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Effect of rice distillers dried grains with solubles and rice gluten meal along with enzyme supplementation on the growth performance, nutrient utilization, production efficiency, and cost economics of broiler chicken production

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Abstract: An experiment was conducted to evaluate the effect of feeding rice distillers dried grains with solubles (rDDGS) and rice gluten meal (RGM) combination with enzyme supplementation on the production performance of broiler chickens. The experimental diets consisted of the following: T1 (no rDDGS/RGM/enzyme), T2 (no rDDGS/RGM, multienzyme), T3 (12.5% rDDGS, 15.0% RGM, no enzyme), T4 (12.5% rDDGS, 15.0% RGM, protease enzyme), T5 (10.0% rDDGS, 12.5% RGM, no enzyme), and T6 (10.0% rDDGS, 12.5% RGM, protease enzyme). Each treatment was assigned 6 replicate groups of birds randomly with 8 birds in each group (48 birds/treatment). The results revealed the poor growth performance, nutrient utilization, and production efficiency of birds fed a combination of 12.5% rDDGS and 15.0% RGM, followed by the combination of 10.0% rDDGS and 12.5% RGM compared to birds fed no rDDGS and RGM. Enzyme supplementation resulted in significantly ($P < 0.01$) better growth performance, nutrient utilization, and production efficiency of the birds compared to unsupplemented birds. It was concluded that inclusion of a combination of 10.0% rDDGS and 12.5% RGM as a replacement for soybean, along with dietary enzyme supplementation, can be a potential nutritional strategy for economic broiler chicken production.

Key words: Rice distillers dried grains with solubles, rice gluten meal, protease, broiler performance, nutrient utilization, cost economics

1. Introduction

The search for alternative feed ingredients in poultry nutrition is a continuous process in the pursuit of economical poultry production. Feed accounts for 65%–75% of total production cost in poultry rearing. India is among the largest rice producing countries of the world with an annual production of approximately 105 million tons in 2015–2016 [1]. A variety of by-products from rice processing industries, particularly rice distiller-dried grains with solubles (rDDGS) and rice gluten meal (RGM), which are both potential protein sources, can be used as a economically efficient replacements for soybean in broiler chicken rations [2]. Thus, rDDGS and RGM are 2 potential and economically feasible protein rich feed ingredients for poultry ration produced by the rice processing industries. rDDGS is a by-product of the dry-grind fuel ethanol industry and is abundantly available as livestock feed [3]. However, during ethanol production, the drying process destroys most of the lysine in DDGS, which can exert negative effects on the growth performance of broiler chickens [4]. RGM is a byproduct of the wet milling of rice and is available in significant volumes and at low cost compared to soybean; it contains 3152 kcal ME/kg, 46.45% crude protein, 3.4% ether extract, and a favorable amino acid profile with a relatively higher abundance of methionine [5]. On the other hand, exogenous enzyme supplementations in poultry diets have nutritionally, economically, and environmentally proven benefits [6]. Exogenous enzyme supplementation increases nutrient digestibility, reduces water content, and lowers the viscosity of the excreta in the gut [7,8]. Thus, the present study was conducted to evaluate the effect of dietary inclusion of rDDGS and RGM, along with suitable enzyme supplementation, on the growth performance, nutrient utilization, and production efficiency of broiler chickens with the hypothesis that inclusion of rDDGS and RGM, along with enzyme supplementation, reduces the feed cost in broiler chicken production.

2. Materials and methods

2.1. Ethical approval

All of the procedures carried out and animal welfare were reviewed and approved by the Institutional Animal Ethics

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Committee of the Indian Veterinary Research Institute in Bareilly, India (452/01/ab/CPCSEA).

