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Effects of Incorporation of *Moringa Oleifera* Leaf Meal on Production Performance of Rhode Island Red Laying Hens

D. G. Vaghamashi, D. D. Garg, G. P. Sabapara, H. H. Savasani, M. R. Chavda, K. B. Vala, J. A. Chavda, A. A. Mathakiya and B. J. Solanki
College of Veterinary Science and Animal Husbandry, Kamdhenu University, Junagadh, 362001, India
*Correspondence:dgvaghamashi@gmail.com

ABSTRACT

The objective of the study was to evaluate the effect of *Moringa oleifera* leaf meal (MOLM) on production performance of Rhode Island Red (RIR) layers. One hundred and eighty, 24-week-old Rhode Island Red layer birds were randomly allotted to four dietary treatments having replicates with 15 birds in each. The treatments were T1 (Control: Basal diet); T2: 1% MOLM in basal diet; T3: 3% MOLM in basal diet; T4: 5% MOLM in basal diet.The results revealed that average daily feed intake per bird (g/day) was higher ($P<0.05$) for hens in T1 than hens in T2, T3 and T4. Overall mean body weight for hens in T1 was significantly higher than T3 and T4 but not significantly differ with T2 ($P>0.05$). No statistical difference for feed conversion ratio (FCR) was observed between groups or within group. The average monthly HDEP % of experiment was significantly ($P<0.05$) higher in T3 and T4 groups as compared to T1 but at par with T2 group. The average values of monthly HHEP % of experiment was in the order of T4>T3>T2>T1 with significant difference between T1 and T4. In the current study, total feed intake per bird was not differed by MOLM addition, but total feed cost per bird was significantly decreased in MOLM fed groups. Additionally, more number of eggs laid by MOLM fed groups leads to higher receipt from egg sale and net return over feed cost.

KEY WORDS: Egg production, Feed conversion ratio, *Moringa* leaf meal Rhode Island Red

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INTRODUCTION

Poultry is one of the fastest growing segment of agricultural sector in India. As a result, India is the third-largest egg producer with 138.38 billion numbers in the world after China and the USA. Poultry industry is a prime source of best quality animal protein, so poultry production plays a vital role in social and economic securities in both developed and developing countries. According to Adenjimi et al.(2011), the expansion of the chicken sector is significantly dependent on the availability of high-quality feed in quantities sufficient for both producers as well as consumers and at costs they can pay. In developed countries, poultry production industries face the challenge of raising feed costs by 60-70% (Tesfaye et al., 2013). Poultry feed production and availability of raw materials are limited to meet the demand of poultry industry.Addition of antibiotic growth promoters to feed, which increased feed productivity, efficiency and financial gain, has been eliminated from poultry feed (Fallah et al., 2013). Alternative approaches are required to enhance the health and production characteristics of the chicken sector. Tree leaves are good source of vitamins, vital amino acids, proteins and minerals and have a wide range of nutrient composition (Fasuyi, 2006). The greatest alternative protein source in this situation might be *Moringa oleifera* leaves.

Moringa oleifera leaves are so nutrient-dense, supplementing livestock feed with them may be advantageous. Among the other vital elements found in *Moringa oleifera* leaves, protein, vitamin B complexes, vitamin C, beta-carotene, vitamin K and manganese are the most nutrient-dense components (Leone et al., 2015). *Moringa* leaves have high levels of carbohydrates, vitamins, minerals and fatty acids, they can compete with soybeans nutritionally due to their high levels of quality protein. Potentially less expensive sources of protein for chicken feed are *Moringa leaves*. Therefore, the present study was conducted to find out the effects of dietary supplementation of MOLM on the production performance of Rhode Island Red laying hens.

MATERIALS AND METHODS

The experiment was conducted at the Livestock Farm Complex, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Junagadh Gujarat (latitude 21°29' N, longitude 70°26' E and altitude 60 meters above the mean sea level). Laboratory work was carried out in the Department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Junagadh. The climate in Junagadh is tropical and arid.

