forbes, 2000; Scott, 2002) and utilization of phytate phosphorus in poultry (Kornegay, 2001). Birds prefer wet feed to dry feed (Sampath and Atapattu, 2007). The improved performance of broilers given wet feed could be due to higher feed intake and/or better feed utilization. Forbes (2003) suggested that wet feeding facilitates rapid and more complete digestion due to better penetration of digestive enzymes into food particles thereby increasing feed intake. Forbes (2003) further reported that improved broilers performance by wetting is more pronounced with low quality feeds. Recently, Atapattu and Wickramasinghe (2008) have found better feed efficiency in broilers fed better quality commercial feed in wet form than in dry form.

Therefore, it is hypothesized that negative effects of high dietary RB inclusion levels in broiler diets on feed intake, growth performance, bone status and nutrient excretion could be mitigated by giving such diets in wet form. The objective of this study was to test the above hypothesis.

MATERIALS AND METHODS

Day-old broiler chicks (Cobb), bought from a commercial hatchery, were brooded for 7 days on deep litter with heaters. Birds were given a commercial broiler starter feed *ad libitum* from day 1 to 20. On day 20 chicks ($n=72$) were weighed and allocated to 24 floor pens (0.65 m x 0.65 cm) so that between pen weight variation was minimum. Two iso energetic and iso proteonic feeds were formulated to

meet or exceed the nutrient requirements set out by NRC (1994). One feed contained 20 while the other had 40% dietary RB.

The ingredient composition and calculated nutrient composition of the feeds are given Table 1.

Table 1 Ingredients and nutrient composition of the experimental diets

Ingredients	Dietary rice bran level (%)	
	20	40
Coconut poonac g/kg	85.53	59.38
Yellow maize meal g/kg	350.00	139.29
Fish meal g/kg	30.00	20.00
Rice bran g/kg	200.00	400.00
Sesame oil meal g/kg	178.72	107.82
Soybean meal g/kg	63.75	144.25
Coconut oil g/kg	69.77	105.22
Shell powder g/kg	6.07	10.00
Di-calcium phosphate g/kg	8.65	8.01
Common salt g/kg	2.50	2.50
Vitamin mineral premix g/kg	2.50	2.50
L-Lysine g/kg	2.50	1.03
Nutrient composition		
¹ Crude protein g/kg	187.00	185.00
Lysine g/kg	10.00	10.00
Methionine g/kg	4.61	4.10
Methionine + Cystine g/kg	7.95	7.47
Non-Phytate Phosphorous (NPP)	3.50	3.50
Metabolizable Energy (MJ/kg)	13.5	13.7
Fibre g/kg	60.00	75.00

¹ Analyzed

Each pen had one feeder and a drinker. Pens were assigned to an experiment of 2 x 2 factorial design having 6 replicate pens per each treatment. Main treatment factors were two dietary RB levels (20 or 40%) and two forms of the diet (dry or wet).

Fresh feed was offered *ad libitum* once a day, at 9.00 am. Drinking water was freely available at all times. In wet feeding, the dry foods were mixed with tap water in the ratio 1:1 (w/w). Wet feeds were prepared and provided daily and left over feeds were discarded in next morning and the feeders were washed.

Two other feeders with wet feeds were kept in two bird-free pens at the same height as the other wet feeders, to determine the evaporative weight losses. In calculating the feed intake of the wet feeders, a correction was made for the evaporation weight losses. Daily feed and water intake and weekly live weights were measured from day 21 to 42. The mean day time temperature during the experimental period was 30.2 °C.

On day 35, birds in four randomly selected pens from each treatment combination were transferred to raised wire-floors fixed to the same pens. A total collection of feces was done for three days (from day 37 to 39), after two days of acclimatization. N retention was determined as described by Leeson and Zubair (1997). Nutrient retentions were ex-

pressed as g/100 g of mean body weight between day 35 and 42. Diets and excreta samples were analyzed for total N by the method outlined by AOAC (1990).

On day 42, one randomly selected bird from each cage was killed by cervical dislocation and dissected for carcass parameters. The left tibias of these birds were removed and analyzed for fat free tibia ash contents as described by Kim *et al.* (2004).

Data were analyzed using SAS (1996) as completely randomized design in 2 x 2 factorial arrangement. Pen means were used as replicates in growth parameter analysis, including feed and water intake. Individual birds selected were considered as replicates in visceral organ weight and tibia ash data analysis. Effects were considered significant when $P < 0.05$. Significant main effects were compared using DMRT procedure. Significant interactions were compared using the LS mean comparison procedure (SAS, 1996).

