RESEARCH ARTICLE

# Influence of Feeding Different Maize Varieties on Production Performance and Egg Quality of White Leghorn Birds in India

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## Abstract

The study was carried out on 100 White Leghorn layer birds randomly divided into four treatments at the age of 20$^{th}$ week with 5 replicates in each (5 layers per replicate) and were fed treatment ration from 24$^{th}$ to 40$^{th}$ week of age. Four different layer rations ($T_1$ to $T_4$) were prepared by incorporating four different varieties of maize, *viz.,* White maize-Gujarat Maize-3 (GM-3, $T_1$), Gujarat Anand Yellow Maize Hybrid-1 (GAYMH-1, $T_2$), High-Quality Protein Maize-1 (HQPM-1, $T_3$) and Purple Maize ($T_4$), respectively. The levels of lysine, tryptophan, carotenoid, total antioxidant activity (TAA), anthocyanin and protein were estimated in each maize variety and in treatment ration once as well as in eggs before and at different stages of the experiment (*i.e.,* at 24$^{th,}$ 28$^{th}$, 34$^{th}$ and 40$^{th}$ week of age). Egg production, egg weight, body weight, and feed consumption traits were recorded. Beta carotene, protein content and deep yellow color of egg yolk were significantly ($p < 0.05$) higher in the eggs of White Leghorn layer birds which were fed layer ration prepared by using GAYMH-1 yellow maize variety ($T_2$). However, oil content was significantly ($p < 0.05$) higher in the eggs of birds fed layer ration prepared by using white maize (Gujarat maize-3) as compared to other varieties of maize. Significantly ($p < 0.05$), higher contents of lysine, tryptophan, anthocyanin, and total antioxidant activity were observed in eggs of White Leghorn layer birds fed layer mash containing purple color maize compared to other varieties of maize.

**Keywords:** Anthocyanin, Carotenoid, Egg quality, Lysine, Maize varieties, Protein, Total antioxidant activity, White Leghorn.

*Ind J Vet Sci and Biotech* (2022): 10.21887/ijvsbt.18.1.10

## Introduction

India's poultry sector contributes Rs. 350 (US$ 6.3) billion annually to the country's gross national product and has grown at a compound growth rate of 15% per annum over the past two decades (PDP, 2011). Chicken eggs have been considered a wholesome and complete food because of their balanced nutrient profile suitable for human beings. Interest in modifying the nutrient composition of egg has also been extended beyond production to design a high-quality food for the consumption of health-conscious human beings. Demand for poultry products is often cross-correlated with demand for maize, an important feed crop (Marsh, 2007). Hence, alongside the expansion of the poultry industry, the cultivation of maize has also spread at a rapid pace in India (Sethi *et al.,* 2009; Singh, 2001). About 7 million tons of maize is produced annually to feed poultry, supporting 20 million maize farmers (Saxena, 2009).

The industry's substantial growth has largely been driven by the demand from the rapidly expanding population of middle-income households and their changing consumption preferences (Gulati *et al.,* 2007). This, in turn, has spurred the domestic production of poultry feed crops, *viz.,* maize and soybean. Maize is the main source of energy in the rations of both broilers and layers, while soybean meal provides the required protein (Hellin and Erenstein, 2009). Maize grain is a poor source of essential amino acids for poultry (Atlin *et al.,* 2011). Therefore, to meet the requirement of these amino acids, farmers and feed producers usually supplement poultry ration with synthetic amino acids. Quality maize has a higher level of lysine and tryptophan and/or carotenoid pigment than normal maize. More than 50% of the maize produced in India is currently used by the poultry feed sector (Sethi *et al.*, 2009). Hence, the development and distribution of Quality Protein Maize (QPM) containing enhanced limiting amino acid levels might hold significant economic potential in India. So, the present study was planned to find out the effect of inclusion of quality maize *vis-a-vis* other varieties of maize on egg quality and production performance of layers.

