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Sunita Sondaliya

M.Sc. Scholar, Department of
Animal Production, RCA,
MPUAT, Udaipur, Rajasthan,
India

JL Choudhary

Emeritus-Professor, Department
of Animal Production, RCA,
MPUAT, Udaipur, Rajasthan,
India

Siddhartha Mishra

Professor and Head, Department
of Animal Production, RCA,
MPUAT, Udaipur, Rajasthan,
India

Hari Singh

Professor, Department of Ag.
Economics, RCA, MPUAT,
Udaipur, Rajasthan, India

HS Meena

Assistant Professor, Department
of Plant Physiology, RCA,
MPUAT, Udaipur, Rajasthan,
India

Avinash Gurjar

M.Sc. Scholar, Department of
Animal Production, RCA,
MPUAT, Udaipur, Rajasthan,
India

Corresponding Author:

Sunita Sondaliya

M.Sc. Scholar, Department of
Animal Production, RCA,
MPUAT, Udaipur, Rajasthan,
India

Impact of linseed meal (*Linum usitatissimum* L.) supplementation on carcass characteristics in Japanese quail (*Coturnix japonica*)

Sunita Sondaliya, JL Choudhary, Siddhartha Mishra, Hari Singh, HS Meena and Avinash Gurjar

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Abstract

The present study was conducted to assess the “Impact of Linseed Meal (*Linum usitatissimum* L.) Supplementation on the Growth Performance of Japanese Quail (*Coturnix japonica*).” One hundred sixty unsexed Quail chicks (day-old) were used in a completely randomized design in 4 treatments with 4 replications, each consisting of 10 chicks. The treatments were T₁: control, T₂: T₁+4% Linseed Meal, T₃: T₁+6% Linseed Meal, T₄: T₁+8% Linseed Meal. In the present study carcass traits viz., live weight, dressed weight, dressing percentage, eviscerated weight, eviscerated percentage, giblet weight, giblet percentage and economic were measured to assess the effect of different treatments in Japanese quails. The carcass traits viz. live weight, dressed weight, dressing percentage, eviscerated weight, eviscerated percentage, giblet weight and giblet percentage had non-significant effect was found in treated groups fed with i.e. 4 to 8% linseed meal in the Japanese quail diet as compared to control group. The carcass yield was highest in the control group (T₁) followed closely with a statistically non-significant difference in linseed treated groups. However, the difference among all the treated groups was non-significant.

Keywords: Japanese quail, carcass traits, linseed meal, live weight

Introduction

Poultry production is one of the most dynamic and fastest-growing sub-sectors of animal agriculture worldwide, providing affordable animal protein in the form of meat and eggs. Among poultry species, Japanese quail (*Coturnix coturnix japonica*) have gained significant attention due to their rapid growth rate, early onset of sexual maturity (about 5-6 weeks), high egg production and efficient feed conversion ratio (FCR) compared to other poultry species. At present, quail rank as the third most important poultry species in India, following chickens and ducks, as reported in the 21th Livestock Census (2024-25). The contribution of eggs and chicken meat to total animal protein availability showed a substantial upward trend, increasing from 4.47% in 1951-1952 to over 9% by 2015-2016. In India, the poultry industry plays a vital role in rural employment and national food supply, contributing significantly to the agricultural economy. With India ranked among the top global producers of poultry meat and eggs, small-scale quail farming has become a popular enterprise among farmers aiming to diversify production and improve household incomes.

Although much of this research has focused on oils, the potential of linseed meal containing not only lipids but also protein, fiber and various bioactive compounds warrants investigation, as its effects on growth and nutrient utilization may differ from those of oil alone (Nobakht *et al.* 2018; Ghobashy *et al.* 2020) [11, 6]. Supplementation of quail diets with linseed oil has been associated with improvements in body weight gain, feed conversion efficiency, and antioxidant capacity. These effects are attributed to the high omega-3 fatty acid content of linseed, which enhances lipid metabolism and overall physiological performance in birds (Ahmed *et al.* 2024) [1].

Linseed meal, a by-product of oil extraction, is rich in crude protein and various bioactive

compounds, which can enhance growth performance in poultry when included at appropriate levels in the diet. The importance of conducting species-specific research, particularly for Japanese quail, has also been highlighted to ensure optimal dietary application (Khan *et al.*, 2024). Dietary inclusion of flaxseed meal has been shown to improve gut morphology and nutrient absorption in poultry, resulting in enhanced growth performance. These findings indicate that linseed meal may similarly promote digestive efficiency in Japanese quail (Popescu *et al.*, 2021) [14].

