Effect of low-protein diet on growth performance and production efficiency of Japanese quail (*Coturnix coturnix japonica)* under intensive management

J. John[1], R. Buragohain[2*], B.K. Das[3], A.K. Samanta[4], J.M.Rao Gali[5] and G. Kalita[6]

[1,2,3,4]Department of Animal Nutrition, [5]Department of Veterinary Physiology & Biochemistry, [6]Department of Livestock Production & Management, College of Veterinary Sciences and Animal Husbandry, Central Agricultural University (Imphal), Selesih, Aizawl, Mizoram - 796015, India
[*]Corresponding author, Email: drrajat57@gmail.com

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Abstract

The study was to assess the effect of low-protein diet on growth performance and production efficiency of Japanese quails (JQ) reared under intensive system of management. One-day old 280 JQ chicks were randomly distributed into 7 homogenous treatments (T-1, T-2, T-3, T-4, T-5, T-6 and T-7) and fed rations formulated following ICAR (2013) recommendations except the crude protein level which was at 95%, 90%, 85%, 80%, 75% and 70% of ICAR (2013) recommendations for T-2, T-3, T-4, T-5, T-6 and T-7, respectively. Starter ration was fed from 1st to 3rd weeks and grower ration from 4th to 6th weeks *ad libitum*. The JGs were housed in cages with optimum ventilation under intensive system of management. A metabolic trial for 3 days was carried after completion of 6 weeks. Production efficiency was evaluated in terms of FCR and EPEI. Findings revealed that average daily feed intake was significantly ($P<0.05$) reduced from 4th to 6th weeks as dietary protein level reduced. The weekly body weight changes of JQs were significantly ($P<0.01$) different from 4th to 6th week. The average final body weight at 6th week was statistically similar between T-1, T-2 and T-3. Metabolizability of nutrients were reduced as dietary crude protein level was reduced in the ration and apparent digestibility of DM, CF, CP and NFE were significantly different between the treatments. FCR decreased linearly as the dietary crude protein level decreased and it was significantly better in T-3 followed by T-1, T-2 and T-4. The EPEI was significantly ($P<0.01$) highest in T-3 followed by T-2 and T-1 at 6th week of age. From the findings of the study, dietary crude protein level of 23.61% during 1st to 3rd week of age and 21.50% during 4th to 6th week of age was recommended in the rations of Japanese quails.

Key words: Low-protein, feed intake, growth, digestibility, FCR, EPEI, Japanese Quail.

Introduction

In recent years, Japanese quails are emerging as income generating species for the farmers/entrepreneurs. The popularities of quail eggs and meat are increasing day-by-day for their unique medicinal and peculiar nutritional properties, and also for unique tastes unlike other poultry eggs and meat (Gaitov et al., 2021). Besides, rearing of Japanese quails have advantages for their smaller body size requiring less space, feed, rapid growth rate, early sexual maturity and shorter generation interval.

Nutritional requirements of Japanese quails are different from other poultry species (Gogaev et al., 2020). The growing Japanese quails needs 27.77% crude protein during 1-3 week of age and 25.00% crude protein during 4-6 week of age on dry matter basis (ICAR, 2013). However, there are reports of optimum growth performance of Japanese quails at lower dietary protein level in the rations. Dowarah and Sethi (2014) reported 20% CP with 3000 Kcal ME/kg as optimum protein-energy combination for growing and finishing Japanese quail during autumn with significantly increased nutrient digestibility and mineral (Ca & P) balance. Wen *et al*. (2017) recorded 22.0% CP as optimum for growing meat quails (France *Coturnix coturnix*) without any adverse effects on growth performance and carcass traits. Similarly, Retes *et al*. (2022) observed 22% CP as sufficient for optimum reproductive efficiency of Japanese quails. Many other works also reported different dietary levels of protein as optimum for growth performance of Japanese quails from different parts of the world. Rabie and Abo El-Maaty (2015) reported 24% CP as optimum for growing Japanese quails (14-42 days of age), Ashour et al. (2022) recommended 24% CP and 3000 Kcal ME/kg as optimum for growing Japanese quails (1-6 weeks) during summer season, Omidiwura *et al*. (2016) indicated 26% CP and 3200 Kcal ME/kg as suitable combination for optimum performance of Japanese quail, Zakari *et al*. (2020) reported 20% CP and 2600 Kcal ME/kg as optimum protein and energy level for growing Japanese quails. The different findings might be the indication that requirement of protein for Japanese quails might be different depending on location and climatic condition.