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**How to cite this article:** Mishra, R., Patel, A.B., Bhagora, N.J., Dhruv, J.J., Savaliya, F.P. (2022). Influence of Feeding Different Maize Varieties on Production Performance and Egg Quality of White Leghorn Birds in India. Ind J Vet Sci and Biotech. 18(1), 49-53.

**Source of support:** Nil

**Conflict of interest:** None.

**Submitted:** 25/09/2021 **Accepted:** 20/11/2021 **Published:** 10/01/2022

## Materials and Methods

The experiment was conducted at Poultry Research Station, College of Veterinary Science and Animal Husbandry, Anand. At the age of 15th week, birds were housed individually in layer cages. Bodyweight of birds (n = 100) was taken at 20th week of age, and birds were distributed randomly and equally into four treatment groups and arranged replicate wise (five replicates per treatment, each of 5 birds; 25 birds/treatment). They were fed a normal layer diet up to the 23rd week of age. Four different layer rations ($T_1$ to $T_4$) were prepared by incorporating four different varieties of maize, *viz.*, $T_1$ ration/feed was prepared using White maize-Gujarat maize (GM-3), $T_2$ using Normal Yellow maize (GAYMH-1), $T_3$ using High quality protein maize (HQPM-1), and $T_4$ using Purple maize (Figure 1). These treatment rations were fed treatment-wise to the birds of group $T_1$ to $T_4$ from 24th to 40th weeks of age.

Before preparing various treatment rations, different biochemical constituents, *i.e.*, lysine, tryptophan, beta-carotene, protein, total antioxidant activity (TAA), and anthocyanin present in different maize varieties, were estimated (Table 1).

The biochemical constituents of different treatment rations for lysine, tryptophan, beta-carotene, protein, and oil were also estimated (Table 2).

Various production performance parameters such as body weight, egg production, egg weight and feed consumption were recorded. Body weight and egg weight were recorded at 40 weeks of age. Egg production and four weekly feed consumption were recorded up to 40 weeks of age. Three eggs per replicate were taken for estimation of lysine, tryptophan, beta-carotene, protein, anthocyanin, TAA, and oil before 24th week of age (before treatment), and at 28th, 34th, and 40th week of age. Egg quality parameters, *i.e.*, Haugh unit and yolk colour were also estimated simultaneously using egg quality equipments. Data were analyzed using a completely randomized design and critical difference test (Snedecor and Cochran, 1994).

## Results and Discussion

### Constituents of Different Varieties of Maize

Among different varieties of maize, the highest lysine percentage was observed in HQPM-1 variety (0.51%) and


**Fig.1:** Four different maize varieties used in layer ration

**Table 1:** Biochemical constituents in different maize varieties

| *Constituents* | *GM-3* | *GAYMH-1* | *HQPM-1* | *Purple Maize* |
|---|---|---|---|---|
| Lysine (%) | 0.32 $^{c}$ | 0.38 $^{b}$ | 0.51 $^{a}$ | 0.32 $^{c}$ |
| Tryptophan (%) | 0.064 $^{d}$ | 0.078 $^{c}$ | 0.085 $^{b}$ | 0.147 $^{a}$ |
| Beta carotene (ppm) | 0.89 $^{d}$ | 16.90 $^{a}$ | 10.69 $^{b}$ | 7.65 $^{c}$ |
| Protein (%) | 13.13 $^{a}$ | 12.47 $^{b}$ | 12.69 $^{ab}$ | 12.77 $^{ab}$ |
| TAA (mg/100g) | 0.172 $^{c}$ | 0.211 $^{a}$ | 0.187 $^{b}$ | 0.212 $^{a}$ |
| Anthocyanin (mcg%) | 5.09 $^{c}$ | 15.27 $^{b}$ | 17.82 $^{b}$ | 63.65 $^{a}$ |

Means with different superscripts within the row differ significantly ($p < 0.05$).

