SUPPLEMENTARY MATERIAL AVAILABLE ONLINE

Indian Journal of Animal Sciences **94** (10): 876–880, October 2024/Article
https://doi.org/10.56093/ijans.v94i10.153468

Production performance, carcass characteristics, intestinal morphometry and serum biochemistry in dual purpose chicken fed diet incorporated with rice distillers grain with soluble

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Received: 5 July 2024; Accepted: 20 August 2024

ABSTRACT

This study investigated the effects of rice distillers grains with solubles (rDDGS) on growth performance, production efficiency, carcass characteristics, nutrient metabolizability and serum biochemistry of dual purpose chicken (Kuroiler). Four diets were formulated with graded levels of rDDGS (0, 10, 14 and 18%). Each diet was allocated to 5 replicates with 10 birds in each at random. With the exception of 21 days, there was no difference in body weight gain, feed intake, or feed conversion ratio (FCR) among the treatment groups. The dietary levels of rDDGS had no effect on serum biochemical parameters. Dietary level of 14% rDDGS significantly increased dressing yield and thigh and drumstick percentage. The metabolizability of dry matter, crude protein, ether extract, crude fiber, nitrogen free extract and organic matter was similar among the experimental groups. The addition of rDDGS had no negative effects on jejunum histo-morphometry. In the 18% rDDGS fed group, profit per kg live weight was comparatively higher. In conclusion, rDDGS may be added to dual-purpose chicken diets safely up to an 18% inclusion level as a substitute protein source for profitable production.

Keywords: Body weight, Biochemical, Carcass, Morphometry, Performance

Sixty-five to 75% of the total expenses on chicken production are related to feed. Most of this cost is attributed to protein components. Consequently, feed costs may be reduced by substituting less expensive ingredients replacing costly protein sources. Soybean meal is the main source of protein in chicken diets, but it is expensive and limited in availability, so there is a need to search for other locally available alternate sources.

DDGS, a by-product of the ethanol industry is readily available, has a greater production rate and is relatively less expensive than other cereals. Among several cereals, rice is commonly utilized to produce bioethanol. About 35% of rDDGS is soluble and 65% is distiller's grain (Babcock *et al.* 2008). Broiler performance and carcass characteristics were unaffected by the addition of rDDGS up to a 10% level (ICAR-CARI, Annual Report 2014–15). According to Gupta (2016), rDDGS can be added to layer diets safely up to a 10% inclusion level without having an impact on egg quality or output. The majority of studies on DDGS have only been conducted on corn, wheat, barley, and sorghum; and there are very few studies on the feeding value of rDDGS in chickens.

Native chicken meat and eggs are becoming more and more in demand across the nation. The indigenous chicken's meat and eggs are sold for more money, more than twice as much as the prices of broiler meat and table eggs (Saikia *et al.* 2020). These are advertised as organic eggs and meat in various marketplaces, which has raised consumer demand for them. Therefore, raising native chickens for meat and eggs with balanced poultry feed may be deemed an urgent necessity. For impoverished farmers, raising these hens with relatively cheaper meals and utilizing unconventional, inexpensive substances like DDGS to lower production costs may be a profitable practice. Therefore, the present study was undertaken to investigate the effect of dietary incorporation of DDGS in indigenous chicken.

The study employed Kuroiler (an improved variety for backyard farming with high productivity) which was developed by Kegg Farm Pvt Ltd. in India. Since rice is a staple grain that is widely consumed in the northeastern region of India, dried rDDGS was employed in the study. There are a lot of distilleries in these places that make 'deshi liquor,' which is more affordable. However, the massive amount of byproduct that these distilleries produce is misused and poured or dumped into water bodies, leading to pollution, the extinction of aquatic life,

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and other problems. However, this by-product offers some nutritional benefits to poultry birds (19% CP, 2000 Kcal/kg ME, 1.34% TA, 1.09% EE, 5.00% CF, 0.43% Ca, 1.14% P). Therefore, using this byproduct as feedstock can benefit the environment and the financial return to farmers.

