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Feeding value of rice gluten meal as an alternate protein source in broiler chickens

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Abstract: The objective of this study was to investigate the effect of feeding rice gluten meal (RGM) on broiler chicken performance, nutrient utilization, intestine morphometry, and cost economics of broiler chicken production. Two hundred forty day-old CARIBRO-vishal variety of broiler chickens were randomly divided into six treatment groups having five replicates with eight birds in each. The formulated diets, containing different levels of RGM (0.0%, 5.0%, 7.5%, 10.0%, 12.5%, and 15.0%) as soybean replacement, were fed to birds for 42 days. In general, the results revealed no significant effect of RGM feeding on average daily gain and feed conversion ratio, but a significant decrease in the average daily feed intake was observed at 15% RGM level in the diet of broiler chickens. The utilization of dry matter, nitrogen, calcium, and phosphorous did not reveal any significant effect of RGM feeding in broiler chickens. Similarly, the carcass traits and intestine morphometric measurements did not show any significant effect of RGM feeding in broiler chickens. However, the cost of production of broiler chickens decreased significantly (–10%) by 15% RGM level in broiler chicken ration. Thus, we concluded that 15% inclusion of rice gluten meal in broiler chicken ration as a protein source is as safe and efficient as soybean meal with better economic returns.

Key words: Rice gluten meal, broiler performance, nutrient utilization, intestinal morphology, cost economics

1. Introduction

Feed is a major component in the production of poultry as it constitutes 70% to 80% of the total cost of production. The stark rise in poultry production paralleled by highly intensive feeding systems using better genotypes led to greater demand for better-quality feeds (1). This has led to increased use of cereal products as animal feeds and their share is projected to reach nearly 45%–50% by 2050 in the world. This intensified feed-food competition and the driving demand for foods of animal origin warrant the assessment of alternative feed sources for an economically viable poultry production. The ever increasing cost of conventional energy and protein sources used in poultry, such as maize and soybean meal, have increased the cost of poultry production. This rising cost of production in broiler chicken production can be overcome by the use of rice gluten meal, an energy- and protein-rich alternative feed ingredient. India is one of the largest producers of rice in the world producing approximately 105 million tons of rice in 2015 and 2016 (2). Therefore, a lot of by-products are available from rice processing industry. Rice gluten meal (RGM), a by-product of wet milling of rice, is available in appreciable amounts at a lower cost compared to soybean. Rice gluten meal (RGM) contains 3152 kcal metabolizable energy (ME) per kg, 46.45% crude protein (CP), 3.4% ether extract, and a favorable amino acid profile with relatively high abundance of methionine (3). It has been also designated as a source of rumen nondegradable protein with the highest known metabolizable protein value among plant proteins (4). To the best of our knowledge, there has been only a single investigation (5) on RGM as a protein source in broiler chickens. Thus, the present study was conducted to evaluate the broiler chicken performance, nutrient utilization, intestine morphometry, and cost economics of broiler chicken production with a hypothesis that the inclusion of RGM in broiler chicken ration as a protein source is equally efficient as soybean with better economic returns.

2. Materials and methods

2.1. Birds, diets, and experimental design

Two hundred forty day-old broiler chicks of CARIBRO-vishal variety with uniform initial body weight were obtained from the institutional hatchery and randomly divided into 6 treatment groups each having 5 replicates with 8 birds in each. The prestarter (12.55 MJ/kg ME, 23% CP), starter (12.97 MJ/kg ME, 22% CP), and finisher diets (13.38 MJ/kg ME, 20% CP) were formulated as per

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the Bureau of Indian Standards (6) recommendations employing different levels of rice gluten meal (0%, 5%, 7.5%, 10%, 12.5%, and 15%). The ingredients and nutrient composition of broiler chicken ration is shown in Table 1. The proximate analysis of the RGM used in this experiment was also done.