**Table 2:** Biochemical constituents in different ration/feed material fed to layer birds

| *Constituents* | *GM-3* | *GAYMH-1* | *HQPM-1* | *Purple Maize* |
|---|---|---|---|---|
| Lysine (%) | 0.31 $^{d}$ | 0.44 $^{a}$ | 0.38 $^{c}$ | 0.39 $^{b}$ |
| Tryptophan (%) | 0.40 $^{bc}$ | 0.38 $^{c}$ | 0.67 $^{a}$ | 0.55 $^{ab}$ |
| Beta carotene (ppm) | 3.30 $^{d}$ | 5.75 $^{a}$ | 4.93 $^{b}$ | 4.51 $^{c}$ |
| Protein (%) | 25.39 $^{a}$ | 21.23 $^{c}$ | 22.54 $^{b}$ | 18.60 $^{d}$ |
| Oil (%) | 6.52 $^{a}$ | 4.66 $^{b}$ | 3.82 $^{c}$ | 3.28 $^{d}$ |

Means with different superscripts within the row differ significantly ($p < 0.05$).

the highest tryptophan in purple maize (0.147%), which was significantly ($p < 0.05$) superior to the rest of the varieties. Panda *et al.* (2012) and Krishna *et al.* (2014) also reported more lysine (0.40 and 0.42%) and tryptophan (0.09% each) in quality protein maize as compared to normal maize (0.26%) and (0.04%). While Osei *et al.* (1999) reported a high level of lysine (8.4%) and tryptophan (1.6%) in birds fed with 16% crude protein of quality protein maize as compared to normal maize diet.

Beta-carotene was highest ($p < 0.05$) in GAYMH-1 (16.90 ppm) over the rest of the varieties. Protein content was observed significantly ($p < 0.05$) higher in GM-3 (13.13%) as compared to GAYMH-I, and it was statistically at par with HQPM-1 and purple maize. Krishna *et al.* (2014) reviewed no change in the protein content of normal maize and quality protein maize, while Hatungimana *et al.* (2015) found crude protein content of 7.48 and 9.18% in white maize and yellow maize, with corresponding CP % of 7.5 and 9.18 in ration with white maize and yellow maize material, respectively. Total antioxidant activities were significantly ($p < 0.05$) highest in purple maize and GAYMH-1 as compared to GM-3 and HQPM-1. Anthocyanin was significantly ($p < 0.05$) highest in purple maize as compared to rest of the varieties. Osei *et al.* (1999) reported QPM had higher levels of arginine (+25%), cystine (+35%), tryptophan (+33%), and lysine (+33%) than normal maize.

## Constituents of Different Ration/Feed Material

Significantly ($p < 0.05$) higher lysine percentage was observed in layer ration prepared-using GAYMH-1 (0.44%), while tryptophan was significantly ($p < 0.05$) higher in layer ration prepared-using HQPM-1 (0.67%) and purple maize (0.55%) as compared to GAYMH-1 (0.38%), but GM-3 (0.43%) and GAYMH-1 (0.44%), as well as GM-3 (0.43%) and purple maize, were at par with each other. Significantly ($p < 0.05$) highest beta-carotene was observed in layer ration prepared by using GAYMH-1 (5.75 ppm) than all other treatment rations. Significantly ($p < 0.05$) most elevated protein (25.39%) and oil (6.52%) contents were observed in layer ration prepared by using GM-3 maize variety as compared to all other varieties.