RESULTS AND DISCUSSION

Effects of dietary RB levels and forms on feed intake and growth performance parameters of broilers are given in Table 2. The main effect of RB was not significant ($P > 0.05$) for growth performance parameters such as live weight on day 42 and weight gain from day 21 to 42. Feed conversion efficiency (FCE) was not significantly affected either by the dietary form or dietary RB level*form interaction. The FCE of the birds fed 400 g/kg dietary RB (0.44) was significantly ($P < 0.01$) better than that of birds fed 200 g/kg RB (0.39). The best FCE was given by the birds fed wet form of diet having 400 g/kg RB.

Birds given wet feed drank significantly less water from drinkers (243 mL/bird/d) compared to those fed dry feeds (267 mL/bird/d). However, the total water intake (water from drinker+feed water) of the birds given wet feed (354 mL/bird/d) was significantly higher than those given dry feed (264 mL/bird/d). The interaction between dietary RB levels and the form was significant for feed intake, live weight on day 42 and weight gain from day 21 to 42. The LS mean comparison showed that the feed intake of the birds fed diet with 200 g/kg RB in wet form was significantly higher than that of all other treatment combinations. At both dietary RB levels, birds fed wet feed ate significantly more feed dry matter (DM) than those given dry feed. The increase of RB level from 200 to 400 g/kg significantly reduced the feed intake when offered in dry form and the effect was mitigated when the 400 g/kg RB diet was offered in wet form. The feed intake of birds fed 40% dietary RB in the wet form was not significantly different from those fed 200 g/kg RB diet in the dry form. The interaction between the effect of dietary RB level and form in live

weight on day 42 and the weight gain from day 21 to 42 also showed a similar pattern. At the lower dietary RB level, the form of the diet had no significant effect either on live weight on day 42 or weight gain from day 21 to 42. When given in dry form, the increase of the dietary RB level from 20 to 40% significantly reduced the final live weight and weight gain, but those adverse effects were mitigated when the diet was fed in wet form. The live weight and the weight gain of the birds fed the wet feed with 400 g/kg RB were significantly higher than those of the birds fed 20% RB diet in dry form. However, the feed intake of the above two groups was not significantly different. The dietary RB levels or forms or their interaction had no significant effect on tibia ash contents. The interaction between dietary RB levels and feed form was significant for N retention (Table 2). At the lower dietary RB level, N retention was significantly higher for the dry form diet compared to the wet form. At the 40% dietary RB level, the form of the feed had no significant effect. Increase of the dietary RB level from 20 to 40% reduced the N retention when the diet was in the dry form. However, the N retention of the wet form diet significantly increased when RB level was increased from 20 to 40%. There was a significant ($P < 0.001$) RB level × form interaction with respect to total digestive tract weight (Table 3). When dry form of diet was fed, the digestive tract weight increased with increasing RB level. At 40% RB level, birds fed wet form of diet had significantly lower digestive tract weight compared birds given dry feed. When wet feed was given, the digestive tract weight of the birds given 40% RB was significantly lower than in birds fed 20% RB. None of the other organ weights were significantly affected by the dietary RB levels, form and their interactions.

Reduced feed intake and availability of nutrients due to the anti-nutrients present in RB limit the nutrients available for growth while increasing the N and mineral excretion. The results of this experiment clearly suggest that wetting mitigated the adverse effects of higher RB levels on feed intake. Several authors (Yalda and Forbes, 1996; Coscun and Kutlu, 1997; Svihus *et al.* 1997; Wickramasinghe and Atapattu, 2008; Atapattu and Sudusinghe, 2010) have also reported positive effects of wet feeding on feed intake. The increased feed intake of the birds given 20% RB in wet form diet compared to the dry form of the same diet further suggest that apart from ameliorating the adverse effects, wetting itself has positive effects on feed intake. Some earlier findings (Atapattu and Wickramasinghe, 2008; Atapattu and Sudusinghe, 2010) showed that even intake of high quality feed could be increased when given in wet form support this assumption. Watson *et al.* (2006) found that lower gastric transit time (GTT) increased the feed intake in broiler chickens.