2.2. Birds, experimental diets, and design

A total of 288 Caribro Vishal broiler chicken from the same hatch and uniform weight were procured from the institutional hatchery for the experiment. The birds were divided into 36 replicate groups, with 8 birds in each, and they were housed in specially-designed battery brooder cages with standard watering and feeding facilities (1 replicate group in each battery cage). The broiler chicken ration was formulated by employing different levels of rDDGS and RGM as a replacement for soybean meal in basal diets, along with enzyme supplementation as a prestarter, starter, and finisher [9]. The levels of rDDGS and RGM and the suitable enzymes were standardized in a preliminary trail. rDDGS levels of 10.0% and 12.5% and RGM levels of 12.5% and 15.0%, along with either multienzyme or protease enzyme, were selected to formulate the 6 experimental diets with a 2 × 3 factorial design i.e. T1 (no rDDGS/RGM/enzyme; negative control), T2 (no rDDGS/RGM, with multienzyme; positive control), T3 (12.5% rDDGS, 15.0% RGM, no enzyme), T4 (12.5% rDDGS, 15.0% RGM, with protease enzyme), T5 (10.0% rDDGS, 12.5% RGM, no enzyme), and T6 (10.0% rDDGS, 12.5% RGM, with protease enzyme). Each treatment was randomly allocated 6 replicates of birds, and the birds were fed ad libitum with ample, clean drinking water. The feed ingredients and the nutrient composition of the diets are given in Table 1. The multienzyme contained *a*-amylase, *b*-glucanase, xylanase, carboxymethylcellulase, pectinase, proteinase, *a*-galactosidase, *b*-galactosidase, lipase, and phytase.

2.3. Growth performance

The weekly body weight and daily feed intake were recorded to arrive at overall (0–14 days, 14–28 days, 28–42 days, and 0–42 days) body weight gain (BWG), feed intake

Table 1. Ingredient and nutrient composition of broiler chicken diets.

Ingredients (%)	Prestarter diet (0–14 days)						Starter diet (14–28 days)						Finisher diet (28–42 days)					
	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6
Maize	54.42	54.42	58.58	58.58	57.78	57.78	55.63	55.63	60.97	60.97	59.81	59.81	62.00	62.00	66.77	66.77	65.61	65.61
SBM	38.40	38.40	8.80	8.80	14.30	14.30	37.10	37.10	7.40	7.40	13.00	13.00	31.30	31.30	2.00	2.00	7.50	7.50
DORB	0.00	0.00	0.70	0.70	0.90	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.5	0.5	0.5	0.5	0.5	0.5
DDGS	0.00	0.00	12.50	12.50	10.00	10.00	0.00	0.00	12.50	12.50	10.00	10.00	0.00	0.00	12.50	12.50	10.00	10.00
RGM	0.00	0.00	15.00	15.00	12.50	12.50	0.00	0.00	15.00	15.00	12.50	12.50	0.00	0.00	15.00	15.00	12.50	12.50
Oil	3.00	3.00	0.00	0.00	0.40	0.40	3.50	3.50	0.20	0.20	0.80	0.80	3.22	3.22	0.00	0.00	0.70	0.70
LSP	1.40	1.40	1.30	1.30	1.10	1.10	1.35	1.35	1.15	1.15	1.23	1.23	0.70	0.70	0.40	0.40	0.33	0.33
DCP	1.82	1.82	2.00	2.00	2.00	2.00	1.55	1.55	1.70	1.70	1.67	1.67	1.45	1.45	1.70	1.70	1.64	1.64
Lysine	0.00	0.00	0.35	0.35	0.25	0.25	0.00	0.00	0.32	0.32	0.22	0.22	0.00	0.00	0.36	0.36	0.30	0.30
Methionine	0.20	0.20	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00
Constant*	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765	0.765
Enzyme	--	M	--	P	--	P	--	M	--	P	--	P	--	M	--	P	--	P
Nutrient composition (calculated based on the analysed values of ingredients)																		
CP (%)	21.99	21.99	22.02	22.02	22.02	22.02	21.52	21.52	21.50	21.50	21.49	21.49	19.51	19.51	19.52	19.52	19.49	19.49
ME (kcal/kg)	2998	2998	3002	3002	2998	2998	3050	3050	3051	3051	3050	3050	3100	3100	3099	3099	3104	3104
Ca (%)	1.03	1.03	1.08	1.08	1.00	1.00	0.95	0.95	0.95	0.95	0.96	0.96	0.86	0.86	0.85	0.85	0.86	0.86
Available P (%)	0.45	0.45	0.45	0.45	0.46	0.46	0.41	0.41	0.40	0.40	0.40	0.40	0.38	0.38	0.39	0.39	0.39	0.39
Lysine (%)	1.19	1.19	1.19	1.19	1.20	1.20	1.38	1.38	1.12	1.12	1.13	1.13	1.20	1.20	1.00	1.00	1.04	1.04
Methionine (%)	0.52	0.52	0.53	0.53	0.51	0.51	0.48	0.48	0.53	0.53	0.50	0.50	0.41	0.41	0.50	0.50	0.48	0.48
Threonine (%)	0.80	0.80	0.81	0.81	0.82	0.82	0.79	0.79	0.81	0.81	0.80	0.80	0.86	0.86	0.79	0.79	0.81	0.81
Cost (Rs./kg)	28.52	28.93	23.02	23.63	23.68	24.29	28.03	28.43	22.88	23.48	23.65	24.25	26.72	26.72	22.03	22.03	22.93	22.93

