Research Article

# Addition of Moringa Leaf Meal in the Diet of Hy-Line Brown Laying Hens: Influence on Productive and Egg Quality Parameters

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**Abstract** | The present research examined the influence of *Moringa oleifera* leaf (MOL) meal on productive parameters and egg quality characteristics of Hy Line Brown laying hens. Laying hens were offered 0%, 2.5% or 4.5% MOL supplemented feeds, using a completely randomized design with three treatments and 12 replications with five hens each. Laying hens were randomly divided into three groups: Control: no addition of *Moringa oleifera* leaves, MOL2.5: diets with 2.5% MOL; and MOL4.5: diets with 4.5% MOL. The results showed a significant effect (P<0.05) on productive parameters like feed intake, live weight and feed conversion ratio at MOL2.5. Egg quality characteristics like whole egg weight and egg albumen weight, were improved (P<0.05) at MOL2.5 and MOL4.5, whereas higher (P<0.01) eggshell weight was observed only at MOL2.5. There was no significant difference (P>0.05) in the average egg weight/week and egg yolk weight. The egg production and laying percentage were also improved at MOL2.5. In conclusion the addition of 2.5% MOL in diets, increased all productive parameters and some egg quality characteristics, in Hy Line Brown laying hens.

**Keywords** | Egg production, *Moringa oleifera*, Laying hens, Growth performance, Egg characteristics

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## INTRODUCTION

Poultry farming in Peru and around the world is a very important productive activity and is the most developed in the livestock sector. The poultry industry has achieved high levels of food production and food security to the growing population. In the year 2021, the national production of chicken eggs was 504,112 thousand tons, with a population of 28,938,922 laying birds, producing a total of 8,406 million eggs (Contreras, 2019). In Puno the chicken population is 371,554 units with a production of 1752 tons of eggs (MIDAGRI, 2022).

The demands for quality and low-cost food products, and since chicken egg producers face increased feed costs, alternative protein and energy resources are sought that improve productivity, and are organic (Aguirre y Pizarro, 2018; Contreras, 2019). There are plant species, native or introduced (i.e., *Moringa oleifera*), that are low-cost food resources and contribute to the productivity and quality of

eggs, a staple food for consumers.

*Moringa oleifera* is a tree species with great forage and economic potential. It adapts to poor soils and has great power to withstand during periods of drought. Nutritionists have incorporated the plant in bird diets (Abbas, 2013) that leads to lower consumption, greater weight gain, excellent feed conversion (Abou-Elezz et al., 2012; Mendiola and Aguirre, 2015), larger eggs with greater shell weight, egg white and a lower proportion of yolk (D'Mello and Acamovic, 1989; Kakengi et al., 2004; Valdivié et al., 2016).

*Moringa oleifera* adapts to desert areas, tolerates water scarcity, and can sustain production of green matter. The nutrient content makes this plant a viable alternative to help boost the production of quality food to meet the needs of our society (El-Hack et al., 2018). So, the hypothesis of this study was that addition of *Moringa oleifera* leaf meal in Hy-Line Brown hens fed diets would increase productive parameters and egg quality characteristics. The aim of this study was to determine the effect of different levels of *Moringa oleifera* leaf meal on productive parameters and egg quality characteristics of Hy Line Brown laying hens in the Andean region of Peru.

## MATERIALS AND METHODS

### Location

This study was carried out at the experimental poultry farm of the Faculty of Veterinary Medicine and Zootechnics of the National University of the Altiplano located in Puno Department, Peru. The poultry farm is located at 3848 meters above sea level, 16°35'36" south latitude, 68°34'02" western length, whose temperatures vary between 8.4 and 15.6 °C, relative humidity between 64 and 77% and rainfall reaching 868.9 mm/year (SENAHMI, 2017).

### Experimental data and feed preparation

A total of 180 (average weight = 1820 ± 120 g, 30-week-old) Hy-Line Brown hens were assigned to three treatment diets including *Moringa oleifera* leaves (MOL) at 0, 2.5, and 4.5%, for nine weeks. *Moringa oleifera* leaves powder were added to a small amount of basal feed and mixed. The mixture was then added to the preset amount of feed for each treatment and mixed thoroughly before being fed to each group. Each treatment had 12 replicates with five hens each.

The moringa plants were collected from the Moquegua region. Leaves were dried in the shade, then ground and incorporated in the poultry feed in two proportions. The poultry house was 16m$^2$ with 2 batteries and 12 battery cages incorporated with a gutter-type feeding and drinking trough.