2.2. Experimental procedure, measurement, and analysis
All the experimental procedures used in the study were approved by the Institutional Animal Ethics Committee (IAEC). The birds were housed in specially designed battery brooder cages with controlled temperature conditions and adequate watering and feeding facilities. The weekly body weight and feed intake was recorded to get the overall (0–14, 14–28, 28–42, and 0–42 days) average daily body weight gain (ADBWG), average daily feed intake (ADFI), and feed per unit gain (F/G). The mortality of the birds was recorded as and when it occurred. In order to study the utilization of dry matter, nitrogen, calcium, and phosphorous, a metabolism trial of four days was conducted at 4th week of age (24th to 27th days). The net feed consumed by the birds of each treatment group was recorded and the droppings voided over the same period were collected quantitatively and placed into the forced draft hot air oven at 60 ± 5 °C during all 4 days of collection

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)**					
	C	**T1**	**T2**	**T3**	**T4**	**T5**	**C**	**T1**	**T2**	**T3**	**T4**	**T5**	**C**	**T1**	**T2**	**T3**	**T4**	**T5**
Maize	54.14	53.94	54.38	54.33	54.18	54.13	59.0	59.3	59.6	59.9	60.2	61.0	64.7	65.1	65.4	65.9	66.0	66.4
RGM	**0.0**	**5.0**	**7.5**	**10.0**	**12.5**	**15.0**	**0.0**	**5.0**	**7.5**	**10.0**	**12.5**	**15.0**	**0.0**	**5.0**	**7.5**	**10.0**	**12.5**	**15.0**
Soybean	38.5	33.5	30.5	28.0	25.5	23.0	33.0	27.6	25.0	22.5	19.8	16.8	27.2	2.20	19.4	16.6	14.0	11.3
Fish meal	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Oil	1.1	1.2	1.2	1.2	1.3	1.3	1.8	1.7	1.5	1.3	1.0	0.6	1.8	1.6	1.3	1.1	1.0	0.7
Limestone	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.9
DCP	1.7	1.7	1.7	1.7	1.7	1.7	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.65	1.65
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
DL-Methionine	0.1	0.1	0.1	0.1	0.1	0.1	0.14	0.10	0.08	0.04	0.03	0.0	0.11	0.07	0.05	0.03	0.01	0.0
Lysine	0.0	0.09	0.15	0.20	0.24	0.29	0.10	0.20	0.25	0.29	0.34	0.39	0.10	0.20	0.25	0.29	0.34	0.39
TM. Premix1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.08	0.1	0.1
Vit. Premix2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
B complex3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ch. Chloride	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Toxin binder	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nutrient composition (Calculated based on the analyzed values of ingredients)																		
CP (%)	23.1	23.1	23.0	23.0	23.1	23.1	22.1	22.0	22.0	22.1	22.1	22.0	20.0	20.0	20.1	20.0	20.0	20.0
ME (MJ/kg)	12.6	12.6	12.6	12.6	12.6	12.6	12.96	13.02	13.02	13.03	12.99	12.95	13.38	13.40	13.42	13.41	13.36	13.34
Ca (%)	1.07	1.07	1.07	1.07	1.07	1.07	1.00	1.02	1.01	1.01	1.01	1.04	1.01	1.00	1.00	1.02	1.00	1.03
Available P (%)	0.50	0.50	0.49	0.49	0.49	0.49	0.45	0.46	0.46	0.45	0.46	0.45	0.46	0.45	0.44	0.46	0.44	0.44
Lysine (%)	1.26	1.25	1.25	1.26	1.25	1.26	1.2	1.2	1.2	1.2	1.2	1.2	1.07	1.07	1.07	1.06	1.07	1.07
Methionine (%)	0.49	0.50	0.49	0.49	0.50	0.50	0.51	0.51	0.50	0.49	0.50	0.49	0.45	0.45	0.46	0.46	0.46	0.47
Threonine (%)	0.93	0.89	0.87	0.85	0.83	0.81	0.85	0.80	0.78	0.76	0.74	0.72	0.76	0.72	0.70	0.67	0.65	0.63
Cost (Rs./kg)	21.90	21.74	21.57	21.45	21.41	21.30	21.67	21.26	20.96	20.65	20.31	19.81	20.79	20.33	19.98	19.67	19.43	19.07

