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EVALUATING MUSTARD MEAL AS A PARTIAL REPLACEMENT FOR SOYBEAN MEAL IN PERFORMANCE OF JAPANESE QUAIL

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ABSTRACT

This experiment evaluated the effects of partially replacing soybean meal (SM) with mustard meal (MM) at varying crude protein (CP) levels on the growth performance, egg production, and economic viability of Japanese quail. A 3 x 3 factorial experiment in a Completely Randomized Design employed nine dietary treatments were used. These comprised three CP levels (20%, 22%, and 24%) and three protein source combinations: SM only, 3% SM replaced by MM, and 5% SM replaced by MM. A total of 450 birds were distributed across five replicates per treatment. Over a 65-day period, data on feed intake, body weight gain, feed conversion ratio (FCR), age at first egg, egg number, and egg weight were collected and analyzed using ANOVA in R Studio, with benefit-cost (B:C) ratio calculated for economic assessment. Results indicated that dietary CP level significantly influenced performance, with 24% CP promoting the best weight gain and FCR during their growth. Protein source also had a significant effect; 3% MM inclusion (replacing SM) consistently resulted in higher weight gain and egg production compared to SM-only or 5% MM diets. The interaction was significant for key laying parameters: birds fed a 24% CP diet with 3% MM inclusion (CQ) exhibited the earliest sexual maturity (36.67 days), the highest egg production (22.33 eggs/bird), and the optimal B:C ratio (1.91). It is concluded that soybean meal can be partially replaced with 3% mustard meal in a 24% CP diet without compromising the growth performance. This formulation enhances egg production, improves feed efficiency, and maximizes economic returns, providing a cost-effective alternative for quail production in Nepal.

Key words: *Japanese quail, mustard meal, protein replacement, soybean meal*

INTRODUCTION

Japanese quail are small game birds that are reared as a source of eggs and meat (Odafe Shalome & Nojuvwevwo, 2021). Old World quail are found in the family Phasianidae and new world quail are found in the family Odontophoridae (Cox, Kimball and Braun, 2007). Japanese quail is highly prolific and hardy poultry species that have short generation interval, low space requirement, early maturity age with high laying intensity which increases its preference as a viable and feasible enterprise (Malla et al., 2018). Further, quail farming is getting popularity because of early sexual maturity and small body size necessitating a lower housing space and feed (Taheri et al., 2017). Wild Japanese quail feed on insects, grains, grass and various seeds. When fed a high-protein diet, they have also been observed to thrive and develop efficiently in captivity (Odunsi et al., 2007). Feeding cost accounts 70-75 % of cost involved in quail production (Mnisi et al., 2023).

Quail diets are mostly composed of plant materials; the most widely utilized plant products include maize, soybean meal, mustard cake, groundnut cake, sorghum, millet, and rice or wheat bran. However, these plant products do not meet protein requirements since they contain low levels of methionine and lysine. Protein is the most expensive item for preparing quail ration (Lima et al., 2023). Soybean meal is used primarily to support the protein requirements of chicken feed. Soybean meal contains a lot of lysine and other necessary amino acids, but not much methionine. However, soybean is expensive and, if not adequately processed, might decrease animal performance due to the presence of trypsin inhibitors (Asghar et al., 2024). Mustard cake is used as a source of protein for poultry, cattle and aquatic animal (Sehwag and Das, 2015) but there is dearth of information on the proportion of its requirement in poultry feed. Tripathy et al., (2003) showed partial replacement of 80 gm/kg soybean meal with mustard meal has no effect on the growth and health of growing chicken. While investigating the effects of mustard cake in layers, egg characters were affected adversely only upon 15% or above mustard cake inclusion rate (Zhu et al., 2018). Soybean meal may be replaced in the poultry and quail ration by other protein sources such as mustard cake with a lower price and desirable nutrient content. Although there are very small numbers of commercial quail farming and hatchery in Nepal till now, the number is growing rapidly in recent years. Similar to broiler production, quail production also faces the problem of the higher cost of production which relies on the soybean as a base source of protein. Since it is an emerging enterprise in Nepal there are limited studies regarding its feed requirement and best alternative source of protein. In this context, this research is aimed to study the effectiveness of replacing soybean oil meal by mustard oil meal at different level, which may be alternative to high cost soybean based protein sources in the Nepalese poultry feed sector.