Experimental details

Rhode Island Red layer birds (n=180) of 24weeks of age were selected at random and divided into four equal groups of 45 birds with three replicates of 15 in each group in a completely randomized design. The birds were raised in cages under uniform management and fed the respective diets from 24th to 40th weeks of age.Research protocol was approved by the animal ethics committee, vide protocol no.: KU-JVC-IAEC-SA-96-2022.

Four experimental diets were prepared with MOLM as T1 (Control: Basal diet); T2: 1% MOLM in basal diet; T3: 3% MOLM in basal diet; T4: 5% MOLM in basal diet (Table 1). Feed was offered ad libitum in weighed quantity twice a day at 9:00 AM and 5:00 PM. Manual turning and mixing of feeds in the feeder were done frequently at least twice daily. Clean, fresh, wholesome drinking water was provided to all experimental birds *ad libitum*. Light bulbs were placed for the lighting system to increase the lighting period to 16 h per day.

Table 1. Ingredient and nutrient composition of the experimental diets

Ingredients (%)	T1	T2	T3	T4
Ingredient composition (% DM basis)				
Maize	53.4	53.4	50.0	45.0
Soyabean DOC	27.7	26.7	24.7	22.7
Deoiled Rice Bran	6.41	6.41	9.81	14.8
Moringa oleifera leaf meal (MOLM)	0	1.0	3.0	5.0
Calcite Powder	3.0	3.0	3.0	3.0
Limestone	6.9	6.9	6.9	6.9
DCP	1.63	1.63	1.63	1.63
Salt	0.3	0.3	0.3	0.3
Premix (Vitamins, Enzymes etc.)	0.66	0.66	0.66	0.66
Total %	100	100	100	100
Calculated nutrient composition				
ME (Kcal/kg)	2613	2616	2622	2629
DM %	89.5	89.3	89.3	89.8
OM %	93.0	93.0	92.9	92.8
CP %	18.0	18.4	18.6	18.3
CF %	8.17	8.01	7.92	7.94
EE %	3.45	3.51	3.67	3.8
NFE %	63.4	63.0	62.6	62.7
Total Ash %	6.92	6.95	7.1	7.2
Silica %	1.11	1.22	1.16	1.19
Calcium %	3.05	3.21	3.28	3.36
Phosphorus %	0.38	0.39	0.39	0.4

Feed intake, body weight, Egg production, egg weight and cost

Feed consumption of each replicate was recorded daily. The amount of feed consumed per bird was determined as the difference between the feed offered and left overto calculate weekly/daily feed intake (g). Body weight (g) of experimental birds were recorded fortnightly and changes in the body weights (g) were calculated. Feed conversion ratio was determined weekly as a unit feed consumed per unit egg weight (Abou-Elezz et al., 2011). Eggs were collected two times a day at 9:00 and 17:00 hours. The sum of the two collections along with the number of birds alive on each day was recorded and summarized at the end of the period. Hen-day egg production (HDEP) and hen housed egg production (HHEP) as percentage were determined by usingthe following formula.

$$\%\text{HDEP} = \frac{\text{Total no. of eggs produced}}{\text{Total no. of hens present on that day}} \text{ X } 100$$

$$\%\text{HHEP} = \frac{\text{Total no. of eggs produced}}{\text{Number of hens originally housed}} \text{ X } 100$$

Eggs were weighed weekly immediately after collection and average egg weight was computed by dividing the total egg weight to the number of eggs.Economics of egg production was calculated based on prevailing market price of feeds, supplements and eggs. To estimate the profitability of feeding MOLM, the return over feed cost was calculated as the difference between the feed costs incurred during the experimental period per bird and sale of eggs. For calculation of economics of feeding in present study, institutional and purchase prices of feed (₹ 33.06, 33.15, 33.06 and 32.58 per kgin the T1, T2, T3 and T4 groups, respectively) and selling price of egg (₹ 6.00/egg) was considered, while for supplements market price of MOLM (₹ 75/kg); was taken into consideration.