SBM: soybean meal; DORB: deoiled rice bran; DDGS: dried distillers grains with solubles;RGM: rice gluten meal; LSP: limestone powder; DCP: di-calcium phosphate; CP: crude protein; ME: metabolizable energy; M: multienzyme; P: protease.

*Constant (0.4 % salt, 0.1 % trace mineral premix, 0.15 % vitamin premix, 0.015 % vitamin B complex, 0.05 % choline chloride, and 0.05% toxin binder).

1: trace mineral premix supplied (mg/kg diet): Mg 300; Mn 55; I 0.4; Fe 56; Zn 30; Cu 4.

2: vitamin premix supplied (per kg diet): vitamin A 8250 IU; vitamin D3 1200 IU; vitamin K 1 mg; vitamin E 40 IU.

3: B complex: vitamin B1 2 mg; vitamin B2 4 mg; vitamin B12 10 μg; niacin 60 mg; pantothenic acid 10 mg; choline 500 mg.

(FI), and feed conversion ratio (FCR). The mortality of the birds was recorded as and when it occurred.

2.4. Nutrient utilization

A 4-day metabolism trial was conducted to study the digestibility coefficients of dry matter, nitrogen, calcium, and phosphorous, along with the estimation of apparent metabolizable energy, (AME) from the 24th to 27th day of the feeding trial. As a preliminary preparation, the birds were starved for 3 h from 08:00 to 11:00 before the start of the metabolism trial to evacuate the gut of birds in terms of previous ingesta. From each treatment, 6 birds were taken and transferred to individual cages with a feeder, watering device, and feces collection tray. The net feed consumed by the birds from each treatment group was recorded, and the droppings voided over the same period were collected quantitatively and placed into a forced draft hot air oven at 60 ± 5 °C during the 4 days of collection until a constant weight was attained which represented the net dried fecal output. The representative samples of test diets and excreta samples were ground and stored in airtight containers until further analysis of digestibility coefficients of dry matter, nitrogen, phosphorous, calcium, and AME [10]. The intake and excretion of DM, CP, calcium, and phosphorous were calculated for individual birds per day, and digestibility coefficients were calculated as follows:

Ø DM digestibility = (DM intake – DM voided)/DM intake

Ø N digestibility = (N intake – N voided in excreta)/N intake

Ø Calcium digestibility = (Ca intake – Ca voided in excreta)/Ca intake

Ø Phosphorous digestibility = (P intake – P voided in excreta)/P intake

Ø AME = [(feed intake × gross energy of feed) – (excreta weight × gross energy of excreta)]/feed intake

2.5. Production efficiency parameters

The protein efficiency ratio (PER) and energy efficiency ratio (EER) of birds under different treatment groups were calculated as follows [11]:

PER = weight gain (g) × 100 /protein intake

EER = weight gain (g) × 100/total energy intake (ME Kcal)

2.6. Cost economics of production

The cost economics of chicken production was analyzed taking into consideration the price of feed ingredients, feed consumption during the feeding trial, and the prevailing market price at the time of the experiment. The feed cost was calculated as:

$$\text{Feed cost/kg live weight (INR)} = \frac{\text{feed consumption (kg)} \times \text{feed cost}}{\text{live weight (kg)}}$$

$$\text{Feed cost/kg dressed yield (INR)} = \frac{\text{feed consumption (kg)} \times \text{feed cost}}{\text{dressed yield (kg)}}$$

$$\text{Feed cost/kg eviscerated yield (INR)} = \frac{\text{feed consumption (kg)} \times \text{feed cost}}{\text{eviscerated yield (kg)}}$$

The data collected were analyzed by two-way ANOVA using the General Linear Model procedure to present the results as means and standard errors (IBM SPSS Software Version 20.0, IBM Corp., Armonk, NY, USA). The significant mean differences were separated with a Tukey post hoc analysis with a significance level set at P < 0.05.