### Feeding

The ration was formulated through the AEZO- FD II program, the composition of the food was adjusted according to FEDNA (2010) and the adjustment of the nutritional requirements was carried out according to the laying stage. The basal diet (Table 1) was formulated to meet all the nutrient requirements for hens (NRC, 1994).

**Table 1:** Composition and nutrient levels of the basal diet formulated for hens in the laying stage (30-37 weeks).

| Ingredients, % | Treatments | | |
|---|---|---|---|
| | Control[b] | MOL2.5 | MOL4.5 |
| Ingredient (%, as fed basis) | | | |
| MOL[a] | 0 | 2.5 | 4.5 |
| Yellow corn | 35 | 35 | 35 |
| Extruded whole soybeans | 17.95 | 16.83 | 15.97 |
| Rice powder | 29.22 | 27.84 | 26.70 |
| Fish flour | 4 | 4 | 4 |
| "Chako" Clay | 0.5 | 0.5 | 0.5 |
| Common salt | 0.4 | 0.4 | 0.4 |
| Minerals | 1.17 | 1.17 | 1.17 |
| Oil | 2.95 | 2.95 | 2.95 |
| Limestone | 8.71 | 8.71 | 8.71 |
| Vitamin Premix[c] | 0.10 | 0.10 | 0.10 |
| Chemical composition (DM basis) | | | |
| Metabolizable energy (MJ/kg) | 3.17 | 3.17 | 3.17 |
| Crude protein | 16.86 | 16.86 | 16.86 |
| Calcium | 3.39 | 3.40 | 3.40 |
| Available phosphorus | 0.25 | 0.24 | 0.23 |
| ethereal extract | 4.65 | 4.79 | 4.90 |
| Crude fiber | 3.13 | 3.01 | 2.92 |
| Ash | 1.34 | 1.29 | 1.24 |
| Carbohydrate | 5.16 | 4.48 | 4.59 |
| Arginine | 1.34 | 1.30 | 1.26 |
| lysine | 0.68 | 0.65 | 0.62 |
| methionine | 0.31 | 0.30 | 0.29 |
| Cystine | 0.30 | 0.28 | 0.27 |
| Tryptophan | 0.14 | 0.13 | 0.13 |

[a]MOL: *Moringa oleifera* leaf (MOL2.5 and MOL4.5, hens fed the basal diet with 2.5% or 4.5% MOL).
[b]Control group, hens fed a basal diet;
[c]Provided per kg of diet: 94.7% DM, 54,000,000 IU/kg vitamin A, 10,800,000 IU/kg vitamin D, 18,000 IU/kg vitamin E.

### Productive Measurements

Food intake (FI) was evaluated by cages, the weight of the food offered and food not consumed was also recorded.

The live weight (LW) was weighed every week by a digital balance with ± 0.01 g precision. Feed conversion ratio (FCR) was estimated as the ratio of feed consumed (g)/egg weight (g). The average egg weight/week (AEW), egg weight (EW), weight of the offered food and weight of the rejected food were calculated daily. Egg weight and its components such as whole egg weight (WEW), eggshell weight (ESW), egg yolk weight (EYW) and egg albumen weight (EAW) were weighed individually on a digital scale at 20, 40 and 60 days. Eggs were collected daily, and hen-day egg production was calculated.

### Statistical Analysis

Experimental data were analyzed through one-way ANOVA by means a Completely Randomized Design, using the Minitab v.17 statistical software (Minitab Inc., State College, PA). We tested the null hypothesis that the addition of MOL in laying hens' diets does not affect the productive parameters and egg quality characteristics when compared to the control group (no MOL). The Prior to ANOVA analysis, all data were tested for normality using the Shapiro-Wilk test. Data were expressed as mean ± standard error of the mean, and significance was considered at $p < 0.05$. Comparisons between the control and each of the treatments were performed using a Dunnett test at 5%.

## RESULTS

### Productive parameters

The addition of MOL meal showed significant effect on FI, LW and FCR with 2.5% MOL in the diet compared to the untreated group ($P < 0.05$, Table 2). However, there was no significant difference between 4.5% MOL and the untreated group. Moreover, FI and FCR in all dietary treatments slightly increased with age as shown in Figure 1 and 2, respectively. The trend in the initial and middle phase (1 to 5 weeks) is similar for all treatments, but from the 5th to 7th week, FI and FCR in the control group declined compared to the treated group. FI and FCR increased progressively in all treatment groups from the 7th week until the end of experiment. With the exception of the 1st, 2nd and 5th weeks, the hens fed on 2.5% MOL had the highest live weight followed by hens fed 4.5% MOL and the control diet (Figure 3).