Materials and Methods

Experimental birds and diets

In the present study, a total of 160 day-old, unsexed and apparently healthy Japanese quail chicks were obtained from the hatchery unit of the Department of Animal Production, Rajasthan College of Agriculture, Udaipur. All chicks were individually weighed and randomly distributed into four experimental treatment groups. Each treatment consisted of four replications with 10 birds per replication, making a total of 40 chicks in each group.

Throughout the six-week experimental period, the quail chicks were provided with a grower ration. The diet was formulated using maize, digestible crude protein (DCP), soybean de-oiled cake (DOC) and linseed meal (*Linum usitatissimum* L.). Four experimental diets were prepared and offered to Japanese quail under different dietary treatments. The treatments included a basal diet without linseed meal (T₁, control), T₂ (basal diet supplemented with 4% linseed meal), T₃ (basal diet supplemented with 6% linseed meal) and T₄ (basal diet supplemented with 8% linseed meal). All experimental diets were formulated to be isonitrogenous and isocaloric for the grower phase, containing 24% crude protein and 2900 kcal/kg metabolizable energy. The crude protein and metabolizable energy values.

Table 1: Treatment wise Ingredient composition of ration

Feed ingredients	Quantity of feed ingredients (kg)			
	T ₁	T ₂	T ₃	T ₄
Maize (kg)	55.5	54	53.5	53
Soya DOC (kg)	42.5	40	38.5	37
DCP (kg)	2	2	2	2
Linseed Meal (kg)	0	4	6	8
Total	100	100	100	100
CP	24.12	24.22	24.18	24.14

Observations

3 Carcass Parameters

Carcass traits were assessed following the slaughter, dressing, and evisceration of the chicks. At the end of the experiment, four chicks were randomly selected from each treatment group (one chick per replication) for evaluation of carcass parameters, resulting in a total of sixteen chicks. The selected chicks were provided ad libitum access to water but were fasted for 12 hours prior to slaughter. Live weights were recorded immediately before slaughter. Chicks were slaughtered using standard procedures and allowed to bleed for 180 seconds in bleeding cones, after which bleed weights were measured. Feathers were removed manually following a 120-second scalding process at 62 °C and the defeathered weights were recorded. Subsequently, the chicks were processed further by removing the skin, head, shanks, feet and preen glands.

The viscera were removed by making an incision around the vent. The liver (excluding the gall bladder), gizzard and heart

(excluding the pericardium), collectively referred to as giblets, were opened, cleaned and weighed separately. The eviscerated carcass was also weighed individually. Wings and the neck were removed by cutting through the shoulder joint at the proximal end of the humerus. The drumsticks were separated from the thighs by cutting through the joint formed by the femur, fibula and tibia. The breast and back portions were removed by cutting along both sides of the vertebral column from the middle of the sternal ribs, with the breast completely separated from the back. This process resulted in two wings, two drumsticks, two thighs, one breast and one back portion per chick. After detaching the gall bladder from the liver and removing the gizzard contents, the weights of individual organs, including the heart, liver and gizzard, were recorded.

The following observations were made on various measurements of carcass and cut-up parts.

(1) Live weight

Chicks were weighed prior to slaughter using an electronic balance.

(2) Dressing weight

Prior to slaughter, chicks were weighed and then slaughtered by cutting the jugular vein, allowing bleeding for 180 seconds. The weights of blood, feathers, shanks and head were recorded separately to determine the dressing weight.

$$\text{Dressing weight (\%)} = \frac{\text{Live weight of bird} - \text{Weight of blood, feather, Shanks and head}}{\text{Live weight}} \times 100$$

(3) Eviscerated weight

The weight of the viscera, excluding the giblets (heart, liver and gizzard), was subtracted from the dressing percentage to calculate the eviscerated weight.

$$\text{Eviscerated weight (\%)} = \frac{\text{Dressed weight} - \text{Weight of viscera except giblet}}{\text{Live weight}} \times 100$$

(4) Giblet weight

The giblets, comprising the heart, liver and gizzard, were carefully removed from the slaughtered chicks and weighed using an electronic balance to assess the effects of different treatments on the growth and development of these organs.

$$\text{Giblet weight (\%)} = \frac{\text{Weight of giblet (g)}}{\text{Pre-slaughter live weight (g)}} \times 100$$

Effect on economics of production

The cost of production at six weeks of age was calculated by summing all variable costs, including feed costs with supplements and other miscellaneous expenses. Gross return was determined by multiplying the total body weight gain of the birds by the prevailing market price. Net return was calculated by subtracting the total cost from the gross return. The benefit-to-cost (B:C) ratio was subsequently computed using the following formula:

$$\text{B:C Ratio} = \frac{\text{Total return}}{\text{Total cost}}$$

Statistical analysis

The experiment was conducted using a completely randomized design (CRD), and the data collected for various

parameters were analyzed using analysis of variance (ANOVA) as described by Snedecor and Cochran (1994) [17].

