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Cost Economics of Feeding Rice Gluten Meal and Soybean Meal through Dietary Addition of Enzymes in Broilers

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ABSTRACT

Background: The rice gluten meal a relatively newer feedstuff is by-product of wet-milling of rice obtained after starch extraction and syrup preparation. The rice gluten meal is high crude protein and energy ingredient which is priced lower than soybean meal. Substitution of expensive protein sources with lower cost ingredients would potentially reduce the cost of the feed.

Methods: A biological experiment of 42 days duration was undertaken in day old chicks (n= 384) divided into 12 dietary treatments as per 3×4 factorial design having 4 replicates per treatment with 8 birds in each. Twelve experimental diets were prepared by incorporating control, two different levels of rice gluten meal RGM consisted of (15 and 17.5%), without and with three different types of enzymes xylanase (X), protease (P) and multienzymes (M).

Result: The rice gluten meal at the inclusion level of 15% reduced feed cost per kg live weight, meat yield and eviscerated yield by 5.44, 5.13 and 4.69%, respectively. Protease enzyme supplementation in 15% rice gluten meal further reduced feed cost per kg live weight by 2.60%. Thus, it may be concluded protease enzyme is most cost effective in rice gluten meal diet.

Key words: Cost economics, Enzymes, Feed cost, Rice gluten meal.

INTRODUCTION

The search of alternative feed ingredients in poultry nutrition is a continuous process in the pursuit of economical poultry production. Feed is the major constituent in the poultry production accounts for 65-75% of total recurring expenditure. Feed costs are primarily driven by the cost of protein sources. Substitution of expensive protein sources like soybean meal with lower cost ingredients like rice gluten meal (RGM) would potentially reduce the cost of the feed (Dinani *et al*., 2019). India is the second largest producers of rice in the world after China, producing approximately 109.7 MT rice in 2016-17 (Agriculture Statistics, 2018). Now-a-days, certain newer rice by products are available in appreciable quantities from rice processing industries and at cheaper rate such as rice gluten meal (RGM), which can be utilized in feeding poultry.

The RGM is a by-product of wet-milling of rice obtained after starch extraction and syrup preparation. It is relatively a newer feedstuff having brownish color and coarse powdery texture. Commercial traders categorise RGM as a high crude protein and energy ingredient which is priced lower than soybean meal.

Strategic development of substrate specific suitable enzyme in diet will enhance the nutritive value of diets (Chesson, 2001). No information is available on the appropriate enzyme that is specific for broiler diets based soybean meal partially replaced with RGM.

Initial research finding showed that RGM can be included up to 10% level in broiler chicken without affecting feed efficiency and dressing percentage (Sherazi *et al*., 1995). Metwally and Farahat (2015) found that broiler fed RGM with different inclusion rates up to 12.5% had the same growth performance. Kumar *et al*. (2016) found that RGM could replace groundnut cake in the concentrate mixture of growing calves up to 75% level without any adverse effects on growth performance and nutrient utilization. Malik *et al*. (2017) reported that replacement of groundnut cake by RGM and maize gluten meal at 75% level did not affect feed intake, feed efficiency and average daily gain in growing Sahiwal cattle.

Overall, very little research data is available on feeding value of RGM in poultry and no data is available regarding cost economics of feeding rice gluten meal and soybean meal through dietary addition of enzymes in broilers. Cost of feed ingredients used for diet formulation was Rs.1858, 3405 and 2500 per quintal for the maize, soybean meal and rice gluten meal, respectively.

MATERIALS AND METHODS

Experimental layout for feeding different level of RGM with or without enzymes is presented in (Table 1). The experiment

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was conducted as per 3 × 4 factorial completely randomized design (CRD) in 384 broiler chicks (CARIBRO vishal). The birds were randomly divided into 48 replicates of eight birds each. There were twelve different treatments with 4 replicates for each treatment. Two levels of rice gluten meal were taken, the best inclusion level from earlier experiments as first level (15%) and then adding over and above the best level of 2.5% RGM to this level. Protease, xylanase and multienzymes supplementation under different treatments were used to find out the most suitable enzyme for RGM diets.