MATERIALS AND METHODS

The research was carried out at Lamjung Campus, Sundarbazar Municipality 07, Lamjung to identify the protein requirement and economical source of protein for Japanese quail from 9th March to May 12, 2025. The experiment was carried out in Completely Randomized Design with nine treatment replicated five times with ten birds in each unit. The experimental research was bifactorial with different level of protein; 20%, 22% & 24% made available from an alternate source; soybean meal, 3% replacement of soybean meal by mustard meal & 5% replacement of soybean meal by mustard meal.

Table 1: Factorial composition of treatments

Factor A Protein Level	Factor B Protein Source
A = 20%	P = Soybean meal
B = 22 %	Q = Soybean meal + Mustard meal (3% inclusion)
C = 24%	R = Soybean meal + Mustard meal (5% inclusion)

The combination of two factor makes the nine treatment details as;

AP - 20% CP (soybean meal)
BP - 22% CP (soybean meal)
CP - 24% CP (soybean meal)
AQ - 20% CP (17% soybean meal + 3% mustard meal)
BQ - 22% CP (19% soybean meal + 3% mustard meal)
CQ - 24% CP (21% soybean meal + 3% mustard meal)
AR - 20% CP (15% soybean meal + 5% mustard meal)
BR - 22% CP (17% soybean meal + 5% mustard meal)
CR - 24% CP (19% soybean meal + 5% mustard meal)

Different type of ration was fed to the birds as based upon treatment specification. Drinking water and feed was provided *ad libtum*. The ration used for the experimental research was as:

Table 2: Ration composition for different treatments

Ingredients (kg) / Treatment	AP	BP	CP	AQ	BQ	CQ	AR	BR	CR
Maize	50	50	45.5	51.5	49.35	44	52	48	47
Wheat Bran	9.6	1.1	0.6	6.05	2.6	0.6	3.6	1.6	0.6
Rice Polish	9	12	11.5	10	10	10	10	10	6
Soybean Meal	30	35.5	41	27	32	38	25	30	33
Mustard Meal				4.05	4.65	6	8	9	12
LSP Powder	1	1	1	1	1	1	1	1	1
Salt	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Trace Mineral	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Toxin Binder	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Choline Chloride	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	100	100	100	100	100	100	100	100	100
Calculated									
Crude Protein (%)	20	22	24	20	22	24	20	22	24
Metabolizable energy (Mj/kg)	2842	2961	2908.4	2904	2919	2868	2943	2910.71	2879
Crude Fiber	5.2	4.87	5.05	5.05	4.98	5.08	5.03	5.08	4.94

Different growth parameters like daily feed intake, body weight gain, FCR was recorded. Similarly, egg laying parameter as days to first egg lay, weight of egg and number of eggs laid during the period was recorded. B: C ratio was calculated for each dietary composition to know the economic viability at the end. The data on various traits were analyzed for CRD using R Studio (version 1.1.423 - © 2009 – 2018 R Studio, Inc.). Analysis of variance (ANOVA) was done. Significant difference was declared for means with $p < 0.05$.

RESULTS AND DISCUSSION

Feed intake

The results showed that there is no significant difference in the cumulative feed intake of birds at different stage of growth due to the interaction effects of different levels of protein made available from different sources however; feed intake is observed higher in birds fed with diet containing 20% CP made available from 3% replacement of soybean meal (SM) by mustard meal (MM) and lower in birds fed with 24% CP made available from 5% replacement of SM by MM during all growth stage of quail. Although there is no significant difference in feed intake of birds by the interaction effect, feed intake is significantly ($p < 0.001$) higher in birds fed with 20% CP and lower in birds fed with higher level of protein during brooding and growing stage. During the laying stage, feed intake is significantly ($p < 0.1$) higher in birds fed with 20% CP and lower in bird fed with higher content of protein. Feed intake of birds also varied significantly ($p < 0.01$) with replacement of SM by MM during brooder and grower stage. Higher feed consumption is observed in birds fed with diet containing 3% replacement of SM although it is not statistically different from birds fed with SM as protein source. Lower feed consumption in birds fed with 5% replacement of SM might be due to the toxic substances present in MM. This result is in line with the findings of Tangtaweewipat et al., (2004), who reported increasing levels of mustard meal in poultry diets reduced feed intake due to the presence of glucosinolates and their hydrolysis products, which negatively affect palatability and induce adverse physiological responses. During laying stage there is no significant difference in feed intake of birds from different protein sources however feed intake is higher in bird fed with feed with 3% replacement of SM.