Results and discussion of carcass parameters

The data with respect to carcass traits of Japanese quail is presented in table 2 and depicted graphically in figure 1. The parameters evaluated included live weight, dressed weight, eviscerated weight, dressing percentage, giblet weight and organ weights expressed as a percentage of live weight.

The live weight (g/chick) was recorded as 210.43 ± 6.49 , 205.35 ± 2.52 , 200.13 ± 0.95 and 198.36 ± 1.95 g in T₁, T₂, T₃ and T₄, respectively. The highest live weight was recorded in T₁ (210.43 ± 6.49 g), while the lowest was observed in T₄ (198.36 ± 1.95 g). statistical analysis showed no significant differences among treatment.

The dressed weight (g/chick) was 173.26 ± 5.37 , 167.06 ± 2.43 , 165.09 ± 2.22 and 163.34 ± 3.02 g in T₁, T₂, T₃ and T₄, respectively. The highest value was found in T₁ (173.26 ± 5.37 g) and the lowest in T₄ (163.34 ± 3.02 g), showing non-significant variation.

The dressing percentage was 82.37 ± 0.93 , 81.35 ± 0.51 , 82.49 ± 0.87 and 82.34 ± 1.06 g in T₁, T₂, T₃ and T₄, respectively. The highest dressing percentage was observed in T₃ (82.49 ± 0.87 g), whereas the lowest was in T₂ (82.37 ± 0.93 g). the difference among treatment were found to be non-significant.

The eviscerated weight(g/chick) was 135.95 ± 3.73 , 131.75 ± 1.69 , 128.49 ± 2.46 and 125.69 ± 2.71 g in T₁, T₂, T₃ and T₄, respectively. The highest value was recorded in T₁ (135.95 ± 3.73 g) and the lowest in T₄ (125.69 ± 2.71 g). However, the difference among treatment was no significant variation.

The eviscerated percentage was 64.65 ± 0.42 , 64.17 ± 0.67 , 64.19 ± 0.98 and 63.35 ± 0.95 g in T₁, T₂, T₃ and T₄, respectively. The highest percentage was observed in T₁ (64.65 ± 0.42 g) and the lowest in T₄ (63.35 ± 0.95 g), with non-significant differences.

The giblet weight (g/chick) was 12.40 ± 0.52 , 11.87 ± 0.47 , 11.64 ± 0.48 and 11.26 ± 0.43 g in T₁, T₂, T₃ and T₄, respectively. The highest value was found in T₁ (12.40 ± 0.52 g) and the lowest in T₄ (11.26 ± 0.43 g), showing non-significant variation.

The giblet percentage was 5.89 ± 0.13 , 5.78 ± 0.19 , 5.81 ± 0.23 and 5.68 ± 0.19 g in T₁, T₂, T₃ and T₄, respectively. The highest value was observed in T₁ (5.89 ± 0.13 g), whereas the lowest was recorded in T₄ (5.68 ± 0.1 g), with non-significant differences.

Discussion

These findings are consistent with previous studies. Ahmed *et al.* (2024) [1] reported that inclusion of soybean oil and linseed oil at varying levels had no significant effects on carcass yield parameters in growing Japanese quail. Similarly, Tamasgen *et al.* (2021) [18] found that replacing soybean meal with graded levels of linseed meal in broilers did not significantly affect carcass yield, though a slight numerical improvement was noted when 50% of soybean meal was replaced with linseed meal. Mirshekar *et al.* (2021) [10] also observed that flaxseed oil supplementation, alone or with sunflower oil, had no significant effect on live weight, eviscerated weight or giblet weight in Japanese quail.