**Table 3:** Effects of feeding different varieties of maize on egg constituents of White Leghorn birds

| *Constituents* | *Treatments/ Stages* | *GM-3* | *GAYMH-1* | *HQPM-1* | *Purple Maize* |
|---|---|---|---|---|---|
| Lysine (%) | 24 Wk | 0.293 | | | |
| | Pooled (28 to 40 Wk) | 0.365 $^{d}$ | 0.395 $^{c}$ | 0.415 $^{b}$ | 0.427 $^{a}$ |
| Tryptophan (%) | 24 Wk | 0.232 | | | |
| | Pooled (28 to 40 Wk) | 0.197 $^{c}$ | 0.212 $^{a}$ | 0.203 $^{b}$ | 0.216 $^{a}$ |
| Beta Carotene (ppm) | 24 Wk | 9.218 | | | |
| | Pooled (28 to 40 Wk) | 1.931 $^{d}$ | 8.559 $^{a}$ | 6.402 $^{c}$ | 7.852 $^{b}$ |
| Protein (%) | 24 Wk | 13.00 | | | |
| | Pooled (28 to 40 Wk) | 12.081 $^{b}$ | 13.223 $^{a}$ | 13.067 $^{a}$ | 13.193 $^{a}$ |
| Anthocyanin (mcg%) | 24 Wk | 0.427 | | | |
| | Pooled (28 to 40 Wk) | 0.457 $^{d}$ | 0.757 $^{b}$ | 0.686 $^{c}$ | 0.874 $^{a}$ |
| TAA (mg/100g) | 24 Wk | 9.322 | | | |
| | Pooled (28 to 40 Wk) | 9.773 $^{c}$ | 12.791 $^{b}$ | 12.768 $^{b}$ | 13.876 $^{a}$ |
| Oil (%) | 24 Wk | 7.49 | | | |
| | Pooled (28 to 40 Wk) | 9.149 $^{a}$ | 8.842 $^{b}$ | 8.595 $^{c}$ | 8.446 $^{c}$ |
| HU | 24 Wk | 85.10 | 89.65 | 92.59 | 96.01 |
| | Pooled (28 to 40 Wk) | 86.22 | 87.23 | 85.58 | 87.88 |
| Yolk colour | 24 Wk | 7.13 | 6.57 | 6.40 | 5.45 |
| | Pooled (28 to 40 Wk) | 2.68 $^{b}$ | 7.48 $^{a}$ | 4.94 $^{ab}$ | 6.59 $^{a}$ |

Means with different superscripts within the row differ significantly ($p < 0.05$).

**Table 4:** Performance of White Leghorn birds fed layer ration containing different variety of maize (Mean ± SE)

| *Traits recorded* | *GM-3* | *GAYMH-1* | *HQPM-1* | *Purple Maize* |
|---|---|---|---|---|
| Body weight (g) at 40 wks | 1610.200 ± 21.625 | 1544.000 ± 26.520 | 1679.167 ± 15.237 | 1492.600 ± 20.321 |
| Av. egg number produced upto 40 wks | 97.72 ± 3.00 | 96.24 ± 2.70 | 98.20 ± 3.82 | 96.88 ± 2.65 |
| Av. egg weight (g) at 40 wks | 55.52 ± 0.92 | 54.23 ± 0.67 | 55.80 ± 0.74 | 55.84 ± 0.62 |
| Total feed consumption (kg) 21-40 wks | $13.595^{b}$ ± 0.041 | $13.731^{a}$ ± 0.014 | $13.601^{b}$ ± 0.028 | $13.697^{a}$ ± 0.10 |

Means with different superscripts within the row differ significantly ($p < 0.05$).