Feed intake per day

Daily feed intake in birds did not vary significantly among the interaction of treatment in all growth stages, though it is recorded to be higher in treatment interaction of AQ and lower in CR during brooding and growing stage. During laying period too, daily feed intake in birds was observed statistically similar in all treatment combination. The results showed that feed intake per day in birds differed significantly ($p < 0.01$) with protein level during brooding stage and higher feed consumption was documented in birds fed with 20% CP and lower in birds fed with 24% crude protein. Further, feed intake per day differed significantly ($p < 0.05$) with protein level during growing phase too. Feed consumption was found higher in birds fed with 20% CP and lower in 24% CP fed groups. In contrast, daily feed consumption in birds did not vary with different level of protein during laying period, though feed intake was recorded higher in birds fed with 20% crude protein. Interestingly, feed intake per day is not influenced by different source of protein in all growth stage of quail.

Table 3: Average feed intake by Japanese quail

Treatment		Cumulative feed intake (g/ bird)			Net feed intake (g/ day / bird)		
		(0-14) days	(0-35) days	(0-65) days	(1-14) days	(15-35) days	(36-65) days
Main Effect							
PL (%)	A	119.97^{a} ± 1.51	543.59^{a} ± 2.22	1388.28^{a} ± 1.54	8.57^{a} ± 0.10	20.17^{ab} ± 0.08	28.16 ± 0.06
	B	113.73^{b} ± 1.14	538.83^{a} ± 1.58	1385.17^{a} ± 2.61	8.12^{b} ± 0.08	20.24^{a} ± 0.09	28.21 ± 0.07
	C	110.95^{c} ± 0.67	528.60^{b} ± 2.60	1377.14^{b} ± 2.98	7.93^{b} ± 0.05	19.89^{b} ± 0.13	28.28 ± 0.10
LSD		2.60	5.04	7.52	0.18	0.28	0.23
CV (%)		2.29	0.95	0.56	2.29	1.44	0.86
Probability		***	***	*	***	*	NS
PS	P	115.32^{a} ± 1.74	537.13^{a} ± 3.26	1383.03 ± 3.48	8.24^{a} ±`0.12	20.08 ± 0.11	28.28 ± 0.09
	Q	117.15^{a} ± 1.95	541.81^{a} ± 2.14	1386.98 ± 1.49	8.37^{a} ± 0.13	20.22 ± 0.10	28.19 ± 0.08
	R	112.17^{b} ± 0.96	532.07^{b} ± 2.78	1380.17 ± 3.06	8.01^{b} ± 0.08	19.99 ± 0.11	28.17 ± 0.05
LSD		2.60	5.04	7.52	0.18	0.28	0.23
CV (%)		2.29	0.95	0.56	2.29	1.44	0.86
Probability		**	**	NS	**	NS	NS

Cumulative weight gain (g/ bird)

Cumulative weight gains in quail at different stage of growth did not differ significantly due to the interaction of protein levels and sources. However, protein levels and its sources individually displayed significant difference on weight gain (Table 4). During the brooding and rearing stage, protein levels have significant ($p < 0.01$) effect in weight gain. Weight gain was observed higher in protein level of 24% and lower in protein level of 20 %. Furthermore, weight gain was recorded higher in protein level of 22% which is significantly different ($p < 0.05$) than other levels during the laying stage.The result is in accordance with findings of Soares et al., (2003) who reported increasing dietary crude protein levels significantly improved body weight gain and growth performance in Japanese quail, particularly during the growing and early laying periods, due to improved amino acid availability and enhanced protein deposition. The protein source wasn't observed to be a significant factor for weight gain during brooding stage in Japanese quail but higher weight gain was found in 3% replacement of SM by MM and lower in SM as a sole protein source. During grower stage, protein sources played a significant ($p < 0.01$) role in weight gain, displaying higher gain in 3% replacement of SM by MM and lower in SM as protein source. The weight gain was found to be significantly ($p < 0.05$) affected by the protein source laying period too, with evidence of higher weight gain in 3% replacement of SM.