In broilers, studies corroborate these findings. Shunthwal and Sheoran (2017) [16] reported that replacing sunflower oil with linseed oil did not significantly influence dressing percentage

or eviscerated yield, although giblet percentage was slightly lower in treated groups. Panda *et al.* (2015) observed that dietary supplementation with linseed oil at 2-3% levels did not affect dressed weight, eviscerated weight or giblet weight but enriched meat with n-3 fatty acids and improved the n-6: n-3 ratio. Nobakht *et al.* (2011) [12] demonstrated that dietary replacement of sunflower oil with soybean or mustard oil had no effect on dressing yield, breast meat, thigh meat, gizzard yield or abdominal fat deposition in broilers. Arshami *et al.* (2010) [2] also reported non-significant results for breast weight percentage among pullets fed 5, 7.5 and 10% flaxseed compared to the control. Lopez-Ferrer *et al.* (2001) and Chekani-Azar *et al.* (2007) [8, 3] reported no significant influence of dietary inclusion of fish oil (3-4%) on relative carcass parameters.

Results of Economics of Japanese quail birds

The data pertaining to economics is presented in table 3 and illustrated in figures 2. The analysis considered key parameters, including feed cost, gross return, net return and the benefit-cost (B:C) ratio.

The overall body weight at the end of the experimental period was 232.29 ± 0.64 , 205.37 ± 2.37 , 188.68 ± 2.27 and 179.63 ± 2.40 g in T₁, T₂, T₃ and T₄, respectively. The differences among treatments were significant ($P < 0.05$), with T₁ (205.37 ± 2.37 g) showing the highest body weight and T₄ (179.63 ± 2.40 g) the lowest.

The total gross return per chick was recorded as 46.46 ± 0.13 , 41.07 ± 0.47 , 37.74 ± 0.45 and 35.93 ± 0.48 ₹ in T₁, T₂, T₃ and T₄, respectively. Significant differences were observed among all treatment groups ($P < 0.05$), reflecting the variation in final body weight and market value.

Overall feed intake was recorded as 494.44 ± 2.08 , 503.41 ± 1.41 , 506.69 ± 2.11 and 510.12 ± 0.84 g in T₁, T₂, T₃ and T₄, respectively. Feed intake increased slightly with higher inclusion of linseed meal. The differences were significant ($P < 0.05$), with T₄ (510.12 ± 0.84 g) consuming the most feed and T₁ (494.44 ± 2.08 g) the least.

The total feed cost per chick was 14.81 ± 0.06 , 15.08 ± 0.04 , 15.18 ± 0.06 and 15.28 ± 0.03 ₹ in T₁, T₂, T₃ and T₄, respectively, which also differed significantly ($P < 0.05$). The lowest feed cost was observed in T₁ (14.81 ± 0.06 ₹) due to lower feed intake, while the highest feed cost occurred in T₄ (15.28 ± 0.03 ₹) because of slightly higher consumption and cost of feed ingredients.

The total cost per chick, which includes feed cost and other management expenses, was 34.81 ± 0.06 , 35.08 ± 0.04 , 35.18 ± 0.06 and 35.28 ± 0.03 ₹ in T₁, T₂, T₃ and T₄, respectively. The differences among treatments were significant ($P < 0.05$). T₁ (34.81 ± 0.06 ₹) had the lowest total cost due to both lower feed consumption and efficient management, whereas T₄ (35.28 ± 0.03 ₹) incurred the highest total cost.

The net return per chick was 11.64 ± 0.14 , 5.99 ± 0.46 , 2.56 ± 0.46 and 0.64 ± 0.50 ₹ in T₁, T₂, T₃ and T₄, respectively, with significant differences among all treatments ($P < 0.05$). The highest net return was recorded in T₁ (11.64 ± 0.14 ₹), while T₄ (0.64 ± 0.50 ₹) produced the lowest, indicating that higher linseed meal levels reduced profitability.

The benefit-to-cost (B:C) ratio was 1.33 ± 0.001 , 1.17 ± 0.013 , 1.07 ± 0.013 and 1.02 ± 0.014 ₹ in T₁, T₂, T₃ and T₄, respectively, showing significant differences ($P < 0.05$). Birds in T₁ (1.33 ± 0.001) achieved the highest economic efficiency, whereas T₄ (1.02 ± 0.014) had the lowest B:C ratio. Overall, the results indicate that moderate or no linseed

supplementation (T₁) was most profitable, while higher inclusion levels reduced economic returns.