Table 2 Effects of dietary rice bran levels and the forms of the diets on feed and water intake, growth performance, tibia ash contents and N retention of broiler chickens

RB level (%)	20		40		ANOVA ²			
	D ¹	W	D	W	SEM	RB	Form	RB*Form
Live weight (g)								
Day 21	870	869	869	875	0.1	NS	NS	NS
Day 42	1784	1820	1664	1909	17	NS	*	*
Weight gain (g)	914	950	795	1034	17	NS	*	*
Total feed intake (g)	2257	2422	1868	2200	15	*	*	*
FCE (gain:feed)	0.40	0.39	0.42	0.47	0.01	**	NS	NS
Water intake (m/b/d)								
From drinker	270	231	264	262	3.8	NS	*	NS
Drinker + feed	270	346	264	362	3.7	NS	*	NS
Water:Feed	2.52	2.02	2.98	2.43	0.05	*	*	NS
Tibia ash (%)	41	43	43	43	0.25	NS	NS	NS
N retention (g/100 BW)	1.6	0.92	1.15	1.25	0.04	NS	NS	*

¹ D: dry form; W: wet form.² SEM: standard error of the mean; NS: non significant (P>0.05); * P<0.05; ** P<0.01.**Table 3** Effects of dietary rice bran levels and the forms of the diets on visceral organ weights of broilers

RB level (%)	20		40		ANOVA ²			
	D ¹	W	D	W	SEM	RB	Form	RB*Form
Organ weight % ³								
Liver	3.01	2.87	2.95	2.59	0.14	NS	NS	NS
Heart	0.56	0.53	0.52	0.45	0.03	NS	NS	NS
Gizzard	1.60	1.59	1.6	1.43	0.1	NS	NS	NS
Pancreas	0.24	0.22	0.24	0.17	0.02	NS	NS	NS
Total digestive tract weight	6.15	6.8	6.94	5.58	0.29	NS	NS	*

¹ D: dry form; W: wet form.² SEM: standard error of the mean; NS: non significant (P>0.05); * P<0.05; ** P<0.01.

Increase of the dietary full fat RB content from 20 to 40% (Atapattu and Wickramasinghe, 2007) and defatted RB content from 15 to 25% (Puminn, 2003) had no significant effect on GTT of broiler chickens. Also, Atapattu and Wickramasinghe (2008) found no significant differences in GTT between the broilers fed a commercial diet either in dry or wet form. If the increased feed intake was due to the faster evacuation rate of the digesta through the tract, it would have influenced the digestion and absorption process and thereby the performance. However, that was not the case in this experiment and thus it is unlikely that increased feed intake is due to faster feed evacuation rate through the digestive tract. One possible explanation for increased feed intake of the wet feed given to birds is that wetting improves the palatability of feeds. Findings of recent studies (Atapattu and Wickramasinghe, 2008; Atapattu and Sudusinghe, 2010) reported that even the intake of high quality feed is increased when given in wet form by supporting this hypothesis. Alternatively, wetting may reverse the adverse effects of phytate and fibre on feed intake. A number of studies (Jongbloed *et al.* 1991; Kamme and Jongbloed, 1993; Nasi *et al.* 1995; Liu *et al.* 1997; Kornegay, 2001) with pigs have found that wetting increased the utilization efficiency of phytate P.

Jin *et al.* (1994) have reported that high fibre diets increased the intestinal crypt cell proliferation rate. Meanwhile, Yasar and Forbes (2000) have reported that crypt cell proliferation rate of broilers was significantly reduced by wet feeding and that wet feeding had marked stimulatory effects on food intake. Therefore, it is possible that wetting had mitigated the adverse effects of phytate and fibre on feed intake. This hypothesis is further supported by the growth performance parameter. Even though the main effects of RB on final live weight and weight gain were not significant, the LS mean comparison of the performance parameters from the birds fed 20 and 40% RB diets in dry form clearly indicated that 400g/kg RB has negative effects on performance. Several other studies (Warren and Farrell, 1990a; Farrell, 1994; Madrigal *et al.* 1995; Martin *et al.* 1998; Oladunjoye and Ojebiyi, 2010) have also reported adverse effects higher inclusion levels of RB in broiler diets on growth performance, bone status and mineral and N excretion of broilers. The presence of some anti-nutrients such as phytate (Puminn, 2003), fibre (Warren and Farrel 1990a; Warren and Farrell, 1990b; Martin *et al.* 1998), anti-proteolytic substances (Kratzer and Payne, 1977; Deolankar and Singh, 1979) and lipase (Ramezanzadeh *et al.* 1999) have found to be the contributory factors.

Only limited studies have attempted to increase the dietary RB inclusion levels in broilers diets above 20%. Supplementation of a broiler finisher diet having 40% RB with citric acid did not mitigate the adverse effects on growth performance. Other strategies such as formulation of diets based on digestible amino acids of RB (Atapattu and Wickramasinghe, unpublished data) and digestible amino acid levels of all the dietary ingredients (El Gamri *et al.* 2005), balancing of up to four amino acids in RB based diets (Piyaratna *et al.* 2009) and the alteration of the dietary energy level check this reference because it doesn't appear in the References section) have also not mitigated the adverse effects of high dietary RB levels on the growth performance of broilers. Interestingly, in this experiment, the adverse effects of 40% dietary RB not only on feed intake but also on final live weight and weight gain were mitigated by wet feeding.