The data generated during the experiment were collected and statistically analyzed by Chi-square test for frequency data and analysis of variance (ANOVA) for comparison of mean as per procedures suggested by Snedecor and Cochran (1994). Pair-wise mean differences between groups were compared by Tukey test.

RESULTS AND DISCUSSION

The proximate composition of MOLM usedin this experiment was(% DM basis): moisture of 5.9, crude protein of 31.7, crude fiber 14.8, ether extract 5.72, nitrogen free extract 39.5, ash 8.25, calcium 2.76, phosphorus 0.36.

Effect on feed intake

The effect of feeding MOLM at different levels on feed intake in Rhode Island Red laying hens are presented in Table 2. The overall means of daily feed intake per bird of experimental birds were 116± 0.44, 114± 0.36, 112± 0.55 and 111± 0.85 g/day in T1, T2, T3 and T4 groups, respectively. In the current study, it was found that average daily feed intake per bird (g/day) was higher ($P<0.05$) for hens in T1 than hens in T2, T3 and T4. Hens in T2 had higher ($P<0.05$) average daily feed intake per bird (g) than hens in T4, however, T3 group did not differ significantly ($P>0.05$) with T2 and T4.

The results are supported by Raphael et al. (2015) noted that addition of 5% and 10% MOLM to the laying hen diet reduced feed consumption. Similarly, Abu and Akangbe (2017) reported that adding MOLM in Japanese quail significantly reduced feed intake in birds fed with 1 and 2% MOLM as compared to control group. These authors attributed the significant decline in feed intake with increasing amount of leaf meal due to its high fibre content as well bitter taste.

In contrast, Sharmin et al. (2021) observed that average daily feed consumption of laying hens fed diets containing 1.5% MOL was significantly higher than that of the hens fed diet with 0%, 0.5% and 1% MOL. Whereas, Kakengi et al. (2007) found no significant impact on feed consumption as compared to a control diet on use of MOLM in diet of White leghorn pullets.

Table 2. Average daily feed intake per bird (g) of Rhode Island Red hen in different dietary levels of MOLM

Week	T1	T2	T3	T4	Mean ± SE	SEM	P Value
1	116±0.78	114±0.82^{abc}	114±2.61^{ab}	113±1.88^{abc}	114± 0.79	2.95	0.71
2	115±1.2	114±0.22^{abc}	112±2.76^{abcd}	110±1.62^{abc}	113± 0.94	2.97	0.23
3	117±0.78^{A}	116±0.41^{Aa}	116±0.68^{Aa}	113±0.26^{Bab}	116± 0.48	0.99	0.09
4	115±2.08	111±0.01^{bc}	112±1.99^{abcd}	109±1.49^{abc}	112± 0.92	2.81	0.18
5	117±2.09^{A}	109±0.97^{Bc}	114±0.87^{ABab}	110±0.84^{Babc}	112± 1.06	2.26	0.01
6	117±1.45^{A}	113±1.61^{ABabc}	114±0.29^{Aab}	109±0.76^{Babc}	113± 1.04	2.01	0.005
7	115±0.21^{A}	115±1.02^{Aabc}	114±0.29^{Aab}	110±0.99^{Babc}	113± 0.71	1.27	0.003
8	115±0.47	114±0.84^{abc}	114±0.95^{ab}	105±6.12^{abc}	112± 1.77	5.43	0.18
9	118±2.02	115±0.69^{abc}	115±0.16^{ab}	117±1.97^{a}	116± 0.75	2.52	0.34
10	117±0.91	116±0.62^{a}	116±0.54^{a}	116±2.33^{ab}	116± 0.6	2.29	0.78
11	117±2.79	116±0.86^{ab}	113±0.39^{ab}	116±3.6^{ab}	115± 1.06	4.03	0.74
12	118±2.83	116±0.81^{a}	115±1.03^{a}	118±4.38^{a}	117± 1.21	4.66	0.81
13	117±1.64	115±0.63^{abc}	113±0.83^{abc}	114±2.96^{ab}	115± 0.9	3.06	0.38
14	115±1.34	116±0.87^{ab}	112±1.3^{abcd}	113±3.11^{abc}	114± 0.93	3.23	0.44
15	115±1.76^{A}	114±1.17^{Aabc}	107±1.45^{Bbcd}	109±0.57^{ABabc}	111± 1.08	2.28	0.01
16	113±2.5^{A}	110±1.91^{ABc}	105±2.18^{ABcd}	103±0.97^{Bbc}	108± 1.44	3.42	0.02
17	112±2.82^{A}	110±1.46^{Ac}	105±1.94^{ABd}	100±0.88^{Bc}	106± 1.61	3.32	0.009
Mean ± SE	116± 0.44^{A}	114± 0.36^{B}	112± 0.55^{BC}	111± 0.85^{C}			
SEM	3.15	1.72	2.49	4.41			
P Value	0.49	<0.0001	<0.0001	<0.0001			