Along with other livestock and poultry farming, Japanese quail farming is also gaining popularity in Mizoram, the southernmost state of North-East region of India bordering Myanmar and Bangladesh. Due to hilly terrain with limited suitable land available for livestock farming for undulating topography, rearing of Japanese quail is comparatively easy and less expensive for their smaller size. Eggs and meat of Japanese quails are highly priced in Mizoram (Rs.5-6/egg and Rs.80-90/quail at 6 week) with the possibility of adopting it as start-up or MSME for livelihood of farmers and entrepreneurs. However, one of the main limitations associated with poultry farming in Mizoram is non-availability of feed ingredients. Prices of feed ingredients in Mizoram are nearly double/more than the mainland for expenditure involved in long-distance transportation coupled with geographical constraints. Thus, feeding becomes very expensive for the farmers in Mizoram. As nearly 60-70% of total expenditure in poultry enterprise is only for feeding, it is imperative to reduce the cost of feeding of the birds to make the enterprise profitable and sustainable. Among the feed ingredients, protein ingredients are the costliest ingredients in quail ration. Therefore, protein level of the diet directly contributes to the feed cost and hence the feeding cost. Besides, considering the ever-increasing prices of protein feed ingredients and other ingredients as well, it has become imperative to look for options to reduce the feeding cost to ascertain remunerative return from quail enterprise. In this regards, region-wise optimisation of protein level in the ration is the need of the hour. Therefore, the present study was undertaken to assess the effect of low-protein ration on growth performance, nutrient digestibility and production efficiency of Japanese quails in Mizoram to ascertain optimum CP level without compromising growth performance.

Materials and methods

Site of experimentation

The study was conducted at experimental animal shed, Department of Animal Nutrition, College of Veterinary Sciences & Animal Husbandry, Central Agricultural University (Imphal), Selesih, Aizawl, Mizoram. The study was approved by the Institutional Animal Ethics Committee via approval no: CVSC/CAU/IAEC/23-24/P-4, dated:21/10/2024.

Duration of experiment

The experiment was carried out for 42 days from May to July, 2024 during which the environmental temperature was in the range of 21^0C to 29^0C.

Design of experiment

Two hundred-eighty-one-day-old Japanese quail chicks were homogenously distributed into seven treatments (T-1 to T-7) with 40 quail chicks in each treatment following completely randomized block design (CRD). Each group was divided into 4 homogenous replicates of 10 quail chicks in each replicate. Quail starter and finisher rations were formulated following ICAR (2013) standard; but reducing the crude protein (CP) percentage by 5%, 10%, 15%, 20%, 25% and 30% respectively for T-2, T-3, T-4, T-5, T-6 and T-7, respectively (Table 1). Quail starter ration was fed up to 3 weeks and thereafter, quail finisher rations up to 6 weeks. The rations with isocaloric with other nutrients as per ICAR (2013) standards (Table 2).

Table.1: Ingredient composition (%) of the starter and finisher rations of experimental Japanese quails.

Ingredients	T-1		T-2		T-3		T-4		T-5		T-6		T-7	
	G	F	G	F	G	F	G	F	G	F	G	F	G	F
Yellow Maize	44	51	45	52	48	54	50	57	53	59	56	60	59	60
Soyabean Meal	38	26	34	26	30	25	28	20	26	20	23	22	21	18
Ground nut cake	12	13	12	9	12	7	10	8	8	5	7	0	5	0
Wheat bran	1	4	3	7	4	8	6	9	7	9	8	11	9	15
Vegetable oil	3	4	4	4	4	4	4	4	4	5	4	5	4	5
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Common Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
L-Lysine	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	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Coccidiostat*	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Toxin Binder**	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Trace Mineral-Vitamin Premix***	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Anti-oxidant#	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