### Egg quality characteristics

Dietary treatments showed no significant ($P>0.05$) effect on AEW and EYW. However, WEW and EAW of Hy-Line Brown hens fed diets including MOL were significantly higher compared to the control group (Table 3). WEW, ESW and EAW were significantly ($P<0.05$) decreased with increasing levels of MOL. Hy-Line Brown hens fed MOL at 2.5 and 4.5% produced heavier WEW ($p<0.05$) than those from untreated birds. Hy-Line Brown hens fed MOL at 2.5% produced heavier ESW ($p<0.05$) than control group hens during the 9-wk period. Hy-Line Brown hens offered a diet including MOL had higher ($p<0.05$) EAW than those from the untreated group. However, Hy-Line Brown hens given MOL, produced eggs with similar ($p>0.05$) EYW than those on untreated diets (Table 3).

**Table 2:** Effects of *Moringa oleifera* leaf meal on production parameters (mean ± standard deviation) in Hy-Line Brown hens.

| Productive parameters | Treatments | | |
|---|---|---|---|
| | Control | MOL2.5 | MOL4.5 |
| Feed intake (FI), g/day | 114.91 ± 0.98 | 112.70 ± 2.91* | 113.34 ± 1.06 |
| Live weight of hens (LW), kg | 1.86 ± 0.15 | 1.98 ± 0.10* | 1.97 ± 0.10 |
| Feed conversion ratio (FCR), g feed/g eggs | 1.89 ± 0.12 | 1.82 ± 0.05* | 1.84 ± 0.04 |

Means marked with * were significantly different from the control by Dunnett test ($p<0.05$).

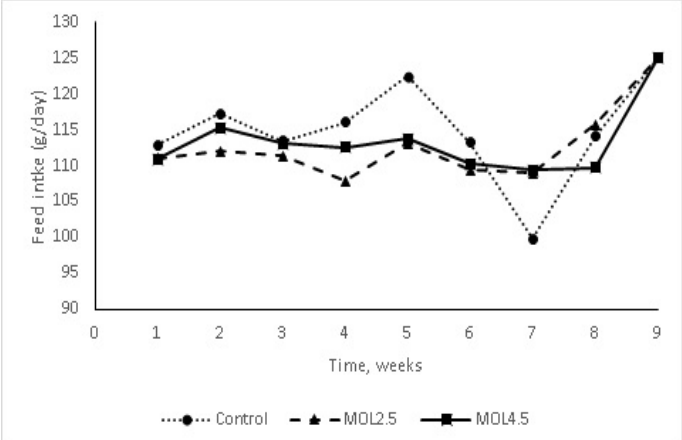


**Figure 1:** The effect of different dietary treatments on weekly feed intake of laying hens over a period of 9 weeks

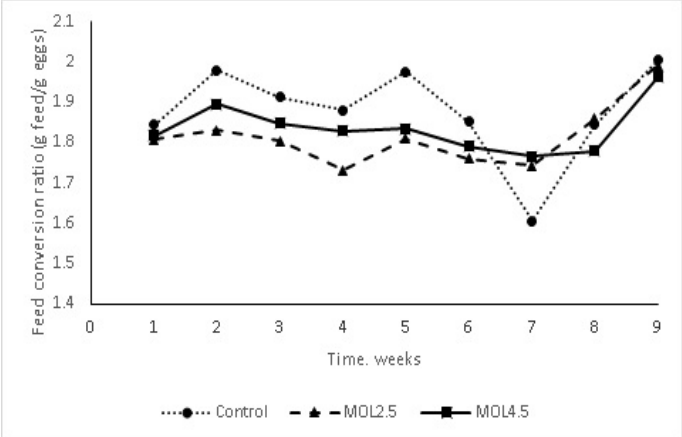


**Figure 2:** The effect of different dietary treatments on weekly feed conversion ratio of laying hens over a period of 9 weeks