Analyzed chemical composition of dietary ingredients (%) as per (AOAC, 2000) on as such basis is presented in (Table 2). Ingredients and nutrient composition (%) of pre-starter (0-14 days), starter (14-28 days)and finisher (28-42 days) diets with or without enzymes for different level of RGM are presented respectively in (Table 3, 4 and 5) as per ICAR (2013) standard.

The three commercial enzyme preparations protease, xylanase and multienzymes were used as per manufacturer instructions after assessing their activity as per standard methods complied by Kamra and Agarwal (2003).Protease activity was estimated 600,000±849 units per g. Xylanase activity was estimated 150,000±683 units per g. Multienzymes activity were estimated cellulase 15,000, xylanase18, 500±328, beta glucanase 12,500±128, amylase 1500±46, pectinase 150±16, protease 5000±136, lipase 15± 3.8 and beta mannanase 400±31.Mixing ratio 50 g per 100 kg feed for protease, 10 g per 100 kg feed for xylanase and 25 g per 100 kg feed for multienzymes were used as per manufacturer instructions.

The research work was carried out at the Division of Avian Nutrition and Feed Technology, ICAR-Central Avian Research Institute (CARI), Izatnagar, India in the year 2017 as per the guidelines and approval of Institute Animal Ethical Committee (IAEC) and Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA).

The phase wise pre-starter, starter, finisher and overall body weight gain (BWG), feed intake (FI) g/bird and feed conversion ratio (FCR) were recorded.

Feed cost were calculated taking into consideration the price of feed ingredients, feed consumption during 0-42 days and price prevailing at the time of conducting the experiment.

Feed cost (Rs.)/kg live wt. =

$$\frac{\text{Feed consumption (kg)} \times \text{Feed cost (Rs. /kg)}}{\text{Body weight gain (kg)}}$$

Similarly feed cost per unit meat production was calculated as follows:

Feed cost (Rs.)/kg meat yield =

$$\frac{\text{Feed consumption (kg)} \times \text{Feed cost (Rs./kg)}}{\text{Meat yield (kg)}}$$

Data subjected to test of significance as per 3 × 4 factorial completely randomized design (CRD) were analyzed for mean, standard errors and analysis of variance by Snedecor and Cochran (1989) using statistical package for social sciences (SPSS) 16.0 version and comparison of means were done using Tukey's test (1949).

RESULTS AND DISCUSSION

The data pertaining to cost economics in broiler chicken by feeding different levels of RGM with or without enzymes are presented in Table 6. Cost economics were calculated in Microsoft excel by using formulas mentioned in the methodology and statistical analysis were done by using SPSS software version 16.0 as per experimental design 3 × 4 factorial completely randomized design (CRD). Feeding different levels of RGM (0, 15 and 17.5%) revealed that feed cost per kg live weight, meat yield (dressed wt.) and eviscerated yield were significantly ($P<0.01$) lower in 15 and 17.5% RGM levels as compared to 0% RGM level. There was no significant ($P>0.05$) difference in 15 and 17.5% RGM

Table 1: Experimental layout for feeding different level of RGM with or without enzymes.

Experimental design			3 × 4 factorial CRD		
Treatment	Rice glutenmeal (%)	No. of replicates	Birds/ replication	Total	Enzymes
T1	0.0	4	8	32	-
T2	0.0	4	8	32	Xylanase
T3	0.0	4	8	32	Protease
T4	0.0	4	8	32	Multienzymes
T5	15	4	8	32	-
T6	15	4	8	32	Xylanase
T7	15	4	8	32	Protease
T8	15	4	8	32	Multienzymes
T9	17.5	4	8	32	-
T10	17.5	4	8	32	Xylanase
T11	17.5	4	8	32	Protease
T12	17.5	4	8	32	Multienzymes