G: Grower ration; F: Finisher ration ;* Amproforte (Brand name);** Toximar (Brand name); # Vimeral (Brand name)
*** Per kg contains Vitamin A:700,000 IU, Vitamin D3: 70,000 IU, Vitamin E: 250 mg, Calcium: 25.5%, Phosphorous: 12.5%, Sulfur: 0.72%, Zinc: 9600 mg, Magnesium: 6000 mg, Manganese: 1500 mg, Copper: 1200 mg, Iodine: 325 mg, Cobalt: 150 mg, Potassium: 100 mg, Sodium: 5.9 mg.

Table 2: Nutritional composition (on DM basis) of starter and finisher rations of experimental Japanese quails.

Attributes	T-1		T-2		T-3		T-4		T-5		T-6		T-7	
	S	F	S	F	S	F	S	F	S	F	S	F	S	F
DM (%)	89.31	89.58	89.29	89.68	89.12	89.72	89.36	89.47	89.06	89.30	88.51	89.69	88.54	89.06
CP (%)	27.24	24.24	26.23	22.94	25.13	21.36	23.21	20.38	22.49	18.82	21.00	17.89	19.52	16.29
EE (%)	4.03	4.95	4.29	4.46	4.28	4.97	4.67	5.30	4.12	5.25	4.83	5.15	4.80	4.95
CF (%)	4.96	4.82	4.5	4.65	3.56	4.48	4.43	4.26	4.58	4.00	4.68	3.88	3.75	3.85
TA (%)	6.84	5.56	6.68	5.31	5.20	5.61	6.66	5.35	6.51	4.74	5.54	5.87	6.47	5.02
NFE (%) *	56.91	60.40	58.28	62.62	61.81	63.55	61.00	64.69	62.28	67.17	63.92	67.19	65.44	69.87
Ca (%)	0.85	0.85	0.85	0.85	0.86	0.84	0.85	0.85	0.84	0.85	0.84	0.84	0.85	0.85
P (%)	0.45	0.35	0.46	0.34	0.46	0.34	0.45	0.35	0.45	0.35	0.44	0.35	0.45	0.35
ME (kcal/kg) *	2913	3002	2957	2981	2974	2990	2972	3007	2991	3084	3009	3075	3028	3031
Lysine (%)*	1.45	1.20	1.45	1.20	1.44	1.19	1.44	1.2	1.45	1.19	1.45	1.2	1.45	1.2
Methionine (%) *	0.55	0.5	0.56	0.49	0.56	0.49	0.54	0.5	0.54	0.5	0.55	0.5	0.55	0.5

*Calculated value
DM= Dry matter; CP=Crude protein; EE= Ether extract; CF=Crude fibre; TA= Total ash; NFE= Nitrogen free extract; Ca= Calcium; ME= Metabolizable energy; P= Phosphorus

Feeding and management of Japanese quails

Japanese quails were housed in battery brooder for 15 days during brooding and then transferred into well-ventilated house where each replicate was housed in separate cages providing recommended space. No artificial light was provided. Feeding and watering were done at *ad libitum*.

Parameters recorded during the feeding trial

The daily feed consumption was recorded from the difference between the amount of feed provided to each replicate and the residue left in the feeder after 24 hours. The body weight of quails was recorded at a weekly interval. A metabolic trial was conducted after 42 days of the feeding trial. Eight quails from each group were selected for the metabolic trial. After 2 days of adaptation, the actual collection period of 5 days had been started. The daily feed provided and residue left were recorded. Total amount of faeces voided by individual quails was recorded in every 24 hours. A suitable aliquot of faeces was taken for dry matter estimation and after grinding was

stored in labelled container for further analysis. A separate aliquot of faeces mixed with sulphuric acid (1:4) was preserved for 5 days in previously weighed wide - mouth stoppered glass bottles for nitrogen estimation.