3. Results

The results of the growth performance influenced by different levels of rDDGS and RGM combinations are given in Table 2. The results of nutrient utilization in broiler chickens are presented in Table 3. The production efficiency parameters are given in Table 4, and the cost economics of broiler chicken production is shown in Table 5.

4. Discussion

The growth performance in the present study revealed significantly (P < 0.01) poor BWG, FI, and FCR of birds fed a combination of 12.5% rDDGS and 15.0% RGM, followed by a statistically different combination of 10.0% rDDGS and 12.5% RGM compared to birds fed no rDDGS and RGM. The enzyme supplementation resulted in significantly (P < 0.01) better BWG, FI, and FCR of birds compared to unsupplemented birds. The mortality pattern of birds did not show any significant dietary effects as only 3 birds died during the experiment (data not shown). There are highly conflicting and inconclusive reports on the use of rDDGS and RGM, along with enzyme supplementation in broiler chickens.

Significantly poor growth performance of broiler chickens has been previously reported by feeding them DDGS at 15.0% or more because of the poor weight gain during starter period [12–15]. The inclusion of DDGS at less than 15.45% level with Avizyme (multienzymes) supplementation could improve the nutritive value of DDGS for layer chickens [16]. Furthermore, corn gluten meal at higher levels (20.0%) resulted in lower feed intake and weight gain of broiler chickens [17]. However, the supplementation of enzyme mixture (amylase, phytase, protease, and xylanase) has shown positive effects on the growth performance of broiler chickens [18]. These observations clearly suggest that rDDGS and RGM can be used up to a 15.0% level individually in broiler chicken ration without any adverse effects. However, when used jointly at higher levels, they exert negative effects. However, in contrast to the present study, DDGS has been reported as a good alternative feed ingredient in diets for broiler chickens at levels up to 24% of the diet when diets

Table 2, Effect of feeding different level of rDDGS and RGM combinations on growth performance of broiler chickens.

Parameters		Body weight gain (BWG)				Feed intake (FI)				Feed conversion ratio (FCR)			
		0–14 days	14–28 days	28–42 days	0–42 days	0–14 days	14–28 days	28–42 days	0–42 days	0–14 days	14–28 days	28–42 days	0–42 days
rDDGS (%) / RGM (%)													
0.0	0.0	332[a]	330[a]	1088[a]	1751[a]	364	472[a]	2252[a]	3088[a]	1.09[c]	1.44[c]	2.0[b]	1.76[c]
12.5	15.0	253[c]	261[b]	852[c]	1367[c]	356	458[b]	1961[c]	2786[c]	1.40[a]	1.79[a]	2.30[a]	2.03[a]
10.0	12.5	289[b]	278[b]	1000[b]	1568[b]	361	468[a]	2075[b]	2894[b]	1.24[b]	1.66[b]	2.07[b]	1.84[b]
Enzyme supplementation													
Without enzyme		286	273[b]	964[b]	1524[b]	358	461[b]	2055[b]	2874[b]	1.27	1.69[a]	2.15	1.90[a]
With enzyme		298	306[a]	996[a]	1600[a]	363	471[a]	2137[a]	2971[a]	1.24	1.57[b]	2.15	1.86[b]
Pooled SEM		6.90	7.67	19.45	30.39	1.54	2.07	25.02	26.84	0.03	0.04	0.02	0.02
Significance													
rDDGS/RGM combination		P < 0.01	P < 0.01	P < 0.01	P < 0.01	NS	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01
Enzyme supplementation		NS	P < 0.01	P < 0.01	P < 0.01	NS	P < 0.01	P < 0.01	P < 0.01	NS	P < 0.01	NS	P < 0.05
Interaction		NS	P < 0.05	P < 0.01	P < 0.01	NS	NS	P < 0.01	P < 0.01	NS	P < 0.01	P < 0.01	NS

Values bearing different superscripts within the column differ significantly.
rDDGS: rice dried distillers grains with solubles; RGM: rice gluten meal; NS: nonsignificant (P > 0.05).