levels in terms of feed cost per kg live weight, meat yield and eviscerated yield. Effect of feeding RGM without or with enzymes (xylanase, protease and multienzymes) revealed that feed cost per kg live weight was significantly (P<0.05) lower in protease supplemented group as compared to xylanase and without enzymes groups. Protease and multienzymes groups did not show any significant (P>0.05) difference in terms of feed cost per kg live weight, but protease enzyme supplementation showed numerically lower feed cost per kg live weight. Interaction of RGM with enzymes did not show any significant (P>0.05) difference in feed cost per kg meat yield and eviscerated yield. Feed cost per kg live weight was significantly (P<0.05) decreased in 15 and 17.5% RGM without and with enzymes groups as compared to control and 0% RGM with enzymes groups.

Thus, it may be concluded that 15% RGM with protease was found most cost effective. RGM at the inclusion level of 15% reduced feed cost per kg live weight, meat yield and eviscerated yield by 5.44, 5.13 and 4.69% respectively. Protease enzyme supplementation in 15% RGM further reduced feed cost per kg live weight by 2.60%. Multienzymes supplementation was found most cost effective in corn-soya diet and it reduced feed cost per kg live weight by 1.03%.

Table 2: Analyzed chemical composition of dietary ingredients (%) on as such basis.

Ingredients	Moisture	DM	CP	EE	CF	TA	NFE	Ca	P	GE (kcal/kg)	*ME (kcal/kg)
Maize	8.6	91.3	9	3.9	1.8	1.4	83.8	0.03	0.29	4447	3350
SBM	9.1	90.9	44.5	0.9	6.2	3.1	45.2	0.32	0.68	4097	2400
DORB	10.1	91.8	14	1.6	15.9	5.8	62.6	0.3	1.54	3854	2000
RGM	7.6	92.3	49.9	5.7	7.4	3.3	33.5	0.84	0.98	4742	3031
Soybean oil	-	-	-	-	-	-	-	-	-	8900	8450
Lime stone powder	1.4	98.6	-	-	-	-	-	33.89	-	-	-
Marbal chip	1.3	98.7	-	-	-	-	-	33.84	-	-	-
DCP	7.2	92.7	-	-	-	-	-	22.92	16.04	-	-

*Calculated value.

Table 3: Ingredients and nutrient composition (%) of pre-starter diets with or without enzymes for different level of RGM.

Ingredients	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Maize	54.42	54.42	54.42	54.42	59.40	59.40	59.40	59.40	60.00	60.00	60.00	60.00
SBM	38.40	38.40	38.40	38.40	20.70	20.70	20.70	20.70	17.80	17.80	17.80	17.80
RGM	0.00	0.00	0.00	0.00	15.00	15.00	15.00	15.00	17.50	17.50	17.50	17.50
Oil	3.00	3.00	3.00	3.00	0.70	0.70	0.70	0.70	0.40	0.40	0.40	0.40
LSP	1.40	1.40	1.40	1.40	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
DCP	1.82	1.82	1.82	1.82	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Lysine	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.18	0.18	0.18	0.18
Methionine	0.20	0.20	0.20	0.20	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
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
Enzyme	-	+	+	+	-	+	+	+	-	+	+	+
Total	100.01	100.01	100.01	100.01	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nutrient composition												
CP	21.99	21.99	21.99	21.99	22.06	22.06	22.06	22.06	22.07	22.07	22.07	22.07
Lysine	1.19	1.19	1.19	1.19	1.20	1.20	1.20	1.20	1.21	1.21	1.21	1.21
Methionine	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.54	0.54	0.54	0.54
Threonine	0.81	0.81	0.81	0.81	0.83	0.83	0.83	0.83	0.82	0.82	0.82	0.82
Ca	1.03	1.03	1.03	1.03	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
P	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
ME (kcal/kg)**	2998	2998	2998	2998	3001	3001	3001	3001	3001	3001	3001	3001
Cost (Rs./kg)	28.52	29.03	29.13	28.93	24.68	25.19	25.29	25.09	24.31	24.82	24.92	24.72