Note: Values with different superscripts in a row (A, B, C…) and column (a, b, c…) are significantly different (P<0.01)

Effect on body weight

Change in body weight (kg) of Rhode Island Red hen during experiment were assessed at fortnight intervals and are presented in Table 3. The overall mean body weights during experiment period of Rhode Island Red hens were 1.78±5.05, 1.76±5.14, 1.76±5.41 and 1.75±4.27 g in T1, T2, T3 and T4 groups, respectively. In present study it was found that overall mean body weight for hens in T1 was significantly higher than T3 and T4 but not significantly differ with T2 (P>0.05). The highest overall mean body weight was observed in T1, which could be attributed to the fact that hens in the T1 group had highest feed intake as compared to other three groups.

Abubakar et al. (2021) also observed that addition of MOLM to the laying hen diet reduced body weight. The lower body weight gain in the MOLM supplemented birds compared with the control birds could be attributed to the phytochemicals of the leaf meals, which can modulate fat metabolism in chickens. The present findings are in contrary with the results of Alebachew et al. (2016) who noted that addition of MOLM in diet of dual-purpose Koekoek hens up to 1.5% had increased body weight. However, Gakuya et al. (2014), Biduraet al. (2020) and Sharmin et al. (2021) found that the supplementation of leaf meal had no effect on the body weight gain of layers.

Table 3. Body weight (kg) of Rhode Island Red hen in different dietary levels of MOLM

Fortnight	T1	T2	T3	T4	Mean ± SE	SEM	P Value
0	1.71±25.3^{b}	1.74±26.4^{ab}	1.73±29.0^{ab}	1.71±20.4^{c}	1.72±12.6	171.09	0.80
1	1.76±21.63^{ab}	1.75±25.6^{ab}	1.73±28.6^{ab}	1.72±19.9^{bc}	1.74±12.06	162.39	0.62
2	1.77±20.40^{ab}	1.72±19.9^{b}	1.71±19.8^{b}	1.72±16.0^{bc}	1.73±9.61	128.38	0.21
3	1.77±15.6^{ab}	1.75±15.65^{ab}	1.74±15.82^{ab}	1.73±13.7^{bc}	1.75±7.65	102.24	0.19
4	1.78±13.10^{a}	1.75±13.29^{ab}	1.75±12.66^{ab}	1.74±11.9^{abc}	1.76±6.44	85.59	0.09
5	1.78±11.7^{ab}	1.75±11.64^{ab}	1.75±10.07^{ab}	1.75±9.10^{abc}	1.76±5.39	71.88	0.14
6	1.78±10.53^{ab}	1.76±9.84^{ab}	1.78±8.16^{ab}	1.79±6.17^{a}	1.77±4.46	59.31	0.10
7	1.78±8.32^{ab}	1.79±8.07^{ab}	1.79±7.32^{a}	1.78±6.54^{ab}	1.78±3.80	5.97	0.35
8	1.82±9.55^{Aa}	1.8±7.09^{ABa}	1.8±7.22^{ABa}	1.79±6.10^{Ba}	1.8.11±3.85	51.00	0.05
9	1.82±8.74^{a}	1.8±5.73^{a}	1.8±6.99^{a}	1.79±6.75^{a}	1.8±3.60	47.90	0.07
Mean ± SE	1.78±5.05^{A}	1.76±5.14^{AB}	1.76±5.41^{B}	1.75±4.27^{B}			
SEM	104.5	107.2	112.0	86.2			
P Value	<0.0003	<0.002	<0.0003	<0.0001			