C: Control, T1–T5: Treatments, RGM: Rice gluten meal, DCP: Di-calcium phosphate, Ch. Chloride: Choline Chloride, CP: Crude protein, ME: Metabolizable energy
TM. Premix1: Trace mineral premix supplied (mg/kg diet): Mg 300; Mn 55; I 0.4; Fe 56; Zn 30; Cu 4.
Vit. Premix2: Vitamin premix supplied (per kg diet): Vitamin A 8250 IU; Vitamin D3 1200 IU; Vitamin K 1mg; Vitamin E 40 IU.
B complex3: B complex: Vitamin B1, 2 mg; Vitamin B2, 4 mg; Vitamin B12, 10 µg; niacin, 60 mg; pantothenic acid, 10 mg; choline, 500 mg.

till a constant weight was attained which represented the net dried faecal output. The representative samples of the test diets and excreta samples were ground and stored in airtight containers till further analysis of nitrogen, phosphorous (7), and calcium (8). The intake, excreted and retained amount of DM, nitrogen, calcium, and phosphorous were calculated on g/b/d basis and % retentions were calculated on the basis of total intake by the following formulas:

Dry matter metabolizability (DMM %) = (DM intake – DM in excreta) / DM intake × 100

Nitrogen retention (%) = (N intake – N in excreta) / N intake × 100

Calcium retention (%) = (Ca intake – Ca in excreta) / Ca intake × 100

Phosphorous retention (%) = (P intake – P in excreta) / P intake × 100

At the end of 42 days, 10 birds (2 birds/replicate) from each treatment group were selected randomly and slaughtered after 12 h of fasting with *ad libitum* drinking water for evaluation of carcass characteristics and organ weight. The defeathered weight, dressed weight, eviscerated weight, abdominal fat, drum stick, breast, thigh, back, wings, neck, liver, heart, and gizzard were expressed as percentage of live weight. At 21 and 42 days of age, the cross-sections of 2–3 mm thickness at the midpoint of duodenum, jejunum, and ileum were taken from 5 birds per treatment and washed with physiological saline followed by fixation in buffered formalin. The histological slides were prepared (9) for morphometric examination under the microscope (OLYMTUS BH41) using software Crog Rex C5 to measure villus height and crypt depth. The villus height and crypt depth were measured and their ratio was calculated. Further, the feed cost of broiler chicken production was calculated in terms of weight gain and meat produced based on the prevailing market price of the feed ingredients.

The data obtained from the experiment were subjected to one-way analysis of variance for a completely randomized design, using the GLM procedure (SPSS software-20), and the replicate was used as an experimental unit. The significant mean differences were tested as described by Duncan (10) with significance level defined at $P < 0.05$.

3. Results

The proximate analysis revealed that rice gluten meal contains 92.30% dry matter which consists of 50% crude protein, 6.92% ether extract, 9.47% crude fiber, 21.54% nitrogen free extract, 4.37% ash, 0.62% calcium, 0.78% total phosphorus, gross energy of 18.99 MJ/kg, and metabolizable energy of 12.68 MJ/kg.

3.1. Growth performance

The results pertaining to the growth performance of broiler chicken as affected by feeding different levels of RGM are presented in Table 2. There were no significant differences in ADBWG of birds due to RGM feeding except during the starter phase. During this phase significantly ($P < 0.05$) higher gain was observed at 7.5% RGM level followed by statistically similar 5% RGM level as compared to the control and other RGM levels which did not differ significantly from each other. The prestarter and overall ADFI of birds have revealed significant ($P < 0.01$) differences due to RGM feeding. During the prestarter phase, the ADFI was lower at 15% level which was statistically similar to the control group and 5% RGM level, whereas higher ADFI was observed at 10% level which was statistically similar to 7.5% and 12.5% RGM levels. The overall ADFI was significantly lower at 15% RGM followed by statistically similar 12.5% RGM, whereas the control and other RGM levels were statistically similar to each other as well as 12.5% level. Similarly, the F/G was significantly ($P < 0.01$) influenced by RGM feeding during the prestarter phase only. The F/G ratio was higher at 10% RGM which did not differ from 12.5% and 15% RGM levels, whereas a lower ratio was observed at 5% RGM level which was statistically similar to the control as well as 7.5% level.