The cumulative performance was evaluated at 42nd day of age by calculating the feed conversion ratio (FCR), European productive and economic efficiency index, and profit/bird (Rs.). The FCR for each of the experimental groups was computed by dividing the total feed consumed by the body weight gained during a certain length of time as follows.

$$FCR = \frac{\text{Feed intake (g)}}{\text{Body weight gain (g)}}$$

The European productive and economic efficiency index was calculated using the following formula given by Soltan and Kusainova (2012) as follows.

$$EPEI\ (\%) = \frac{\text{Body weight (g)X Livability (\%)}}{\text{Age(days)X FCR}} \text{ x } 100$$

Analytical methods

Analysis of feed ingredients, formulated rations, residue feed and faeces samples were done following AOAC (2000) methods.

Statistical analysis

The statistical approach outlined by Snedecor and Cochran (1994) was followed for analysing the data using one-way ANOVA in SPSS in a completely randomized design. Probability values $P \leq 0.05$ were called as significant and the values of $0.05 > P \leq 0.01$ were called as trend. When the treatment effect was found to be significant, the Duncan's test was used to evaluate the difference between the treatment means.

Results and discussion

Feed consumption of Japanese quails on low-protein diets

The average daily feed intake of Japanese quails was significantly difference (P<0.01) from 4th to 6th week of age (Fig.1). Feed intake was reduced linearly from T-1 to T-7 as CP level was reduced in the ration. Similar findings were also reported by Rajini and Narahari (1998) in growing Japanese quail during 1-6 week of age. Aami *et al.* (2014) also reported higher feed intake in Japanese quails for increasing dietary protein levels. The total feed intake was also significantly (P<0.01) decreased for reduced dietary protein level in the diets (Table 3). Low protein levels in the diet might result reduced feed intake in Japanese quails as it was known that protein level could regulate appetite and satiety signals in the body, and reduced protein level might affect normal hormonal responses adversely leading to decreased food consumption (Yingga *et al*., 2021).

Growth performance of Japanese quails at reduced crude protein levels

The weekly body weight of Japanese quails was significantly (P<0.05) different among the treatments at 3rd week of age (Fig 2). Within groups, no significant difference was found between T-1, T-2, T-3 and T-4. The findings might be the indication that CP level could be reduced to 23.61% (on dry matter basis) in diets of growing Japanese quails (1-3 week) without any significant (P<0.05) effect on growth rate. Similar findings were also reported by Dowarah and Sethi (2014) who opined that CP level could be reduced up to 23% on dry matter basis during 1st to 3rd week without any significant difference (P<0.05) in body weight gain and final body weight of Japanese quails. Santos *et al*. (2016) found that CP level as low as 16% with 0.672% isoleucine could meet the requirement of Japanese quails for satisfactory performance.

The body weight, recorded at the end of 4th, 5th and 6th week, was significantly different (P<0.01) between the treatments (Fig 3). At the end of 4th and 5th week, significantly (P<0.01) declining trend of body weight was recorded as the CP% was reduced in the diet. Similar significantly (P<0.01) decreasing trend was also recorded at the end of 6th week. However, no significant difference was observed between T-1, T-2 and T-3. Thus, it could be opined that CP level could be reduced up to 21.50% (on DM basis) in Japanese quails (4-6 week) without any effect on growth rate. Sinha and Verma (1984) found 24% CP appropriate for Japanese quails during the finisher phase with 2900 Kcal ME/kg in the ration. Tarasewicz *et al.* (2007) observed equalised body weight at the end of first week and significant differences in body weights of male Japanese quails from 28th day onwards when dietary protein level was reduced. Similarly, Kaur and Mandal (2015) also opined that 25.83% CP with 2700 Kcal ME/kg were optimum for Japanese quails during 0-5 weeks of age.