Note: Values with different superscripts in a row (A, B…) and column (a, b, c…) are significantly different (P<0.01)

Effect on egg production

The values of average monthly hen day egg production (HDEP) % of experiment were 69.0±1.88, 73.7±1.50, 75.6±1.71 and 79.1±1.15 in the T1, T2, T3 and T4 groups, respectively, which were significantly (P<0.05) higher in T3 and T4 groups as compared to T1 group and numerically higher than T2 group (Table 4). The average values of monthly HHEP % of experiment were 65.9±2.11, 72.1±1.79, 74.4±1.91 and 78.7±1.28 in the T1, T2, T3 and T4 groups, respectively. It was in the order of T4>T3>T2>T1 with significant difference between T1 and T4 (Table 5).

Table 4. Hen day egg production (HDEP) % of Rhode Island Red hen in different dietary levels of MOLM

Month	T1	T2	T3	T4	Mean ± SE	SEM	P Value
1	61.8±0.28^{Cb}	69.7±0.45^{B}	72.8±0.15^{AB}	77±0.23^{A}	70.3±1.78	2.51	<0.0005
2	66.5±0.62^{ab}	72.3±0.44	74.8±0.74	77.6±0.56	72.8±1.79	5.31	0.14
3	72±0.38^{ab}	77.7±0.88	76.3±1.36	80.5±0.49	76.6±1.98	7.12	0.55
4	75.8±0.54^{a}	75.2±0.40	78.5±0.19	81.4±0.48	77.7±1.18	3.71	0.22
Mean ± SE	69±1.88^{B}	73.7±1.50^{AB}	75.6±1.71^{A}	79.1±1.15^{A}			
SEM	4.06	4.85	6.49	4.10			
P Value	0.01	0.27	0.74	0.50			

Note: Values with different superscripts in a row (A, B, C…) and column (a, b…) are significantly different (P<0.01)

Table 5. Hen house egg production (HHEP) % of Rhode Island Red hen in different dietary levels of MOLM

Month	T1	T2	T3	T4	Mean ± SE	SEM	P Value
1	60.4±0.55^{C}	69.7±2.16^{B}	72.8±0.78^{AB}	77±1.18^{A}	70±1.92	2.29	<0.0001
2	62.0±2.43^{B}	67.3±0.88^{B}	71.3±2.19^{AB}	77.6±2.92^{A}	69.5±1.96	3.88	0.006
3	67.4±5.90	76.2±5.78	74.9±7.72	78.8±3.78	74.3±2.84	10.33	0.59
4	74.0±0.96	75.2±1.99	78.5±0.96	81.4±2.47	77.3±1.14	2.99	0.057
Mean ± SE	65.9±2.11^{C}	72.1±1.79^{BC}	74.4±1.91^{AB}	78.7±1.28^{A}			
SEM	5.61	5.67	7.03	4.77			
P Value	0.06	0.23	0.63	0.68			

Note: Values with different superscripts in a row (A, B, C…) and column (a, b, c…) are significantly different (P<0.05)