Net weight gain (g/ day/ bird)

The interactions of protein levels and protein sources did not affect net weight gain per day during all growth phases of quail. However, protein levels individually showed significant difference in net weight gain per day during the brooding and the laying stages. Net weight gain per day was evident higher in protein level of 24% during the brooding period which is significantly different ($p<0.05$) than other protein levels. The net daily weight gain varied significantly ($p<0.01$) in different protein levels during the laying period, the higher daily gain in protein level of 22% and the lower in protein level of 24%. The protein sources did not have a significant effect in net daily weight gain during all growth stage of quail but higher net weight gain per day was documented in 3% replacement of SM by MM

Table 4: Average weight gain by Japanese quail

Treatment		Cumulative weight gain (g/bird)				Net weight gain (g/day/bird)		
		1 day	(1-14) days	(1-35) days	(1-65) days	(0-14) days	(15-35) days	(36-65) days
Main Effect								
PL (%)	A	7.72 ± 0.09	60.84^{b} ± 0.57	146.43^{b} ± 0.86	200.71^{a} ± 3.47	3.79^{b} ± 0.04	4.07 ± 0.05	1.81^{a} ± 0.12
	B	7.75 ± 0.12	62.12^{ab} ± 0.65	148.51^{ab} ± 0.88	203.43^{a} ± 3.28	3.87^{ab} ± 0.05	4.11 ± 0.03	1.83^{a} ± 0.10
	C	7.92 ± 0.10	63.65^{a} ± 0.43	150.73^{a} ± 1.47	192.01^{b} ± 2.55	3.97^{a} ± 0.03	4.15 ± 0.06	1.38^{b} ± 0.06
LSD		0.31	1.63	2.48	8.57	0.12	0.13	0.30
CV (%)		4.10	2.66	1.68	4.35	3.23	3.19	18.20
Probability			**	**	*	*	NS	**
PS	P	7.94 ± 0.10	61.38^{b} ± 0.61	146.13^{b} ± 0.79	194.57^{b} ± 3.50	3.81^{b} ± 0.04	4.04 ± 0.05	1.61 ± 0.12
	Q	7.74 ± 0.11	63.23^{a} ± 0.65	150.73^{a} ± 1.31	205.98^{a} ± 3.46	3.96^{a} ± 0.04	4.17 ± 0.04	1.84 ± 0.13
	R	7.71 ± 0.08	62.01^{ab} ± 0.65	148.81^{a} ± 1.04	195.61^{b} ± 2.02	3.86^{ab} ± 0.05	4.13 ± 0.04	1.56 ± 0.09
LSD		0.31	1.63	2.48	8.57	0.12	0.13	18.20
CV (%)		4.10	2.66	1.68	4.35	3.23	3.19	0.30
Probability		NS	NS	**	*	NS	NS	NS

Cumulative FCR

The FCR didn't differ significantly among the interaction of treatment during the different growth stage of quail. However, it is seen lower in the treatment combination of CQ during the brooder and grower stage. FCR in treatment combination AP is observed higher during the brooder and grower stage. Protein levels and protein sources individually have a significant effect in FCR of quail during different growth stage. During the brooder and grower stage, FCR is found lower in the birds fed with protein level of 24% which is significantly ($p<0.01$) different from other protein levels. This finding is in accordance with Omidiwura et al., (2016) who recorded regardless of feed intake, birds fed with 24% CP utilized the nutrients most efficiently during brooding and rearing period. Better FCR in quails during 0-3 weeks of age with increasing CP level was reported earlier by Kaur et al., (2006, 2008). But, during the laying stage, FCR is not significantly affected by protein level though it is found lower in protein level of 22%. Further, protein sources during brooding stage showed the non-significant effect in FCR. FCR is seen lower in 5% replacement of SM by MM. During the grower and the laying phase, protein sources have a significant effect in FCR of quail and displayed a better FCR in birds fed with a diet containing 5% replacement of soybean meal.

FCR at a period

The interaction of protein levels and protein sources didn't have a significant effect in FCR of birds at different period of the growth stage. Though, there is no significant difference, FCR is observed lower in treatment combination of CQ at brooding period and grower period. During the laying period, FCR is seen lower in the treatment combination of BQ and higher in the treatment combination of CR. FCR in birds at brooding period is significantly lower in the protein level of 24% and higher in the protein level of 20%. Interestingly, FCR at the grower stage was observed to be statistically independent of the protein level, and again lower FCR is evident in protein level of 24%. Further FCR at laying period is significantly lower in protein level of 22%. Protein source doses not have a significant difference in FCR of birds at different period of the growth stage.