3.2. Nutrient utilization

The results pertaining to nutrient utilization (Table 3) revealed no significant ($P > 0.05$) differences between the DMM, nitrogen retention, calcium retention, and phosphorous retention (%) of broiler chickens due to the feeding of different levels of RGM. However, all the retention values of the above nutrients were found within the normal range.

3.3. Carcass characteristics

The results pertaining to carcass traits and relative organ weights of broiler chickens, given in Table 4, revealed no significant effect of feeding different RGM levels.

3.4. Intestine morphometry

The results of intestinal morphometry at 21 and 42 days of age are presented in Table 5. No significant ($P > 0.05$) effect of different RGM levels were observed on the intestinal morphometry.

3.5. Cost economics

The results of cost economics of broiler chicken production as affected by feeding of RGM are presented in Table 6. The results revealed significant ($P < 0.01$) progressive decline in feed cost with increasing RGM levels in the broiler chicken ration. The control diet had the highest feed cost per kg live weight/meat yield/eviscerated yield, whereas 15% RGM level resulted in the lowest feed cost. However, the differences in feed cost per kg meat yield and per kg eviscerated yield between the 15% and 12.5% RGM diets were not significant.

4. Discussion

Rice gluten meal, used in the present study, is the dried by-product produced in the manufacture of starch, syrup, or

Table 2. Effect of feeding rice gluten meal on production parameters of broiler chickens.

RGM (%)	0.0	5.0	7.5	10.0	12.5	15.0	Pooled SEM	P value
Prestarter phase (0–14 days)								
ADG (g/bird)	18.54	18.70	18.92	18.31	18.18	17.75	0.14	0.227
ADFI (g/bird)	25.51[ab]	24.77[a]	26.20[bc]	26.84[c]	26.35[bc]	24.72[a]	0.19	<0.001
F/G	1.38[ab]	1.32[a]	1.39[ab]	1.47[c]	1.45[bc]	1.39[abc]	0.01	0.008
Starter phase (14–28 days)								
ADG (g/bird)	40.01[a]	40.71[ab]	42.78[b]	38.84[a]	39.41[a]	38.43[a]	0.40	0.012
ADFI (g/bird)	68.63	66.63	68.40	65.99	67.76	65.51	0.51	0.381
F/G	1.72	1.64	1.60	1.70	1.72	1.71	0.02	0.188
Finisher phase (28–42 days)								
ADG (g/bird)	52.63	51.65	50.95	51.90	51.32	51.66	0.36	0.870
ADFI (g/bird)	109.37[c]	108.92[c]	107.35[bc]	105.70[abc]	103.37[ab]	102.27[a]	0.70	0.003
F/G	2.08	2.11	2.11	2.04	2.02	1.98	0.02	0.086
Overall (0–42 days)								
ADG (g/bird)	37.06	37.02	37.55	36.35	36.30	35.95	0.21	0.220
ADFI (g/bird)	67.84[b]	66.77[b]	67.32[b]	66.18[b]	65.83[ab]	64.17[a]	0.33	0.009
F/G	1.83	1.81	1.79	1.82	1.81	1.79	0.01	0.468
Mortality (%)*	2.5	--	2.5	--	2.5	2.5	--	--

ADG: Average daily gain, ADFI: Average daily feed intake, F/G: Feed/Gain
* only one bird died in the groups shown as 2.5% in the table.

Table 3. Effect of feeding rice gluten meal on nutrient utilization of broiler chickens.