Metabolizability of nutrients in Japanese quails on low-protein diets

The metabolizability of nutrients showed significant differences (P<0.05) in dry matter, crude protein, crude fibre and nitrogen free extract metabolizability (Table 4). Nutrient metabolizability decreased as crude protein level in rations decreased. Ashour et al. (2022) also observed that when CP level increased from 22-26%, there was significant effect on digestion of nutrients. They observed higher digestibility of EE, CF and organic matter for higher dietary protein level in the ration compared to low dietary protein. The reduction of nutrient metabolizability with correspondence decrease of crude protein level in the ration can be due to protein energy imbalance in the ration. Crude protein level might be one of the factors to negatively affect growth by reducing

digestibility of nutrients (Kriseldi *et al*., 2018). As metabolizability of nutrients decreased linearly with the decrease of CP level in the ration, this might contribute to significantly decrease body weight and body weight gain of Japanese quails in the present study.

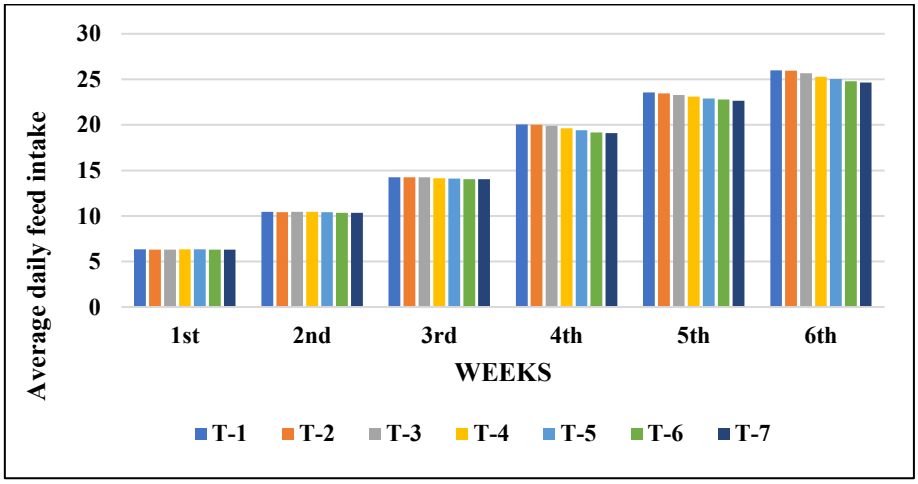

Fig. 1. Average daily feed intake(g) of JQ on different dietary crude protein

Table 3: Growth and production efficiency parameters of Japanese quails under low-protein diets.

Parameter	T-1	T-2	T-3	T-4	T-5	T-6	T-7	SEM/p-value
Day-1 BW (g)	6.41 ±0.021	6.41 ±0.01	6.40 ±0.012	6.39 ±0.021	6.41 ±0.011	6.40 ±0.014	6.41 ±0.01	0.02/0.99
42nd day BW (g)	205.34^{a} ±2.03	205.02^{a} ±1.12	204.95^{a} ±1.22	201.71^{ab} ± 1.60	199.81^{b} ±1.70	197.82^{b} ±1.06	197.55^{b} ±1.51	0.66/0.01**
Total BW gain (g)	198.93^{a} ±1.22	198.61^{b} ±1.19	198.55^{b} ±1.52	195.32^{c} ±1.33	193.4^{d} ±1.62	191.42^{d} ±1.91	191.14^{e} ±1.46	0.66/0.01**
Total feed Intake (g)	704.62^{a} ±0.02	702.93^{b} ±0.01	699.12^{c} ±0.01	692.74^{d} ±0.02	687.56^{e} ±0.01	682.64^{f} ±0.01	679.05^{g} ±0.01	1.78/0.01**
FCR	3.53^{ab} ±0.02	3.54^{abc} ±0.02	3.52^{a} ±0.01	3.54^{abc} ±0.02	3.55^{cd} ±0.01	3.56^{d} ±0.01	3.55^{cd} ±0.01	0.02/0.04*
EPEI	13.82^{a} ±0.02	13.83^{a} ±0.01	13.86^{b} ±0.01	13.58^{c} ±0.02	13.41^{d} ±0.02	13.24^{e} ±0.02	13.27^{e} ±0.01	0.11/<0.01**

BW: Body weight, FCR: Feed Conversion Ratio, EPEI: European Productive and Economic Efficiency Index.

Means bearing different superscripts (a,b,c,d,e) in a row differ significantly (*p≤0.05), (**p≤0.01).