In prestarter diet *Constant 0.765 includes salt 0.4%, trace mineral premix 0.1%, vitamin premix 0.15%, vit. B complex 0.015%, choline chloride 0.05% and toxin binder 0.05%. Trace mineral premix supplied mg/kg diet: Mn, 55; I, 1; Fe, 75; Zn, 60; Cu, 10; Se, 0.15 and Cr, 0.2. The vitamin premix supplied per kg diet: Vit. A, 5000 IU; Vit. D_3, 2400 IU; Vit.E,15 and Vit.K, 1 mg. Vitamin B complex supplied per kg diet: Vit. B_1, 5 mg; Vit. B_2, 6 mg; Vit. B_6 5 mg; Vit. B_{12}, 15 mcg; nicotinic acid, 35 mg; pantothenic acid, 12 mg; biotin 0.15 mg and folic acid 0.5 mg. Choline chloride supplied per kg diet: choline, 1300 mg. (As per ICAR, 2013) **Calculated value.

Table 4: Ingredients and nutrient composition (%) of starter diets with or without enzymes for different level of RGM.

Ingredients	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Maize	55.63	55.63	55.63	55.63	60.70	60.70	60.70	60.70	61.62	61.62	61.62	61.62
SBM	37.10	37.10	37.10	37.10	19.20	19.20	19.20	19.20	16.20	16.20	16.20	16.20
RGM	0.00	0.00	0.00	0.00	15.00	15.00	15.00	15.00	17.50	17.50	17.50	17.50
oil	3.50	3.50	3.50	3.50	1.20	1.20	1.20	1.20	0.80	0.80	0.80	0.80
LSP	1.35	1.35	1.35	1.35	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
DCP	1.55	1.55	1.55	1.55	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Lysine	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Methionine	0.10	0.10	0.10	0.10	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
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
Enzyme	-	+	+	+	-	+	+	+	-	+	+	+
Total	100.00	100.00	100.00	100.00	100.0	100.0	100.0	100.0	100.00	100.00	100.00	100.00
Nutrient composition												
CP	21.52	21.52	21.52	21.52	21.51	21.51	21.51	21.51	21.50	21.50	21.50	21.50
Lysine	1.38	1.38	1.38	1.38	1.09	1.09	1.09	1.09	1.04	1.04	1.04	1.04
Methionine	0.48	0.48	0.48	0.48	0.49	0.49	0.49	0.49	0.50	0.50	0.50	0.50
Threonine	0.80	0.80	0.80	0.80	0.79	0.79	0.79	0.79	0.81	0.81	0.81	0.81
Ca	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
P	0.41	0.41	0.41	0.41	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
ME (kcal/kg)**	3050	3050	3050	3050	3050	3050	3050	3050	3051	3051	3051	3051
Cost (Rs./ kg)	28.03	28.53	28.63	28.43	24.43	25.03	24.93	24.83	23.86	24.46	24.36	24.26

In starter diet *Constant 0.765 includes salt 0.4%, trace mineral premix 0.1%, vitamin premix 0.15%, vit. B complex 0.015%, choline chloride 0.05% and toxin binder 0.05%. Trace mineral premix supplied mg/kg diet: Mn, 55; I, 1; Fe, 60; Zn, 60; Cu, 10; Se, 0.15 and Cr, 0.2. The vitamin premix supplied per kg diet: Vit. A, 5000 IU; Vit. D_3, 2400 IU; Vit. E,15 and Vit. K, 1 mg. Vitamin B complex supplied per kg diet: Vit. B_1, 4 mg; Vit. B_2, 6 mg; Vit. B_6 5 mg; Vit. B_{12}, 15 mcg; nicotinic acid, 35 mg; pantothenic acid, 10 mg; biotin 0.15 mg and folic acid 0.5 mg. Choline chloride supplied per kg diet: choline, 1200 mg. (As per ICAR, 2013) **Calculated value.

Table 5: Ingredients and nutrient composition (%) of finisher diets with or without enzymes for different level of RGM.