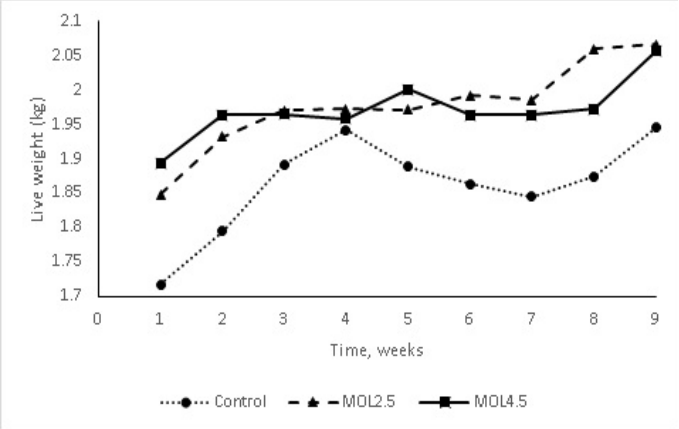


**Figure 3:** The effect of different dietary treatments on weekly live weight of laying hens over a period of 9 weeks

**Table 3:** Effects of *Moringa oleifera* leaf meal on egg characteristics (mean ± standard deviation) in Hy-Line Brown hens.

| Eggs parameters | Treatments | | |
|---|---|---|---|
| | Control | MOL2.5 | MOL4.5 |
| Average egg weight/week (AEW), g | 61.08 ± 2.80 | 62.10 ± 1.08 | 61.78 ± 0.77 |
| Whole egg weight (WEW), g | 61.29 ± 1.88 | 63.81 ± 1.39* | 63.14 ± 2.08* |
| Eggshell weight (ESW), g | 7.71± 0.52 | 8.31± 0.39* | 7.53± 0.39 |
| Egg albumen weight (EAW), g | 37.61± 1.05 | 39.31± 1.71* | 39.17± 1.73* |
| Egg yolk weight (EYW), g | 15.97± 1.05 | 16.19± 0.77 | 16.44± 0.77 |

Means marked with * were significantly different from the control by Dunnett test ($p<0.05$)

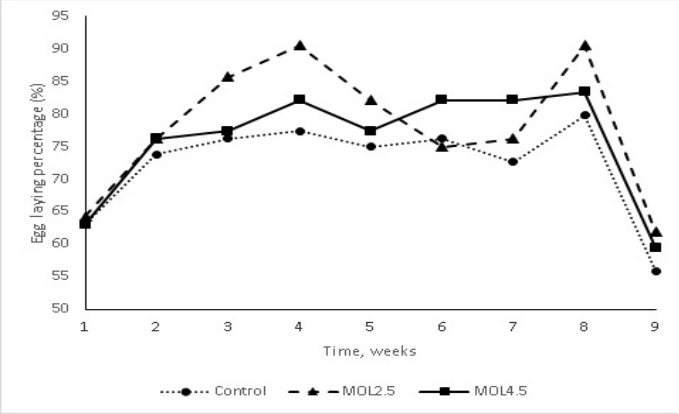


**Figure 4:** Weekly evolution of egg laying percentage (%).

### Egg Laying Percentage

Hens fed MOL at 2.5% showed two production peaks (4th and 8th weeks) and had higher egg laying percentages than hens fed the control diet or MOL at 4.5% (Figure 4). As shown in Figure 5, inclusion of 2.5% MOL induced the highest egg production (81.94%) followed by 4.5% MOL (79.72%) and the control diet (75.83%).