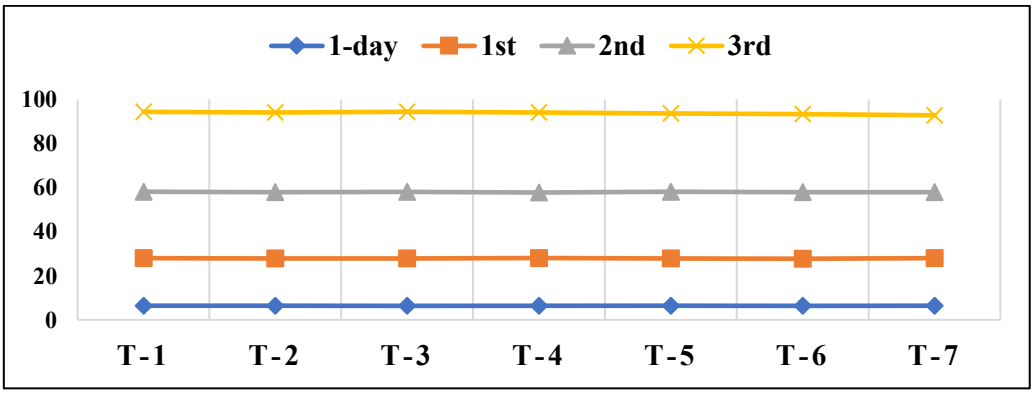

Fig.2. Average weekly body weight (g) of JQ (1-3 week)

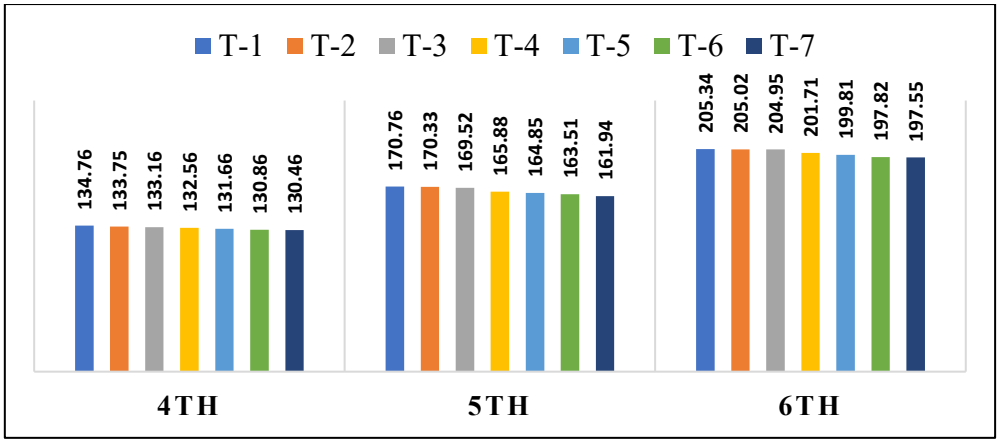

Fig 3. Average weekly body weight (g) of JQ (4-6 week)

Table 4. The Effect of low-protein diet on nutrient metabolizability of experimental Japanese quails

Attributes	T-1	T-2	T-3	T-4	T-5	T-6	T-7	SEM/p-value
DM	79.80^{a} ±0.46	79.63^{a} ±0.98	79.73^{a} ±1.01	78.90^{ab} ±0.17	78.72^{ab} ±0.22	77.56^{b} ±0.08	77.15^{b} ±0.01	0.28/0.03*
CP	78.20^{ab} ±0.05	78.40^{a} ±0.11	78.00^{bc} ±0.17	77.80^{cd} ±0.05	77.50^{de} ±0.17	77.20^{e} ±0.05	76.80^{f} ±0.05	0.12/<0.01**
CF	46.03^{a} ±0.17	46.13^{a} ±0.48	46.80^{b} ±0.08	45.20^{c} ±0.05	45.07^{c} ±0.18	44.37^{d} ±0.09	44.07^{d} ±0.04	0.21/<0.01**
EE	78.80 ±0.23	78.70 ±0.27	78.52 ±0.09	78.29 ±0.02	77.48 ±3.31	77.20 ±3.30	77.12 ± 3.13	0.69/0.99
NFE	78.30^{a} ±0.11	77.90^{b} ±0.05	77.60^{c} ±0.11	77.13^{d} ±0.03	76.80^{e} ±0.05	76.60^{e} ±0.11	76.30^{f} ±0.11	0.15/<0.01**
DM-Dry matter, CP-Crude protein, CF-Crude fibre, EE-Ether extract, NFE-Nitrogen free extract								