The current study was conducted in light of the aforementioned information in order to determine the appropriate amount of rDDGS to include in the diet of dual-purpose chickens in order to maximize production, carcass features, nutrient metabolizability, intestinal morphometry, and serum biochemistry.

MATERIALS AND METHODS

rDDGS were purchased in liquid form from regional traditionally processed rice-based alcohol manufacturers. These were spread out on a sheet of polythene, dried in the sun and then kept in hot air oven at 70°C for overnight. After that, they were ground using a mixer to prepare the experimental ration. The college's Institutional Animal Ethics Committee (F.1/GEN/IAEC/CVS/RKN/2020) examined and approved every procedure employed in the bird experiment. The experiment was carried out in Poultry Unit of the Livestock Farm Complex, College of Veterinary Sciences and Animal Husbandry, R. K. Nagar, Agartala, Tripura. Following a completely randomized design, 200 day-old straight run dual purpose chicks with an average body weight (BW) of 39.54±0.21 g were distributed randomly. The dietary treatments were control (0% rDDGS) and 3 levels of rDDGS (10, 14 and 18%) with 5 replicates per treatment and 10 birds per replicate pen (3.25 × 3.25 feet). The birds were maintained up to 7 weeks. Newcastle disease and Infectious Bursal Disease vaccines were administered. The isocaloric and isoproteinic diets were prepared (Table 1) as per the recommendation of BIS (2007).

Weekly BW and feed intake were recorded and overall (0-3 weeks, 4-7 weeks and 0-7 weeks) body weight gain (BWG) and feed conversion ratio (FCR) were calculated. Mortality was recorded as and when occurred. In order to evaluate the effects of the nutritional treatments administered to the experimental birds, the following efficiency measures were calculated:

Production efficiency factor (PEF) = final BW (kg) × livability (%) × 100/age in days × FCR

Protein efficiency ratio (PER) = weight gain/protein intake

Energy efficiency ratio (EER) = weight gain (g) × 100/ total energy intake (ME kcal) (Mir *et al*. 2017).

At the end of trial, 5 birds from each dietary treatment group (1 birds/replicate) were selected randomly and slaughtered to assess carcass characteristics. The carcass yield was calculated as the proportion of eviscerated to live weight (%). The cuts yield (breast, neck and back, Thigh, drumstick, wings, liver, gizzard, heart, pancreas and spleen) was calculated relative to the eviscerated carcass weight (%). At the time of slaughter, blood samples were taken for analysis of biochemical profile (haemoglobin (Hb), glucose, total protein, albumin, globulin, aspertate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatae (AKP), uric acid and creatinine using commercial kit. For metabolic trial (7 days duration), one bird in each replicate was selected and kept apart in a wire floor metabolism cage and representative fecal samples were examined for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and total ash (AOAC 2005).

By the end of trial, intestinal morphometry was studied using a high-resolution microscope with micrometry and photographic attachment (Lynx, Lawrence and Mayo Binocular Microscope, model no L3201LED) on 12 birds per treatment (3 birds × 4 treatment × 4 replicates). Villus surface area, crypt depth, villus width, crypt depth to villus height ratio, and villus height to villus width ratio were measured (Law *et al.* 2007). Because the jejunum is an important location of nutrient absorption in chickens, it was of particular interest (Horn *et al.* 2009).