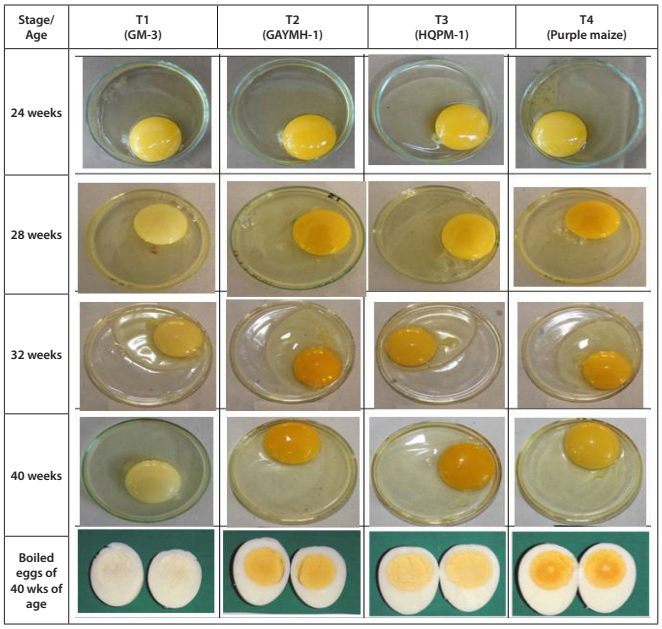


**Fig. 2:** Effects of feeding different varieties of maize on egg yolk color

## Effect of Feeding Different Varieties of Maize on Egg Constituents

Significantly ($p < 0.05$) higher content of protein (13.223%) was found in the eggs of White Leghorn birds fed with layer ration prepared by using GAYMH-1, ($T_2$) maize than GM-3 maize, and it was at par with HQPM-1 and purple maize. Significantly ($p < 0.05$) higher content of beta-carotene (8.559 ppm) was found in the eggs of birds fed with layer ration prepared by using GAYMH-1 maize than all other varieties (Table 3). Further, lysine (0.427 %), anthocyanin (0.874 mcg %), and total antioxidant activity (13.876 mg/100 g) were observed to be significantly ($p < 0.05$) higher in eggs of birds fed layer mash containing purple color maize in comparison with other maize varieties. A significantly ($p < 0.05$) higher level of tryptophan (0.216 %) was found in the birds fed with GAYMH-1 and purple maize as compared to GM-3 and HQPM-1.

These constituents can play an important role in the value addition of eggs, increases the keeping quality of eggs, and prevent malnutrition among consumers. The HU of eggs of four treatment groups, of course, did not vary significantly. The deep yellow color of the yolk was observed significantly ($p < 0.05$) higher in the birds fed with GAYMH-1 maize and was at par in the birds fed with purple maize (Table 3, Figure 2). However, no literature could be searched to debate on the present findings on egg quality.

## Effect of Different Varieties of Maize on Production Performance

Feeding of different varieties of maize in layer ration did not show any significant effects on production traits. No significant differences were found between the treatments for a body weight of birds fed with normal maize and other varieties of maize at any of the stages/monthly periods. Similarly, Subsucan *et al.* (1990), Liu *et al.* (1993) and Osei *et al.* (1999) found no significant differences in body weights or growth rates of birds fed normal maize and quality protein maize. There was a non-significant difference between the treatments for egg number and egg weight up to 40 weeks in our study (Table 4). However, Osei *et al.* (1999) reported significant differences for age at 50 % production and hen housed production. The feed consumption was significantly ($p < 0.05$) higher in the birds fed with GAYMH-1 and purple maize as compared to GM-3 and HQPM-1 maize. Likewise, Panda *et al.* (2012) reported a significant difference in FCR between birds fed with quality protein maize and normal maize.

## Conclusions

The significantly highest content of beta-carotene, protein, and deep yellow color of egg yolk were observed in the eggs of White Leghorn birds fed layer ration prepared using yellow maize (Gujarat Anand Yellow Maize Hybrid-1). Significantly higher content of lysine, tryptophan, anthocyanin and total antioxidant activity were observed in eggs of birds fed layer mash containing purple colour maize in comparison with other maize varieties, which plays an important role in value addition of eggs, increases keeping quality of eggs and helps to prevent mal nutrition. The non-significant effect was found on body weight, egg weight and total egg number at 40 weeks of bird fed different maize verities. So, it can be recommended to use purple maize to obtain higher content of lysine, tryptophan, anthocyanin and total antioxidant activity, which plays an important role in the value addition of eggs, increases keeping quality of eggs and helps to prevent malnutrition.

## Acknowledgement

Authors are thankful to the Director of Research, Anand Agricultural University Anand, Gujarat; and Principal & Dean, College of Veterinary Science and Animal Husbandry, AAU, Anand, for providing funds and facility for conduct of research work.

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