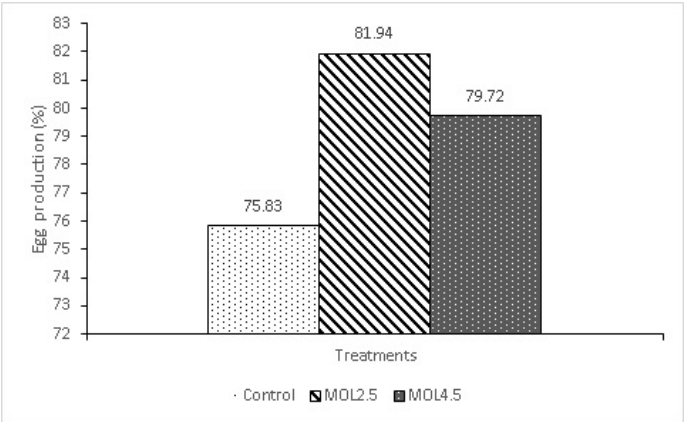


**Figure 5:** Egg production differences between treatments

## DISCUSSION

### Productive parameters

**Feed intake:** The results of this research showed that supplementation with MOL in the diet of Hy-Line Brown laying hens lead to a decrease in Feed intake (FI). These results are in agreement with other studies (Abou-Elezz et al., 2012; Ochi et al., 2015; Swain et al., 2017; Mabusela et al., 2018; Tesfaye et al., 2018; Sharmin et al., 2021; Shen et al., 2021; Umesh et al., 2022). No significant effects about supplemented diet with MOL on FI have been reported (Abou-Elkhair et al., 2020; Ashour et al., 2020; Abdel-Wareth and Lohakare, 2021; Rajesh et al., 2022). The decrease in IF could be attributed to the slight increase of antinutritional factors (e.g.., phytates) in the MOL diets; affecting the absorption and processing of nutrients by the bird, and consequently reducing their palatability and voluntary feed intake (Gadzirayi and Mupangwa, 2014; Tessera, 2016).

**Feed conversion ratio:** On the other hand, the feed conversion ratios (FCR) indicate the quality and utilization of feed given to the hens. A lower FCR indicates a better utilization of the feed by the hens, due to better quality of the ingredients used to formulate the diet, which are more digestible. In this experiment low FCR values of laying hens were achieved with 2.5% MOL, but above this level, these values tended to rise. These values are comparable with those reported in other studies where FCR values increased with increased MOL (Lu et al., 2016; Teteh et al., 2016; Ahmad et al., 2017; Tesfaye et al., 2018; Abou-Elkhair et al., 2020; Shen et al., 2021; Rajesh et al., 2022; Umesh et al., 2022). The low FCR found in this study may be due to higher quality of ingredients; making the feed more digestible and palatable. In addition, it is important to consider future work in the initial, maximum and late stages of growth, because there could be an influence of the inclusion of MOL during the laying time.

### Live weight of hens

In general, the study showed that addition of MOL at 2.5% tends to increase live weight (LW) of Hy-Line Brown laying hens compared to the untreated group (Figure 3, Table 2). This implies that a certain level of MOL in laying hens' diets does not affect palatability. Above this level, FI and LW are negatively affected, possibly due to the anti-nutritional effects present in MOL (Abou-Elezz et al., 2011). This result is in close agreement with other studies (Gadzirayi and Mupangwa, 2014; Alebachew et al., 2016; Mabusela et al., 2018; Tesfaye et al., 2018; Voemesse et al., 2019) that indicated that MOL had a positive influence on growth and egg production in laying hens. However, our result disagrees with other studies (Valdivié et al., 2016; Siti et al., 2019; Bidura et al., 2020; Tutubalang et al., 2022) who reported a non-significant effect on the body weight of laying hens. The difference can be attributed to dietary composition, rearing conditions, environment, genetic variability and different MOL levels.

### Egg quality characteristics

**Egg weight:** In the present study both average egg weight/week (AEW) and whole egg weight (WEW) followed the same trend ($r$ = 0.98) with increasing MOL levels thus, WEW was used to compare egg weight. The WEW was higher in hens fed MOL at 2.5%. These results would indicate that MOL addition at low levels improves egg weights; which is in agreement with other studies (Abou-Elezz et al., 2012; El-Sheikh et al., 2015; Antara et al., 2019; Abou-Elkhair et al., 2020; Abdel-Wareth and Lohakare, 2021; Rajesh et al., 2022; Umesh et al., 2022). N'nanle et al. (2020) who reported positive effect of 1% MOL on egg weight of Sasso breeder hens, suggest that this improvement might be due to the presence of selenium and sulfurous amino acids in moringa leaves. However, in others studies the WEW values were not influenced by the addition of MOL in laying diets (Ebenebe et al., 2013; Gakuya et al., 2014; Ahmad et al., 2017; Mabusela et al., 2018; Ashour et al., 2020; Gayathri et al., 2020; Sharmin et al., 2021; Shen et al., 2021). The difference of our results with the other reports could be associated with factors such as feeding, strain, stage of laying and climate.

**Eggshell weight:** In the present study, the eggshell weight (ESW) improved significantly with the addition of MOL2.5 compared to control group. These findings agree with those reported in other studies (El-Sheikh et al., 2015; Valdivié et al., 2016; Tesfaye et al., 2018; Sharmin et al., 2021; Rajesh et al., 2022), that show the same trend of improvement with relatively low levels of MOL in the diet. The reason may be that only low MOL levels are tolerated by the hens due to the anti-nutritional factors as mentioned in other studies (Abou-Elezz et al., 2011; Gadzirayi and Mupangwa, 2014; Tessera, (2016). However, ESW values in this report contradict the studies of Raphaël et al. (2015) and Shen et al. (2021) who reported that shell weight was not influenced by MOL addition in the laying hen's diet. Mabusela et al. (2018) who tested three levels of moringa supplementation (1, 3 and 5%) in Hy-Line laying hens, reported that ESW was not affected and concluded that, although Moringa inclusion improved some egg quality traits, the deleterious effect that it had on layer performance indicated that maybe is should not be fed to early-lay hens at these levels.