Effects of wetting on feed intake and other growth performance parameters were more obvious at higher RB level than at lower level. At 20% dietary RB level improvement of feed intake, weight gain and FCE of the birds given wet feeds compared to dry feeds given to birds were 7.3, 4 and -3%, respectively. Meanwhile, at 40% dietary RB level, the respective values were 17, 30 and 10%. Forbes (2003) also suggested that the improved performances of broilers are more pronounced when low quality feeds are given in wet form. Both phytate (Selle *et al.* 2000; Selle and Ravindran, 2007) and fibre (Mujahid *et al.* 2003) have negative effects on protein digestibility.

Heating has found to destroy the anti-proteolytic substances (Lu *et al.* 1991) and thus under the present experimental conditions in which heat stabilized RB was used, the major anti-nutrients responsible for the reduced N retention of the broilers fed dry form diet with 40% RB may be high phytates and fibre contents. Interestingly, the negative effects of high RB levels of N retention were also corrected when the diet was in wet form. At lower RB level wet feeding had a negative effect on N retention. N retention of the birds fed wet form diet at 40% RB level was not significantly different from that of the birds given the same diet in dry form. Therefore, it seems that apart from ameliorating the adverse effects of high RB based diet, wetting itself does not have the capacity to improve protein digestibility. Non-significant differences in growth performance parameters of the birds given wet and dry form diets with 20% RB support this hypothesis. Findings that birds in all treatment groups, even those fed 40% RB diet in the dry form had satisfactory tibia ash contents contrary to the argument that wet feeding improves the phytate hydrolysis. Both dietary formulations used in this experiment contained 3.5 g of NPP/kg to meet the NRC (1994) requirements. However, a number of studies (Angel *et al.* 2000a; Angel *et al.* 2000b;

Dhandu and Angel, 2003; Powell *et al.* 2008) have shown that NPP requirements of broilers were substantially lower than the standards set out in NRC (1994). Therefore, those birds fed even the 40% RB diet in dry form might have had sufficient P availability as reflected by tibia ash contents. Several studies have shown increased gizzard (González-Alvarado *et al.* 2008; Jiménez-Moreno *et al.* 2009a; Jiménez-Moreno *et al.* 2009b) and pancreas (Deolanker and Sing, 1979; Desphande and Damodaran, 1989) weights of the birds fed higher levels of fibre. Therefore, the weights of the gizzard and pancreas were expected to be higher for the birds fed 40% dietary RB but that was not the case in this experiment.

Several studies (Hetland and Svihus, 2001; Jiménez-Moreno *et al.* 2009a; Jiménez-Moreno *et al.* 2009b) have reported higher digestive tract weight of birds fed high fibre diets. Interestingly, effects of high fibre on digestive tract weight were also mitigated by wet feeding. González-Alvarado *et al.* (2008) suggested that fibre increased the gastric retention time and the development of musculature of the digestive tract thereby increasing the weight. Results of this experiment suggest that wetting reduced this need for higher muscular development. Possibly, wetting may have a physical effect on fibre allowing easy particle size reduction. Reduced digestive tract weight due to wetting of feed may have two practical implications.

Firstly, reduction of digestive tract growth may spare more nutrients and energy for the growth of the body parts which have direct economic importance. Secondly, lower digestive tract weight may increase the dressing percentage of the birds. Even though the water intake from drinkers was reduced when wet feed was offered, the total water intake (water from drinkers+water intake with feed) was higher for the birds given wet feeds, compared to that of dry-fed birds. Recently, have also found that total water ingestion (from drinkers+with feed) of broilers increased when wet feed was offered. Negative effects of heat stress on feed intake of poultry are well known (Bonnet *et al.* 1997; Hurwitz *et al.* 1980; Savory *et al.* 1986). Coscun and Kutlu (1997) found that under heat stressed conditions, supplemental ascorbic acid in dry diets stimulated broiler performance but not in wet diets. The present experiment was conducted under hot humid conditions. Therefore, under hot environmental conditions, wet feeding may be used as a mean of giving more water to birds thereby preventing the heat-induced negative effects on feed intake and performance.

CONCLUSION

It is concluded that adverse effects of high RB inclusion levels on feed intake, growth performance, N retention and

higher digestive tract weight of broiler chickens could be mitigated by wetting the feed. Increased feed intake of wet feeding will be an added advantage under hot humid conditions.

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