An increase in laying percentages with months of age was noted in all dietary treatments. Similar trend was reported by Ebenebe et al. (2013) in response to various levels (0%, 2.5%, 5.0% and 7.5%) of MOLM in diets of laying chickens. Raphael et al. (2015) also noted significant increase in on egg production when fed 5% MOLM as compared to 0 and 10% MOLM in Kabir strain chickens. In addition Alebachew et al. (2016) observed effect of replacing soyabean meal (SBM) with various levels (0%, 5%, 10% and 15%) of MOLM in diets in dual-purpose Koekoek hens. HDEP was higher when SBM was substituted for MOLM at 5% of the hens' diet when compared to other treatments, but there were no statistically significant differences (P>0.05) was observed between the HHEP of the hens in T1, T3 and T4. The improved balanced nutritional supply provided by MOLM in the diet may be the cause of the greater egg production in layers given the diet containing MOLM. Lysine, methionine, and a variety of other amino acids are present in MOLM, which may account for improved egg production.

Effect on feed conversion ratio (FCR)

Data regarding feed conversion ratio were recorded on weekly basis in experimental Rhode Island Red hen and are presented in Table 6. The overall average FCR were 2.94±0.03, 2.86±0.03, 2.93±0.01 and 2.91±0.05 in the T1, T2, T3 and T4 groups, respectively. In the current study, no statistical difference was observed for FCR in between groups or within group. Olugbemi et al. (2010) also noted that addition of 5% and 10% MOLM to the laying hen diet had no effect on feed conversion ratio.

Similarly, Ashour et al. (2020) reported that adding *Moringa oleifera* leaf meal and/or seeds powder to Japanese quails' diet at 0.1%had no effect on feedconversion ratio. Very similar to the present experiment, Abubakar et al. (2021) added 2.5% MOLM with or without *Adansonia digitata* leaf meal to diet of Amok layers and found no effect (P>0.05) on feed conversion ratio in supplemental groups. However, significantly higher (P<0.01) FCR was observed in 7.5% and 10% MOLM supplemented groups in White leghorn hens (Rajesh et al., 2022).

The better FCR in the present study may be attributed to rich content of nutrients in MOLM and antimicrobial properties of *Moringa*. Since egg production was higher and feed intake was lower in a diet containing MOLM; as a result FCR was numerically improved in the current study.

Table 6. FCR of Rhode Island Red hen in different dietary levels of MOLM

Week	T1	T2	T3	T4	Mean ± SE	SEM	P Value
1	3.04±0.13	3.12±0.15	2.92±0.06	3.04±0.10	3.03±0.05	0.20	0.72
2	2.90±0.20	2.83±0.14	2.88±0.11	2.96±0.09	2.89±0.06	0.25	0.93
3	3.03±0.11	2.87±0.08	2.98±0.04	2.95±0.08	2.96±0.04	0.14	0.62
4	2.98±0.23	2.74±0.09	2.83±0.06	2.84±0.14	2.85±0.06	0.25	0.72
5	2.88±0.20	2.67±0.04	2.72±0.12	2.85±0.03	2.78±0.05	0.21	0.58
6	2.73±0.16	2.87±0.08	2.87±0.03	2.91±0.10	2.84±0.05	0.18	0.67
7	2.91±0.22	2.73±0.06	2.94±0.09	3.12±0.29	2.92±0.09	0.33	0.58
8	3.02±0.26	2.87±0.03	2.91±0.00	2.74±0.03	2.88±0.08	0.23	0.57
9	2.96±0.39	2.92±0.02	2.89±0.09	2.85±0.02	2.90±0.07	0.35	0.98
10	2.93±0.25	2.9±0.10	2.95±0.17	2.81±0.09	2.90±0.07	0.29	0.94
11	2.87±0.27	2.85±0.11	2.94±0.02	2.99±0.18	2.91±0.06	0.30	0.93
12	2.87±0.17	3.04±0.09	2.94±0.07	2.72±0.10	2.89±0.06	0.20	0.35
13	2.75±0.09	3.02±0.05	2.9±0.10	3.09±0.14	2.94±0.05	0.18	0.20
14	3.04±0.24	3.13±0.16	2.99±0.12	3.04±0.15	3.05±0.08	0.30	0.95
15	2.96±0.23	2.67±0.03	2.94±0.19	2.95±0.14	2.88±0.08	0.29	0.58
16	3.06±0.33	2.67±0.06	3.16±0.05	2.8±0.11	2.92±0.09	0.31	0.27
17	3.07±0.16	2.65±0.04	3.02±0.10	2.75±0.07	2.87±0.06	0.18	0.06
Mean ± SE	2.94±0.03	2.86±0.03	2.93±0.01	2.91±0.05			
SEM	0.40	0.16	0.17	0.22			
P Value	0.99	0.059	0.67	0.57			