RGM (%)	0.0	5.0	7.5	10.0	12.5	15.0	Pooled SEM	P value
DMM (%)	72.58	73.4	72.26	72.85	73.31	71.82	0.73	0.32
N-excreted (%)	42.89	41.28	42.74	40.94	40.9	42.67	0.82	0.77
N-retained (%)	57.11	58.72	57.26	59.06	59.1	57.33	0.82	0.77
Ca-retained (%)	36.76	36.99	37.94	36.83	36.6	36.42	1.34	0.68
P-retained (%)	41.53	40.99	40.87	41.59	40.39	41.41	0.96	0.90

DMM: Dry matter metabolizability, N: nitrogen, Ca: Calcium, P: Phosphorous .

glucose by the wet milling process of rice. Similar to the proximate analysis of the present study, RGM has been reported to contain CP as high as 47.3% (11), 46.40% (3), and 57.6% (5) with high metabolizable energy as compared to fish meal (11). However, lower ether extract (5,3) and crude fiber (5) was reported compared to the present results. The total ash of RGM was close to the value reported by Kumar et al. (3) but higher than the value (1.24%) reported by Metwally and Farhat (5). Again, Metwally and Farhat (5) reported lower total phosphorous (0.4%) and calcium (0.23%) of RGM compared to the present study. This variation in the composition of the RGM may be due to grain type, condition of the manufacturing plant, milling process, and the preparation of the final product, especially drying and packaging. Furthermore, the drying process can have crucial influence not only on the variability of nutrients but also on the concentration and availability of amino acids in different samples (12).

4.1. Growth performance

Based on the results of the present study, it can be stated that no stark differences in growth performance of broiler chicken occurred as a result of RGM inclusion in broiler chicken ration. There are only few inconclusive reports of RGM effects on the broiler chicken performance (11,5).

Table 4. Effect of feeding rice gluten meal on carcass traits* of broiler chickens.

RGM (%)	0.0	5.0	7.5	10.0	12.5	15.0	Pooled SEM	P value
Live weight (g)	1753	1742	1749	1721	1771	1654	16.90	0.42
Defeathered weight	91.58	92.13	91.79	91.94	92.87	91.67	16.90	0.64
Dressed weight	72.01	72.46	72.48	72.06	73.69	72.95	0.23	0.09
Eviscerated weight	67.09	64.25	65.59	66.84	66.64	64.68	0.20	0.71
Abdominal fat	1.32	1.70	1.45	1.56	1.79	1.66	0.35	0.27
Drum stick	10.45	10.26	10.22	10.44	10.08	10.64	0.06	0.36
Breast	18.01	16.79	17.83	17.75	18.09	17.12	0.10	0.45
Thigh	10.91	9.64	10.03	10.00	9.93	9.24	0.19	0.43
Back	17.63	17.17	17.73	18.32	17.99	17.76	0.23	0.06
Wings	8.24	8.05	8.07	8.38	8.25	8.03	0.15	0.79
Neck	4.81	4.99	4.56	4.77	4.77	4.80	0.05	0.49
Liver	2.20	2.12	2.04	1.98	1.97	2.07	0.03	0.25
Heart	0.59	0.55	0.53	0.59	0.60	0.53	0.01	0.23
Gizzard	2.40	2.47	2.41	2.47	2.44	2.29	0.03	0.67
Giblet	5.19	5.14	4.99	5.04	5.01	4.89	0.05	0.63

* All traits are expressed as percentage of live weight.

Table 5. Effect of feeding rice gluten meal on intestine morphology in broiler chickens.

RGM (%)		21 days posthatch						42 days posthatch						Pooled SEM	P value
		0.0	5.0	7.5	10.0	12.5	15.0	0.0	5.0	7.5	10.0	12.5	15.0		
Duodenum	VH (m)	1551	1501	1506	1529	1483	1504	2034	1964	1971	2003	1940	1968	10.25	0.49
	CD (m)	226	228	231	224	222	220	291	292	295	289	286	287	3.48	0.97
	VH:CD	6.92	6.69	6.62	6.93	6.73	6.94	7.03	6.77	6.72	6.98	6.78	6.9	0.13	0.97
Jejunum	VH (m)	1126	1076	1081	1104	1058	1079	1606	1537	1543	1576	1512	1540	10.25	0.49
	CD (m)	194	195	198	192	190	190	204	206	209	202	200	200	2.63	0.95
	VH:CD	5.86	5.59	5.53	5.82	5.59	5.73	7.92	7.57	7.48	7.87	7.58	7.75	0.11	0.95
Ileum	VH (m)	912	862	867	890	844	865	1392	1323	1329	1362	1298	1326	10.25	0.49
	CD (m)	176	174	177	166	153	153	195	197	200	193	191	191	4.84	0.14
	VH:CD	5.30	5.07	5.00	5.55	5.56	5.65	7.19	6.82	6.75	7.13	6.82	6.99	0.17	0.27

Table 6. Effect of feeding rice gluten meal on cost economics of broiler chickens.