Discussion

These findings corroborated with the results of Ewa *et al.* (2006) [5] who reported reduced feed cost/kg weight gain, the highest profits and the least cost-benefit ratio from birds under feed restriction. Mahmood *et al.* (2014) [9] concluded that the recommendation to formulate the quail diet containing high energy (3100 Kcal/Kg) to enhance the production efficiency with least cost. levels of 3100 kcal/kg

are best as far as the growth. Tamasgen *et al.* (2021) [18] reported that the total feed cost decreased with increasing replacement levels of linseed meal. The highest net return and marginal rate of return was recorded in 50% linseed meal and 75% linseed meal groups. Shehata *et al.* (2018) [15] concluded that the total return had a significant effect on total cost and about 96% from the changes in total costs attributed to the shifts in the total return with some dietary supplementation and also increasing body weight resulted in an increase of total cost.

Table 2: Impact of linseed meal supplementation on carcass parameters in quail

Carcass traits	T ₁	T ₂	T ₃	T ₄	SEm±	C.D. at 5%
Live Weight (g/chick)	210.43±6.49	205.35±2.52	200.13±0.95	198.36±1.95	3.65	NS
Dressed Weight (g/chick)	173.26±5.37	167.06±2.43	165.09±2.22	163.34±3.02	3.49	NS
Dressing Percentage	82.37±0.93	81.35±0.51	82.49±0.87	82.34±1.06	0.8678	NS
Eviscerated Weight (g/chick)	135.95±3.73	131.75±1.69	128.49±2.46	125.69±2.71	0.48	NS
Eviscerated Percentage	64.65±0.42	64.17±0.67	64.19±0.98	63.35±0.95	0.7887	NS
Giblet Weight (g/chick)	12.40±0.52	11.87±0.47	11.64±0.48	11.26±0.43	0.4758	NS

Figures bearing different superscript in a row differ significantly ($P < 0.05$) from each

*NS= Non-significant

Table 3: Impact of linseed meal supplementation on economics of Japanese Quail

Parameters	T ₁	T ₂	T ₃	T ₄	SEm±	C.D. at 5%
Overall body weight (g/chick)	232.29±0.64 ^a	205.37±2.37 ^b	188.68±2.27 ^c	179.63±2.40 ^d	2.06	6.35
Total gross return (₹/chick)	46.46±0.13 ^a	41.07±0.47 ^b	37.74±0.45 ^c	35.93±0.48 ^d	0.41	1.27
Overall feed intake (g/chick)	494.44±2.08 ^c	503.41±1.41 ^b	506.69±2.11 ^{ab}	510.12±0.84 ^a	1.69	5.22
Total feed cost (₹/chick)	14.81±0.06 ^c	15.08±0.04 ^b	15.18±0.06 ^{ab}	15.28±0.03 ^a	0.05	0.16
Total cost (₹/chick)	34.81±0.06 ^c	35.08±0.04 ^b	35.18±0.06 ^{ab}	35.28±0.03 ^a	0.05	0.16
Net return (₹/chick)	11.64±0.14 ^a	5.99±0.46 ^b	2.56±0.46 ^c	0.64±0.50 ^d	0.42	1.29
B:C ratio	1.33±0.00 ^a	1.17±0.01 ^b	1.07±0.01 ^c	1.02±0.01 ^d	0.01	0.04

Figures bearing different superscript in a row differ significantly ($P < 0.05$) from each