Economic analysis

The expenditure of feeding birds was determined using information on the amount of feed consumed and average price of the ingredients used during the experiment. To calculate the net return over feedcost, the total feed cost was subtracted from the actual income earned from the sale of eggs. Table 7 present detailed information on economics of feeding MOLM to the experimental Rhode Island Red hens during experiment. The results indicated non-significant difference (P>0.05) among all treatments in total feed intake per bird and feed cost per kg. T1 had significantly higher total feed cost per bird than T4. Whereas, T2 and T3 had non-significant difference with T1 and T4 in total feed cost per bird. Higher number of total egg production per bird was recorded in T4 and lowestin T1. Total egg production per bird was linearly increased with level of MOLM (P>0.05). Similarly, receipt obtained from egg sale was higher (P<0.05) for T4 and lowest for T1. There was non-significant difference (P>0.05) between all treatments. Net return over feed cost (29.6±2.56, 47.6±4.46, 83.7±1.22 and 112±7.34 [1]) was calculated for T1, T2, T3 and T4, respectively. There was a non-significant difference (P>0.05) along with all the treatments.

Table 7. Comparative economics of feeding MOLM to Rhode Island Red hens during the experimental period

Particulars		T1	T2	T3	T4	SEM	P value
Total feed intake (kg/bird)		13.8±0.14	13.5±0.07	13.4±0.09	13.2±0.17	0.22	0.0652
Feed cost (₹ /kg)		33.0	33.1	33.0	32.8	-	-
Total feed cost per bird (₹)		457± 4.90^{A}	450± 2.32^{AB}	444± 3.16^{AB}	435± 5.74^{B}	7.36	0.0334
Total egg production (per bird)		81.1±0.96	83.0±1.12	87.9±6.69	91.2±1.50	6.07	0.2358
Receipt from sale of egg (□/bird) (@₹ 6/egg)		486± 5.8	498± 6.74	527± 40.1	547± 9.0	34.46	0.2358
Net return over feed cost per bird (₹)		29.6± 2.56^{C}	47.6± 4.46^{C}	83.7± 1.22^{B}	112± 7.34^{A}	7.90	0.0001
Net return over control	(₹ /bird)		17.9± 2.21^{C}	54.1± 3.63^{B}	82.8± 7.50^{A}	8.62	0.0001
	(%)		60.7	182	279	-	-

Note: Values with different superscripts in a row (A, B, C) are significantly different (P<0.01)

In addition, net return over control was also determined by takingT1 as reference point. Net return over control was higher for T4 and lowest for T3 followed by T2 when compared with T1. At the end, T2, T3 and T4 obtained additional income of 17.9, 54.1 and 82.8[1] per bird, respectively. Thuy and Ha (2022) and Swain et al. (2017) also obtained lowest feed cost for unit egg production and higher egg mass production with *Moringa oleifera* leaves inclusion in the diets. Controversially, Paguia et al. (2014) and Tesfaye et al. (2016) revealed that inclusion of *Moringa oleifera* leaves in the layer ration significantly raised feed cost/kg of generated eggs (P>0.01) without change in return over feed cost.

CONCLUSION

It can be concluded that addition of *Moringa oleifera* leaf meal up to 5 % level in the diet of Rhode Island Red laying hens improved feed conversion ratio, egg production and profitability.

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