Table 5: Average feed conversion ratio of Japanese quail

Treatment		Cumulative FCR		FCR at a period		
		(1-14) days	(1-35) days	(1-14) days	(15-35) days	(36-65) days
Main Effect						
PL (%)	A	$1.97^{a} \pm 0.03$	$3.71^{a} \pm 0.02$	$0.16^{a} \pm 0.003$	4.95 ± 0.05	4.69 ± 0.10
	B	$1.83^{b} \pm 0.03$	$3.63^{b} \pm 0.02$	$0.15^{b} \pm 0.003$	4.92 ± 0.05	4.49 ± 0.14
	C	$1.74^{c} \pm 0.01$	$3.50^{c} \pm 0.03$	$0.14^{c} \pm 0.001$	4.80 ± 0.07	4.38 ± 0.08
LSD		0.07	0.06	0.006	0.15	0.32
CV (%)		3.65	1.79	4.38	3.26	7.38
Probability		***	***	***	NS	NS
PS	P	$1.88^{a} \pm 0.04$	$3.68^{a} \pm 0.03$	$0.16^{a} \pm 0.003$	4.98 ± 0.05	4.49 ± 0.09
	Q	$1.86^{ab} \pm 0.04$	$3.60^{b} \pm 0.03$	$0.15^{ab} \pm 0.003$	4.86 ± 0.05	4.27 ± 0.10
	R	$1.81^{b} \pm 0.03$	$3.58^{b} \pm 0.03$	$0.147^{b} \pm 0.002$	4.84 ± 0.06	4.58 ± 0.11
LSD		0.07	0.06	0.006	0.15	0.32
CV (%)		3.65	1.79	4.38	3.26	7.38
Probability		NS	*	NS	NS	NS

Egg laying parameter

Days of first laying

The results showed the significant ($p < 0.05$) difference in days of first laying by the interaction of protein levels and protein sources (Table 6). The quails in treatment combination of CQ were found to lay egg significantly earlier ($p < 0.05$) than other treatment combinations which is in accordance with findings of Oliveira et al., (2019). The average days of first laying of eggs in treatment combination CQ was observed 36.67 days while that in treatment combination AP were found to lay egg late at an average of 40.33 days.

Number of eggs laid

There is significant ($p < 0.05$) difference in the total number of eggs laid by bird during research period due to the interaction of protein levels and protein sources. Higher number of eggs were laid in the treatment combination of CQ which is significantly different ($p < 0.05$) from the treatment combination of AR, CR, BP, AP and CR. This result is at par with the findings of Salih et al., (2021). The number of eggs laid during research period by the birds in treatment combination of CQ was in average 22.33 while the lowest number of eggs were laid by the birds in treatment combination of AP (18.67).

Table 6: Egg laying parameter of Japanese quail

Treatment		Days of first laying	No of eggs laid	Weight of egg (g)
Main Effect				
PL (%)	A	$39.22^{a} \pm 0.32$	$20.00^{b} \pm 0.47$	9.50 ± 0.12
	B	$38.78^{a} \pm 0.36$	$20.22^{b} \pm 0.36$	9.37 ± 0.19
	C	$37.89^{b} \pm 0.48$	$21.56^{a} \pm 0.56$	9.03 ± 0.18
Probability		**	**	NS
PS	P	$39.00^{a} \pm 0.44$	$20.44^{b} \pm 0.62$	9.28 ± 0.20
	Q	$37.67^{b} \pm 0.33$	$21.56^{a} \pm 0.38$	9.23 ± 0.20
	R	$39.22^{a} \pm 0.31$	$19.78^{b} \pm 0.32$	9.40 ± 0.13
Probability		**	**	NS
Interaction Effect				
PL (%)	PS			
A	P	$40.33^{a} \pm 0.58$	$18.67^{d} \pm 0.33$	9.60 ± 0.26
B	P	$39.00^{abc} \pm 1.00$	$20.00^{bcd} \pm 0.58$	9.53 ± 0.33
C	P	$37.67^{cd} \pm 0.58$	$22.67^{a} \pm 0.33$	8.70 ± 0.25
A	Q	$38.67^{bc} \pm 0.58$	$21.00^{abc} \pm 1.00$	9.57 ± 0.26
B	Q	$37.67^{cd} \pm 0.58$	$21.33^{ab} \pm 0.33$	9.33 ± 0.42
C	Q	$36.67^{d} \pm 0.58$	$22.33^{a} \pm 0.33$	8.80 ± 0.30
A	R	$38.67^{bc} \pm 0.58$	$20.33^{bcd} \pm 0.33$	9.33 ± 0.12
B	R	$39.67^{ab} \pm 0.58$	$19.33^{cd} \pm 0.33$	9.27 ± 0.41
C	R	$39.33^{ab} \pm 1.52$	$19.67^{bcd} \pm 0.88$	9.60 ± 0.06
LSD		1.36	1.65	0.86
CV		2.05	4.67	5.41
Probability		*	*	NS

Weight of egg

The weight of eggs is not significantly affected by the interaction of protein levels and protein sources. Protein levels and protein sources individually too don't have significant effect in weight of eggs.