Table 1. Ingredient and calculated composition of experimental diets

Ingredient	Treatment			
	0%	10%	14%	18%
Maize	48.00	46.00	44.50	51.80
Soybean	28.00	27.00	26.60	26.50
Wheat bran	10.40	4.20	-	-
Rice polish	10.00	9.00	11.00	-
rDDGS	-	10.00	14.00	18.00
DCP	1.20	1.30	1.30	1.20
LSP	1.40	1.40	1.50	1.40
Salt	0.30	0.30	0.30	0.30
Feed additive premix*	0.70	0.70	0.70	0.70
Chemical composition (g/kg)[1]				
ME (Kcal/kg)[2]	2800	2800	2800	2800
DM	881.10	882.80	876.90	878.90
CP	200.00	200.00	200.00	20.00
EE	24.90	24.50	24.70	27.60
CF	59.80	59.30	58.80	56.40
TA	87.0	77.0	86.10	66.40
NFE	628.30	639.30	630.40	649.60
OM	913.0	922.70	913.90	933.60
Ca	10.70	9.90	10.30	9.70
Total phosphorus	6.30	6.40	6.60	5.40
Lysine[2]	11.65	11.30	11.00	11.20
Methionine[2]	3.60	4.20	4.40	4.50

*, Includes mineral supplement 0.15, vitamin supplement 0.05, Choline chloride 0.10, Maduramycin 0.03, Sodium bicarbonate 0.20, Antioxidant (BHT) 0.01, Biophos 0.01, Toximar 0.04, Probios 0.03. Mineral supplement per kg of diet: Zn, 60 mg; Mn, 90 mg; Fe, 110 mg; KI, 2.5 mg. Each g contains (Ventremix): vitamin A, 82,500 IU; vitamin B_2, 50 mg; vitamin D_3, 12,000 IU; vitamin K, 10 mg. Each g contains (Ventribee Plus): vitamin B_1, 4 mg; vitamin B_6, 8 mg; vitamin B_{12}, 40 mg; vitamin E, 40 mg; calcium-D-pantothenate, 40 mg; niacin, 60 mg. [1], Assayed values; [2], Calculated on the basis of standard values applicable under Indian condition (Singh and Panda 1996).

The economics was determined by figuring out the cost of raw ingredients, additives and other supplements and then computing the cost of starter feed. All statistical analysis were performed using Sigma Plot 11.0 software package. The results were expressed as the mean and pooled standard error of mean. Significance was tested by using two-way ANOVA considering treatment and period as factors with the following model:

$$Y_{ijk} = \mu + T_i + P_j + TxP_{ij} + e_{ijk}$$

where, Y_{ijk}, observation associated with each parameters; μ, overall mean; T_i, effect of i^th^ treatment groups (i=1, 2, 3 & 4); P_j, effect of j^th^ periods (j=1, 2 & 3); TxP_{ij}, interaction effect of j^th^ periods within i^th^ treatment group; and e_{ijk}, random error. For comparison between treatment and control groups, Holm-Sidak test was used. Probability values of P<0.05 were stated as significant. No statistical analysis was made for mortality data and cost calculation of different basal diets. The specific P-values were stated in the text where there is a significant difference.

RESULTS AND DISCUSSION

Results relating to growth performance are presented in Table 2. Efficiency parameters are provided in Supplementary Table 1. Results show that chickens with higher dose of rDDGS had higher (P<0.05) BWG during 0-3 weeks in comparison with other treated groups. But during 4-7 weeks and in overall (0-7 weeks) growth phase, there was no effect (P>0.05) of dietary treatments. No influence (P>0.05) was also observed among control and other rDDGS incorporated groups on feed intake and FCR. Protein efficiency and energy efficiency decreased (P>0.05) with increasing dose of rDDGS.

The effect of rDDGS on production performance in present study were in line with Damasceno *et al*. (2020) and Thein *et al*. (2020). In contrast, Campasino *et al.* (2015) and Mir *et al.* (2017) reported a decline in average BWG of broilers fed with increasing level (10, 15%) of DDGS. However, a few reports have shown that broilers fed diets containing 8% DDGS or more showed an increase in growth rate, similar weight gain and the feed: gain ratio at 42 days which support our findings (Shim *et al*. 2011). According to Abudabos *et al.* (2017), significant weight gain after three weeks may have resulted from improved production efficiency, while the non-significant effect on BWG may have been caused by a higher amount of NSP in the rDDGS, which impeded the digestion of other nutrients. The current study disagreed with Raju *et al.* (2021) but agreed with Singh *et al*. (2020) and Thein *et al*. (2020) on feed intake. To counteract the diluting impact of NSP, birds in the current experiment took more feed containing an elevated level of rDDGS in order to meet their energy and nutritional needs (Barekatain *et al.* 2013).