Ingredients	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Maize	62.00	62.00	62.00	62.00	67.07	67.07	67.07	67.07	67.97	67.97	67.97	67.97
SBM	31.30	31.30	31.30	31.30	13.40	13.40	13.40	13.40	10.40	10.40	10.40	10.40
RGM	0.00	0.00	0.00	0.00	15.00	15.00	15.00	15.00	17.50	17.50	17.50	17.50
oil	3.22	3.22	3.22	3.22	0.90	0.90	0.90	0.90	0.50	0.50	0.50	0.50
LSP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DCP	1.45	1.45	1.45	1.45	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Lysine	0.00	0.00	0.00	0.00	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Methionine	0.06	0.06	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marbal chips	1.20	1.20	1.20	1.20	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
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
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nutrient composition												
CP	19.51	19.51	19.51	19.51	19.50	19.50	19.50	19.50	19.50	19.50	19.50	19.50
Lysine	1.20	1.20	1.20	1.20	0.98	0.98	0.98	0.98	0.92	0.92	0.92	0.92
Methionine	0.41	0.41	0.41	0.41	0.43	0.43	0.43	0.43	0.44	0.44	0.44	0.44
Threonine	0.86	0.86	0.86	0.86	0.81	0.81	0.81	0.81	0.80	0.80	0.80	0.80
Ca	0.86	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
P	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.37	0.37	0.37	0.37
ME**	3100.3	3100.3	3100.3	3100.3	3099.1	3099.1	3099.1	3099.1	3099.3	3099.3	3099.3	3099.3
Cost (Rs./kg)	2672	2672	2672	2672	2584	2584	2584	2584	2526	2526	2526	2526

In finisher diet *Constant 0.77 includes salt 0.4%, trace mineral premix 0.1%, vitamin premix 0.15%, vit. B complex 0.015%, choline chloride 0.05% and toxin binder 0.05%. Trace mineral premix supplied mg/kg diet: Mn, 50; I, 1; Fe, 50; Zn, 60; Cu, 8;Se,0.15 and Cr, 0.2. The vitamin premix supplied per kg diet: Vit. A, 5000 IU; Vit. D_3, 2400 IU; Vit. E,15 and Vit.K, 0.8 mg. Vitamin B complex supplied per kg diet: Vit. B_1, 4 mg; Vit. B_2, 6 mg; Vit. B_6 5 mg; Vit. B_{12}, 15 mcg; nicotinic acid, 30 mg; pantothenic acid, 10 mg; biotin 0.15 mg and folic acid 0.5 mg. Choline chloride supplied per kg diet: choline, 900 mg. (As per ICAR, 2013) **Calculated value.

Table 6: Effect of feeding different level of RGM with or without enzymes on cost economics.

Treatment	RGM %	Enzyme	Feed cost Rs. /kg live wt.	Feed cost Rs./ kg meat yield	Feed cost Rs./kg eviscerated wt.
T1	0	-	47.62^{b}	65.05	69.75
T2	0	X	47.44^{b}	64.79	69.17
T3	0	P	47.85^{b}	65.03	69.17
T4	0	M	47.17^{b}	61.13	64.93
T5	15	-	44.15^{a}	60.67	65.07
T6	15	X	44.83^{a}	61.54	66.22
T7	15	P	44.22^{a}	59.73	63.82
T8	15	M	43.54^{a}	60.87	65.08
T9	17.5	-	44.23^{a}	60.81	65.45
T10	17.5	X	43.56^{a}	59.85	64.24
T11	17.5	P	43.67^{a}	59.77	64.04
T12	17.5	M	43.39^{a}	59.97	64.16
		Pooled SEM	0.27	0.37	0.40
		RGM			
		0	46.82^{b}	63.93^{b}	68.19^{b}
		15	44.27^{a}	60.65^{a}	64.99^{a}
		17.5	43.73^{a}	60.06^{a}	64.44^{a}
		Enzyme			
		-	45.33^{b}	62.17	66.72
		X	45.23^{b}	62.08	66.57
		P	44.15^{a}	61.48	65.66
		M	44.86^{ab}	60.63	64.77
		Significance			
		RGM	P<0.01	P<0.01	P<0.01
		Enzyme	P<0.05	NS	NS
		Interaction	P<0.05	NS	NS

Values bearing different superscripts within the column differ significantly*(P<0.01), **(P<0.05) and NS: Non-significant (P>0.05).