Table 3. Effect of feeding different level of rDDGS and RGM combinations on nutrient utilization (digestibility coefficients) in broiler chickens.

Parameters		Dry matter	Nitrogen	Calcium	Phosphorus	AME (kcal/kg)
rDDGS (%) / RGM (%)						
0.0	0.0	0.72[a]	0.58[a]	0.35[a]	0.42[a]	3146[a]
12.5	15.0	0.67[c]	0.51[c]	0.31[b]	0.40[b]	2717[c]
10.0	12.5	0.69[b]	0.53[b]	0.35[a]	0.42[a]	2982[b]
Enzyme supplementation						
Without enzyme		0.68[b]	0.53[b]	0.33	0.41	2907
With enzyme		0.70[a]	0.55[a]	0.34	0.42	2991
Pooled SEM		0.050	0.062	0.043	0.033	34.49
Significance						
rDDGS/RGM combination		P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01
Enzyme supplementation		P < 0.01	P < 0.01	NS	NS	NS
Interaction		NS	NS	NS	NS	P < 0.01

Values bearing different superscripts within the column differ significantly.
rDDGS: rice dried distillers grains with solubles; RGM: rice gluten meal; AME: apparent metabolizable energy; NS: nonsignificant (P > 0.05).

are formulated on a digestible amino acids basis [19]. The inclusion of DDGS for up to a 12.5% level [20], 16.0% level [21], 20% level [22,23], and 24.0% level [24] had no significant effect on the growth performance of broiler chickens. The weight gain and FCR of birds were not affected significantly by RGM inclusion levels up to 17.5%, with or without protease enzyme supplementation [25].

Nutrient utilization by the birds in the present study revealed significantly (P < 0.01) lower digestibility coefficients of dry matter, nitrogen, calcium, phosphorus,

Table 4. Effect of feeding different levels of rDDGS and RGM combinations on production efficiency parameters in broiler chickens.

Parameters		Protein efficiency ratio (PER)				Energy efficiency ratio (EER)			
		0–14 days	14–28 days	28–42 days	0–42 days	0–14 days	14–28 days	28–42 days	0–42 days
rDDGS (%) / RGM (%)									
0.0	0.0	4.35[a]	3.40[a]	2.61[a]	2.96[a]	31.57[a]	23.67[a]	16.10[a]	71.34[a]
12.5	15.0	3.39[c]	2.72[c]	2.34[b]	2.56[b]	24.56[c]	18.91[c]	14.48[b]	57.95[c]
10.0	12.5	3.82[b]	2.96[b]	2.60[a]	2.83[b]	27.73[b]	20.58[b]	16.07[a]	64.39[b]
Enzyme supplementation									
Without enzyme		3.80	2.89[a]	2.53	2.76[b]	27.55	20.09[b]	15.38[b]	63.03[b]
With enzyme		3.92	3.16[b]	2.52	2.81[a]	28.36	22.01[a]	15.72[a]	66.10[a]
Pooled SEM		0.08	0.07	0.03	0.03	0.62	0.52	0.15	1.08
Significance									
rDDGS/RGM combination		P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01
Enzyme supplementation		NS	P < 0.01	NS	P < 0.01	NS	P < 0.01	P < 0.05	P < 0.01
Interaction		NS	P < 0.05	P < 0.01	NS	NS	P < 0.05	P < 0.05	P < 0.01

Values bearing different superscripts within the column differ significantly.
rDDGS: rice dried distillers grains with solubles; RGM: rice gluten meal;
NS: nonsignificant (P > 0.05).

Table 5. Effect of feeding different levels of rDDGS and RGM combinations on the feed cost (INR) per unit weight in broiler chickens.