**Egg albumen weight:** The addition of MOL significantly increased egg albumen weight (EAW) compared to the control group. A similar trend was reported by Ebenebe et al. (2013) who reported that the albumen weight of Isa Brown laying hens was significantly affected by the incorporation of MOL in the diet, with a maximum increase at 2.5% MOL and then decreasing at higher levels of MOL. The present result is in close agreement with the finding of Valdivié et al. (2016) and Tesfaye et al. (2018) who found the same trend in their study with L-33 laying hens with higher percentages of MOL (0 to 20%) in the diet. El-Sheikh et al. (2015) reported an increase albumin weight at a dose of 1.5 and 2mg/kg of moringa. The present study is in disagreement with those reported in other studies (Mabusela et al., 2018; Siti et al., 2019; Garcia et al., 2021) who found no differences in EAW with the inclusion of moringa at different doses ranging from 0 to 6%. The differences might be due to factors such as breed, feeding dose, environment, etc.

**Egg yolk weight:** Egg yolk weight (EYW) was similar in all groups. This finding is similar to other studies (Tesfaye et al., 2018; Swain et al., 2017; Ahmad et al., 2017) who also reported no significant differences in EYW with the inclusion of MOL in the diet of laying hens. Similarly, Abou-Elezz et al. (2011), Mabusela et al. (2018), Gayathri et al. (2020) and Abdel-Wareth et al. (2021) found that MOL supplementation at different levels (ranging 0 to 5%) had no adverse effect on EYW. However, our results differ from others (Ebenebe et al., 2013; El-Sheikh et al., 2015; Raphaël et al., 2015; Valdivié et al., 2016; Tesfaye et al., 2018; Abou-Elkhair et al., 2020; Shen et al., 2021) who concluded that MOL inclusion at 0-20% in laying hens' diets improves egg quality characteristics.

**Egg Laying Percentage:** Figure 4 shows that laying hens fed MOL2.5 presented higher laying percentages (90.5%) than the untreated group, indicating that inclusion of MOL has a positive effect on egg production (Figure 5). Similar trends were reported by Bidura et al. (2020) and Abdel-Wareth and Lohakare (2021), who reported that hens supplemented with MOL achieved higher egg production compared to the control group. Likewise, Valdivié

et al. (2016) reported high values of laying percentage in L-33 hens fed with 10% MOL compared to the control group. These results could be due to several factors such as how birds were able to meet their needs for crude protein, metabolizable energy (ME) and other nutrients. However, increasing the MOL to 20%, causes the laying percentage to decrease due to the lower consumption of ME. Kakengi et al. (2007) and Abou-Elezz et al. (2011), reports a reduction in egg production when feeding 15 or 20% MOL in the diet. Our results are different from those observed by Sharmin et al. (2021) and Shen et al. (2021) who do not report significant effects on the rate of laying and egg production in hens supplemented with MOL. The differences are due to a series of factors such as the bird line used, the age of the hen, the uniformity of body weight, the altitude of the environment, and others, as mentioned by North and Bell, (1993).

## CONCLUSIONS

The results of the present study suggest that addition of MOL at 2.5% might be used successfully as a sustainable and cheap feed resource for Hy-Line Brown hens, without affecting production performance and egg quality.

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## CONFLICT OF INTEREST

The authors declare that there is no any conflict of interest for this publication.

## NOVELTY STATEMENT

The research The study of Addition of Moringa leaf meal in the diet of Hy-Line Brown laying hens: influence on productive and egg quality parameters is novel conducted under altiplano conditions is novel.

## AUTHORS CONTRIBUTIONS

Ali William Canaza-Cayo; Investigation, Writing, Data analysis, Formal analysis. Ali William Canaza-Cayo, Tales Jesus Fernandes, Francisco Halley Rodriguez Huanca, Uri Harold Perez Guerra; Statistical analysis, Methodology, Writing of Original draft. Eliseo Pelagio Fernandez Ruelas, Roxana Churata-Huacani, Ysabel Mendoza Aguilar; Editing, Review.

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