Numerous research studies (Lukaszewicz and Kowalczyk 2014, Thein *et al.* 2020) support the current study's findings about FCR, but in contrast with Borah *et al.* (2019). Better nutrient metabolizability in the control group may be the cause of their lowest FCR. 10% rDDGS group had a relatively higher FCR than the other treated groups, which could also be related to lower DM, EE, and CP metabolizability. Similar to our findings, Lumpkins *et al.* (2004) demonstrated that while feeding DDGS, the amount of dietary protein from maize and the equivalent decrease in soybean protein may have contributed to the poor performance due to a marginal lysine shortage. The non-significant FCR may have resulted from the experimental birds' increased BW in proportion to their increased feed intake.

Among carcass traits, breast, wings and neck of the birds had no effect (P>0.05) by dietary treatments (Table 3), but significantly (P< 0.05) higher dressing yield, thigh, drumstick yields were recorded in 14% DDGS fed group compared with other treated groups. However, supplementing rDDGS had no effect (P>0.05) on relative weight of heart, liver, gizzard, pancreas and spleen. The results of the present study are not in agreement with Saikia *et al.* (2020) who reported no significant difference on

Table 2. Effect of dietary supplementation rDDGS on production performance of dual-purpose chicken

Attribute	Treatment				SEM	P-value
	0%	10%	14%	18%		
BWG (g/bird)						
0-3 weeks	189.43[a]	191.71[ab]	194.65[ab]	224.08[b]	5.11	0.021
4-7 weeks	668.60	613.98	591.51	631.80	12.95	0.305
0-7 weeks	858.03	805.69	786.17	855.88	5.91	0.079
Feed intake (g/bird)						
0-3 weeks	533.19	611.21	614.61	610.66	13.57	0.063
4-7 weeks	2832.97	2783.15	2651.43	2872.66	46.31	0.319
0-7 weeks	3366.16	3394.36	3266.04	3483.32	51.90	0.589
Feed conversion ratio (FCR)						
0-3 weeks	2.82	3.19	3.18	2.73	0.08	0.084
4-7 weeks	4.24	4.55	4.48	4.57	0.09	0.742
0-7 weeks	3.92	4.22	4.15	4.08	0.07	0.560
Mortality%	8.00	8.00	4.00	6.00	-	-

Means bearing superscripts in the same row differ significantly (P<0.05). SEM, Standard error of mean; P, Probability.

Table 3. Effect of dietary supplementation of graded levels of rDDGS on carcass traits, cut up parts and relative organ weight (% of dressed yield) of dual-purpose chicken

Attribute	Treatment				SEM	P-value
	0%	10%	14%	18%		
Carcass yield	465.67[a]	445.33[ab]	454.67[ab]	516.67[b]	10.01	0.020
Dressed yield	60.83[c]	63.91[b]	64.28[b]	58.60[ac]	0.79	0.003
Breast	23.11	23.45	23.16	22.08	0.32	0.514
Neck and Back	33.26	33.34	32.62	33.97	0.28	0.455
Thigh	14.07[ab]	14.93[b]	16.89[c]	13.17[a]	0.47	0.005
Drumstick	14.65[a]	14.94[ac]	16.76[b]	16.09[bc]	0.32	0.030
Wings	14.10	13.35	14.78	13.35	0.29	0.266
Liver	4.91	4.71	4.46	4.75	0.18	0.881
Gizzard	4.21	4.49	4.02	4.43	0.20	0.868
Heart	1.16	1.12	1.10	1.08	0.05	0.789
Pancreas	0.60	0.57	0.48	0.41	0.03	0.053
Spleen	0.33	0.27	0.22	0.34	0.02	0.165

Means bearing superscripts in the same row differ significantly (P<0.05). SEM. Standard error of mean; P, Probability.

carcass and dressed yield when diets were formulated with 15% and 20%DDGS but similar to Mustafa *et al.* (2017) and Borah *et al.* (2019). However, Loar *et al.* (2012) observed significant (P<0.01) decrease in carcass yield, breast meat weight in broilers fed more than 14% maize DDGS.