RGM (%)	0.0	5.0	7.5	10.0	12.5	15.0	Pooled SEM	P value
*Cost/kg live weight	38.88^{d}	37.55^{c}	36.79^{bc}	36.85^{bc}	36.28^{b}	35.02^{a}	0.255	<0.0001
*Cost/kg dressed meat yield	54.29^{d}	52.03^{c}	50.76^{abc}	51.54^{bc}	49.29^{ab}	48.68^{a}	0.443	<0.0001
*Cost/kg eviscerated yield	59.53^{d}	57.54^{cd}	55.76^{bc}	55.44^{abc}	54.02^{ab}	53.02^{a}	0.499	<0.0001

*Cost in Rupees

Therefore, further research on RGM inclusion in broiler chicken ration as protein source need to be conducted. RGM inclusion in broiler chicken ration can promote palatability and increased feed consumption of birds leading to better growth of birds. However, this feature of RGM can be nullified by the presence of higher amounts of soluble nonstarch polysaccharides which increase the gut viscosity and decrease the absorption of the nutrients. There are reports in other species, where it has been observed that 75% of ground nut cake can be replaced by RGM in young calves (3) and Sahiwal cattle (13) without any significant effect on the growth performance.

4.2. Nutrient utilization and carcass characteristics

The replacement of soybean meal with RGM was found to have no effect on the nutrient utilization and carcass traits of broiler chickens in this study. Similar to these results, no significant differences were observed in the nutrient digestibility up to the addition of 12.5% RGM in the broiler chicken diet (5) and 21% RGM in the diet of growing dairy calves (3). The results of carcass characteristics are in agreement with the reports of Sherazi et al. (11) and Metwally and Farhat (5), who reported no significant differences in carcass characteristics at 10% and 12.5% RGM levels, respectively. No further literature is available pertaining to the effects of RGM on the nutrient utilization and carcass characteristics of broiler chickens.

4.3. Intestine morphometry

The surface area of the small intestines is the main determinant of the nutrient absorption capacity of the birds. Longer villi are highly correlated with better intestinal health and absorption of nutrients, whereas shorter villi and longer crypt depths are associated with increased intestinal pathogenic bacterial counts (14,15). In the present study, no significant effect of RGM inclusion in broiler chicken diet was observed on the villi height, crypt depth, or their ratio. To the best of our knowledge, no literature is available elucidating the effects of RGM feeding on the intestinal morphometry of broiler chicken. However, similar to this study, the feeding of corn gluten protein up to 20.1% was observed to have no significant effect on the intestinal VH and CD values (16).

4.4. Cost economics

The inclusion of 15% RGM in broiler chicken ration showed a decrease of 9.92%, 10.33%, and 10.93% in feed cost based on per kg live weight gain, meat yield, and eviscerated yield, respectively with respect to the control diet. However, it was reported by Sherazi et al. (11) that broiler chicken ration containing 10.0% rice gluten protein was the most economical. In calves 75% replacement of ground nut cake by RGM was reported to be cost-effective (3). No further literature is available pertaining to the cost economics of RGM feeding in broiler chicken.

Based on the results, it can be concluded that due to the higher crude protein and energy content with better digestibility, rice gluten meal can act as a protein source equally efficient as soybean meal in broiler chicken ration. The inclusion of rice gluten meal up to 15% level replacing soybean meal by 40.25%, 49.09%, and 58.45% in prestarter, starter, and finisher phases reduces the feed cost by 10% and thus improves the cost economics of broiler chicken production.

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