Parameters		Feed cost/kg live weight	Feed cost/kg dressed yield	Feed cost/kg eviscerated yield
rDDGS (%) / RGM (%)				
0.0	0.0	47.00[a]	65.45[a]	70.84[a]
12.5	15.0	44.64[b]	62.15[b]	67.29[b]
10.0	12.5	42.18[c]	58.55[c]	63.99[c]
Enzyme supplementation				
Without enzyme		44.43[a]	61.93	67.07
With enzyme		43.76[b]	62.18	67.64
Significance				
rDDGS/RGM combination		P < 0.01	P < 0.01	P < 0.01
Enzyme supplementation		P < 0.05	NS	NS
Interaction		NS	NS	NS

Values bearing different superscripts within the column differ significantly.
rDDGS: rice dried distillers grains with solubles; RGM: rice gluten meal;
NS: nonsignificant (P > 0.05).

and lower AME values in birds fed a combination of 12.5% rDDGS and 15% RGM, followed by a statistically different combination of 10.0% rDDGS and 12.5% RGM compared to birds fed no rDDGS and RGM. Enzyme supplementation resulted in significantly (P < 0.01) improved dry matter and nitrogen digestibility in birds compared to unsupplemented birds. In contrast to the present findings, no significant difference in nutrient utilization of broiler chickens was observed due to protease enzyme supplementation [25]. The poor nutrient utilization in rDDGS and RGM diets may be associated with level and type of crude fiber, along with their poor digestibility compared to soybean meal. It has been reported that the laying performance in hens declined with 20.0 % corn DDGS due to decreased nutrient utilization [26]. There were no significant differences in nutrient digestibility up to the addition of 12.5% [20], 20.0% [25], and 21.0% [27] RGM in the diet of broiler chickens. However, nutrients were retained more by broilers fed a 10.0% dietary level of corn DDGS [28], and greater nitrogen and phosphorous retention in hens fed 25.0% DDGS was observed [29].

The PER and EER in the present study were significantly ($P < 0.01$) lower in birds fed combination of 12.5% rDDGS and 15.0% RGM, followed by statistically different combinations of 10.0 % rDDGS and 12.5% RGM compared to birds fed no rDDGS and RGM. The enzyme supplementation significantly ($P < 0.01$) improved the PER of birds during 14–28 days and 0–42 days of age and EER during 14–28 days, 28–42 days, and 0–42 days of age. The results of PER and EER correspond to the growth performance of the birds under different dietary treatments. However, there is no existing literature on the effects of rDDGS and RGM, along with enzyme supplementation on the PER and EER to substantiate the results of this study.

The feed cost per kg live weight, dressed yield, and eviscerated yield were significantly ($P < 0.01$) lower in birds fed a combination of 10.0% rDDGS and 12.5% RGM, followed by a statistically different combination of 12.5% rDDGS and 15.0% RGM compared to birds fed no rDDGS and RGM. Enzyme supplementation significantly ($P < 0.05$) reduced the feed cost per kg live weight, whereas no significant effect was observed on the feed cost per kg dressed yield and eviscerated yield. These results clearly suggest that combination of 10.0% rDDGS, along with 12.5%. RGM decreased the feed cost more than the combination of 12.5% rDDGS and 15.0% RGM because the latter negatively affected the weight gain in birds. However, the control feed is more costly than both of these combinations.

It was reported that inclusion of RGM is safe and economical up to a 15.0% level for broiler chicken meat production [25]; however, the supplementation of protease enzyme alone or in combination with RGM did not have a significant effect on the feed cost involved in broiler chicken production. Similarly, increasing the level of DDGS from 0% to 10.0% tended to reduce the feed cost significantly ($P < 0.01$), and 10.0% of DDGS turned out to be more economical for feed cost per/kg egg mass production [27]. In line with the results of the present study, the ration containing 10.0% rice gluten protein is highly economical [30]. RGM-based diets resulted in a cost-effective average daily gain by replacing 75.0% of ground nut cake in the concentrate mixture of growing calves [31].

Thus, the present study concludes that the inclusion of combination of 10.0% rDDGS and 12.5% RGM as a replacement for costly soybean in broiler chicken ration, along with the dietary enzyme supplementation, can a potential nutritional strategy for economic broiler chicken production.

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