Our results are in agreement with Sherazi *et al*. (1995) and Kumar *et al*. (2016). Sherazi *et al*. (1995) reported ration containing 10% rice gluten protein was the most economical. Kumar *et al*. (2016) reported that RGM based diets produced cost effective average daily gain by replacing 75% of ground nut cake in the concentrate mixture of growing calves. Contrary to our findings Wani (2017) reported supplementation of protease enzyme alone or in combination with RGM was not found beneficial in broiler production.

CONCLUSION

The RGM inclusion at 15% and 17.5% significantly (P<0.01) reduced the feed cost per unit live weight, meat yield and eviscerated yield compared to control. The protease supplementation significantly (P<0.05) reduced the feed cost per unit live weight of birds compared to control and xylanase supplementation. RGM at the inclusion level of 15% reduced feed cost per kg live weight, meat yield and eviscerated yield by 5.44, 5.13 and 4.69% respectively. Protease enzyme supplementation in 15% RGM further reduced feed cost per kg live weight by 2.60%. Multi enzymes supplementation was found most cost effective in corn-soya diet and it reduced feed cost per kg live weight by 1.03%.

REFERENCES

AOAC (2000). Association of Official Analytical Chemists. Official Methods of Analysis. 17th edn., Washington, DC.

Agricultural Statistics. (2018). Agricultural Statistics at a Glance. Department of Agriculture, Cooperation and Farmers Welfare. Government of India, New Delhi.

Chessson, A. (2001). Non starch polysaccharide degrading enzymes in poultry diets: influence of ingredients on the selection of activities. World Poultry Science. 57: 251-262.

Dinani, O.P., Tyagi, Pramod K., Mandal, A.B., Tyagi, Praveen, K. and Dutta, N. (2019). Evaluation of feeding value of rice based distillers dried grains with solubles (DDGS) for broiler chickens. Indian Journal of Animal Research. 53: 901-906.

ICAR. (2013). Nutrient Requirements of Animals-Poultry. Indian Council of Agriculture Research, New Delhi, India. 1: 13-16.

Kamra, D.N. and Agarwal, N. (2003). Techniques in Rumen Microbiology. IVRI Deemed University, Izatnagar, U.P. India.

Kumar, R., Thakur, S.S. and Mahesh, M.S. (2016). Rice gluten meal as an alternative by product feed forgrowing dairy calves. Tropical Animal Health Production. 48(3): 619-624.

Malik, T.A., Thakur, S.S., Mahesh, M.S. and Yogi, R.K. (2017). Replacing groundnut cake with glutenmeals of rice and maize in diets for growing Sahiwal cattle. Asia-Australian Journal of Animal Sciences. 30(10): 1410.

Metwally, A. and Farahat, M. (2015). Nutritive value and feeding of rice gluten meal in broiler chickens. Research Opinions in Animal and Veterinary Sciences. 5: 443-451.

Sherazi, T.H., Alam, M.Z., Gilani, A.H. and Nawaz, H. (1995). Graded replacement of fish meal with rice protein meal in broiler ration. Pakistan Journal of Agricultural Sciences. 32: 2-3.

Snedecor, G.W. and Cochran, W.G. (1989). Statistical Methods, 7th edn. Oxford and IBH. Iowa State University Press, Iowa, USA.

Tukey, J. (1949). Comparing individual means in the analysis of variance. Biometrics. 5: 99-114.

Wani, M.A. (2017). Evaluation of feeding value of rice gluten meal in broiler chicken. Ph.D. thesis submitted to IVRI Deemed University, Izatnagar, U.P. India.