Benefit-cost ratio

Cost analysis of quail farming is significantly ($p < 0.001$) different among the interaction of treatment (Table 7). The highest cost was documented in the treatment combination of CQ, CP and CR which might be due to the higher cost associated with level of protein. As expected the treatment combination with lower levels of protein had a lower cost. Similarly, total benefit obtained from quail farming is also significantly ($p < 0.01$) different among the interaction of treatment. The highest benefit was obtained from the treatment combination of CQ which obviously is associated with higher number of eggs laid in the treatment. The lowest benefit was obtained from the treatment combination of AP due to less number of eggs laid by the bird in the treatment. Interestingly, the benefit- cost ratio was observed non-significant among the interaction of different treatment, however, the highest B: C ratio was observed in treatment combination of CQ.

Table 7: Benefit- cost ratio

Treatment Main effect		**Total Benefit (Rs)**	**Total Cost (Rs)**	**B: C Ratio**
PL (%)	A	$2792.81^{b} \pm 15.98$	$1517.63^{c} \pm 6.71$	$1.84^{a} \pm 0.01$
	B	$2813.26^{b} \pm 17.48$	$1524.22^{b} \pm 2.58$	$1.85^{ab} \pm 0.01$
	C	$2896.81^{a} \pm 31.34$	$1551.46^{a} \pm 4.95$	$1.87^{a} \pm 0.02$
Probability		***	***	NS
PS	P	$2823.92^{b} \pm 30.05$	$1536.24^{a} \pm 7.36$	$1.84^{b} \pm 0.01$
	Q	$2887.03^{a} \pm 23.92$	$1526.50^{c} \pm 9.01$	$1.89^{a} \pm 0.01$
	R	$2791.92^{b} \pm 15.54$	$1530.57^{b} \pm 3.89$	$1.82^{b} \pm 0.01$
Probability		***	***	***
Interaction Effect				
PL (%)	PS			
A	P	$2738.59^{e} \pm 16.00$	$1512.97^{e} \pm 0.48$	$1.81^{b} \pm 0.01$
B	P	$2802.59^{cde} \pm 27.71$	$1532.87^{c} \pm 2.96$	$1.83^{b} \pm 0.02$
C	P	$2930.59^{ab} \pm 16.00$	$1562.88^{a} \pm 3.25$	$1.88^{a} \pm 0.01$
A	Q	$2821.26^{cd} \pm 18.67$	$1497.15^{f} \pm 0.60$	$1.88^{a} \pm 0.01$
B	Q	$2866.59^{bc} \pm 16.00$	$1523.10^{d} \pm 0.62$	$1.88^{a} \pm 0.01$
C	Q	$2973.26^{a} \pm 13.33$	$1559.25^{a} \pm 1.59$	$1.91^{a} \pm 0.01$
A	R	$2818.59^{cd} \pm 16.00$	$1542.77^{b} \pm 2.01$	$1.83^{b} \pm 0.01$
B	R	$2770.59^{de} \pm 16.00$	$1516.69^{a} \pm 2.14$	$1.83^{b} \pm 0.01$
C	R	$2786.59^{de} \pm 42.33$	$1532.26^{c} \pm 0.89$	$1.82^{b} \pm 0.02$
LSD		65.43	5.64	0.042
CV		1.35	0.21	1.33
Probability		**	***	NS

CONCLUSION

This research demonstrated that partially replacing high-cost soybean meal with mustard meal in Japanese quail diets is both nutritionally effective and economically viable. Specifically, a diet containing 24% crude protein with 3% of the soybean meal replaced by mustard meal (CQ) yielded the best overall results, including superior feed conversion ratio, earlier sexual maturity, higher egg production, and the highest benefit-cost ratio. Therefore, incorporating mustard meal as an alternative protein source can reduce feed costs without compromising performance, offering a valuable strategy for sustainable quail production in Nepal.

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Utshav Pandey conducted the research work, collected and analyzed the data, and prepared the manuscript. Prof. Bhargab Dhital conceptualized and supervised the study, and provided critical revision of the manuscript. Huma Neupane, PhD and Dr. Narayan Neupane assisted in designing the experiment, supervised the data collection and analysis, and reviewed the manuscript for intellectual content. All authors read and approved the final manuscript.

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