Means bearing different superscripts (a,b,c,d,e,f) in a row differ significantly (*p≤0.05), (**p≤0.01).

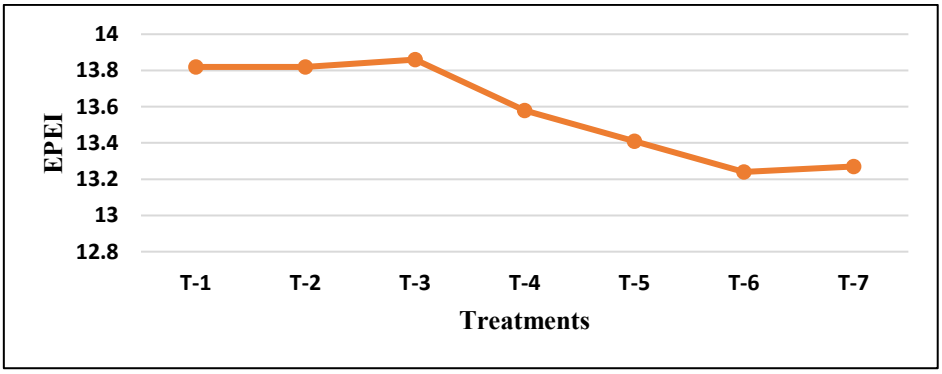

Fig 4. European productive and economic efficiency index

Production efficiency of Japanese quails on low-protein diets

The production efficiency of Japanese quails was evaluated by calculating Feed Conversion Ratio (FCR) and European Productive and Economic Efficiency Index (EPEI) at 42nd day of age. The FCR was significantly (P<0.01) different in the 2nd, 3rd,4th,5th and 6th week among the treatments (Table 4). FCR was observed to be in significantly descending trend when protein level was decreased in the diets. The FCR, calculated at 42nd day of age, was significantly (P<0.05) better in T-3 followed by T-1 and T-2. Negative effect of low-protein diet on feed conversion efficiency was also reported by Siyadati *et al.* (2011) during the starter, finisher and whole rearing periods (P<0.05) in Japanese quails and by Tarasewicz *et al.* (2006) in young male Pharaoh quails when compared effect for protein level at 17%, 19% and 21%, respectively. Attainment of better body weight gain in Japanese

quails for high protein diet compared to low protein diet could lead to better feed efficiency. No significant effect ($P<0.05$) of CP level up to 23% on FCR (0-28 days) of Japanese quail was also observed by Dowarah and Sethi (2014).

The European Productive and Economic Efficiency Index (EPEI) at 6th week of age was significantly ($P<0.01$) variable among treatments (Table 4 and Fig. 4). This might be the indication of significant effect of dietary protein level on production efficiency of Japanese quails. However, highest EPEI was recorded in T-3 followed by T-2 and T-1. The highest EPEI in T-3 might confirmed the possibility of reducing the dietary CP level by 5% to 21.50% during finishing phase without negative effect on productive efficiency of Japanese quails. Similar results were also reported by Cuaresma *et al.* (2021) who observed that as crude protein content in the feed reduced, feed cost can also be reduced and thereby improving the EPEI. Karaalp (2009) also reported that decreased dietary CP level up to 15% of NRC recommendations had no effect in feed intake and bodyweight gain, but feed cost reduced significantly.

Conclusion

It was concluded that dietary CP level of 23.61% during the 1-3 week of age and of 21.50% during the 4-6 week of age could be recommended to Japanese quails with optimum growth performance and production efficiency.

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Conflict of interest

The authors declare no conflict of interest.

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