*NS= Non-significant

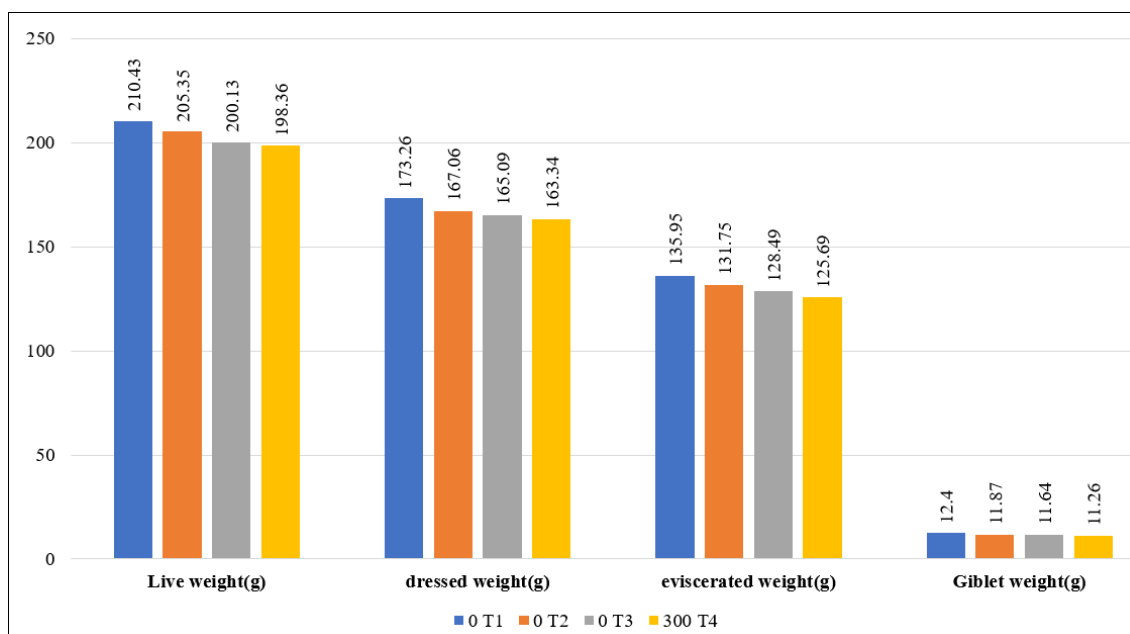


Fig 1: Effect of dietary linseed meal supplementation on carcass parameters in Japanese quail

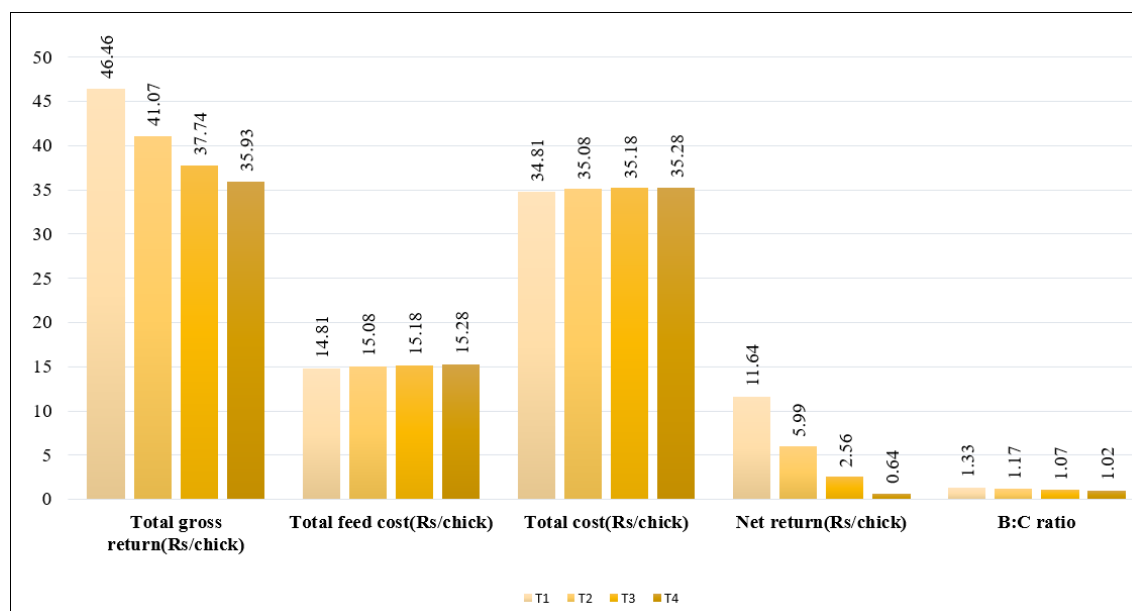


Fig 2: Impact of linseed meal supplementation on economics of Japanese quail

Conclusion

The findings of the present study revealed that dietary supplementation of linseed meal at varying inclusion levels had no significant ($P>0.05$) influence on carcass characteristics of Japanese quails. Parameters such as live weight, dressed weight, dressing percentage, eviscerated weight, eviscerated percentage, giblet weight and giblet percentage remained statistically comparable among all treatment groups. Although minor numerical variations were observed, these differences were not statistically significant. Therefore, it may be concluded that linseed meal can be incorporated into the diet of Japanese quails up to the highest level tested without adversely affecting carcass yield and overall carcass quality.

The benefit-to-cost (B:C) ratio was 1.33 ± 0.001 , 1.17 ± 0.013 , 1.07 ± 0.013 and 1.02 ± 0.014 in T₁, T₂, T₃ and T₄ respectively, showing significant differences ($P<0.05$). Birds in T₁ (1.33 ± 0.001) achieved the highest economic efficiency, whereas T₄ (1.02 ± 0.014) had the lowest B:C ratio. Overall, the results indicate that moderate or no linseed supplementation (T₁) was most profitable, while higher inclusion levels reduced economic returns.

Conflict of Interest

Not available.

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