No significant (P>0.05) differences were observed in serum biochemical parameters among the dietary treatment groups (Supplementary Table 2). These findings are similar to Ghazalah *et al.* (2011), Ghaly *et al.* (2017), Damasceno *et al.* (2020) and Raju *et al.* (2021) but in contrast with Youssef *et al.* (2013), Mustafa *et al.* (2017) and Ghaly *et al.* (2017). The marginally elevated Hb concentration in the rDDGS supplemented birds may be due to higher oxygen consumption linked to higher Hb saturation and dissociation rates (Yahav *et al.* 1998). According to Youssef et al. (2013), blood glucose levels increased in 10% of rDDGS-fed birds as compared to the control group, suggesting that DDGS-fed hens had poorer glucose metabolism. The liver and other important organs from which these enzymes are secreted do not exhibit dystrophy, as the results of the current investigation showed that there was no difference in the liver enzymes throughout the study. Good renal health is indicated by no significant effect on serum albumin concentration in the current investigation. The 10% rDDGS fed group had the lowest uric acid concentration, indicating some protein catabolism, while the control group had the highest concentration. The amount of muscle tissue and its ability to break down phosphocreatine are correlated with creatinine concentration (Wyss and Kaddurah-Daouk 2000). The non-significant fluctuation in creatinine levels observed in this study could potentially be explained by the absence of muscular damage in the experimental birds.

There was no effect (P>0.05) on nutrient metabolizability between the experimental groups (Supplementary Table 3). Corroborating with present result, Thein *et al.* (2020) and Raju *et al.* (2021) reported no effect (P>0.05) on OM, DM and CP metabolizability in broilers fed different levels of rDDGS but in contrast with Thacker and Widyaratne (2007), who reported decreased metabolizability of DM with increasing level of wheat based DDGS. The high fibre content of DDGS, which has a lower digestibility, also reduces the digestibility of other nutrients, which may be the cause of the non-significant but poorer metabolizability seen in this experiment.

The micrometric measurements of jejunal sections of different treatments indicated that villi height (µm), villi area (mm^2), villi width, crypt depth, villi height/crypt depth and villi height/width were similar but there was decreasing trend in treatment groups compared to control (Supplementary Table 4). The observations related to intestinal morphometry are supported by Kaninde *et al.* (2023), but are in disagreement with Ranjan *et al.* (2017) and Dinani *et al.* (2018). In the present study, declining trend of histomorphometry parameters may be associated with lower digestibility of the experimental diets. Effect of supplementation of rDDGS on economics of production are presented in Supplementary Table 5. Total expenditure per bird was the highest in control group and lowest in 14% RRGS fed group. Profit/kg of live weight was the highest in 18% fed group and lowest in $T_{1,}$ respectively. Though the feed intake and final BW of the birds of control and 18% fed group is quite similar, however, highest economic gain and economic index score were observed in the 18% fed group and that might be due to lower feed production cost due to inclusion of 18% DDGS. Therefore, for better economic gain 18% inclusion of DDGS in diet could be recommended. The result is consistent with the findings of Thein *et al.* (2020) and Borah *et al*. (2019).

This study concludes that rDDGS can be added safely up to 18% level in dual-purpose chicken diet without having any negative impact on growth performance, carcass characteristics, nutrient utilization and serum biochemistry. It can also be used as a substitute protein meal for affordable chicken production.

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