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Research Article
Marigold Flower Extract as a Feed Additive in the Poultry Diet: Effects on Laying Quail Performance and Egg Quality

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Abstract

Background: Marigold (*Tagetes erecta*) Flower Extract (MFE) is a natural source of carotenoid as a feed additive in the poultry diet. **Objective:** This study was conducted to determine the effect of MFE as feed additive on production performances and egg quality of quail. **Materials and Methods:** Two hundred and seven weeks old *Coturnix coturnix japonica* laying quail were used in a Completely Randomized Design (CRD) with four dietary treatments: 0, 5, 10 and 15 ppm MFE in the diets with five replicates each. Variable measured were feed intake, hen-day egg production, egg weight, egg mass production, feed conversion, egg cholesterol, egg fat and yolk color. **Results:** It was observed that feed intake, egg production, feed conversion, egg cholesterol and yolk color were significantly affected ($p<0.05$) by increasing MFE content in the diet. Feed intake, hen-day egg production and yolk color achieved the best results when 15 ppm MFE was included in the diet and resulted in the lowest levels of egg cholesterol and feed conversion. **Conclusion:** This study shows that 15 ppm MFE in the poultry diet improved production performance and increased egg quality (reduced egg cholesterol and increased egg yolk color) of *Coturnix coturnix japonica* laying quail.

Key words: Marigold flower extract, quail, production performance, egg quality

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Marigold (*Tagetes erecta* L.) is a rich source of a carotenoid pigments, beneficial to eye health and exhibits antioxidant and anti-cancer effects[1]. Carotenoids, which are considered to be chemopreventive agents due to antioxidant activity have been shown to decrease egg cholesterol and increased egg yolk color[2,3]. The cholesterol content of eggs is often viewed unfavorably especially for patients with hypercholesterolemia, even though an egg provides a complete source of animal protein nutrition at an economical price. The cholesterol content of quail egg has been shown to be 880 mg/100 g higher than eggs from chickens and ducks (350 and 805 mg/100 g, respectively)[2]. Therefore; efforts to decrease egg cholesterol have been made by providing diets high in carotenoids particularly β-carotene[2].

Beta-carotene can be produced through fermentation with *Neurospora crasa*[2,4,5,6] or extracted from yellow orange flower or tubers[3]. It previously found that mixture of 60% tapioca by product and 40% tofu waste fermented with a 9% inoculum of *Neurospora crassa* for 7 days fermentation increased the crude protein content from 3.93-20.44% and β-carotene levels[5] from 20.22-295.16 μg g^{-1}. In addition, providing a fermented 30% mixture of cassava and tofu in the diet of laying hens together with β-carotene decreased egg cholesterol by 43.15% and increased egg yolk color by 20.50%. It also found that durian fruit (50% peel : 50% seed) waste fermented with *Phanerochaete chrysosporium* and *Neurospora crassa* (1:1) for 9 days increased β-carotene levels from 2.09-119.07 μg g^{-1} and increased crude protein content from 10.06-19.37%. However utilization of agro-industrial wastes (sago waste, cassava waste, palm kernel cake, etc.) fermented with *Neurospora crassa* in the poultry diet is currently limited due to resulting high crude fiber content. *Neurospora crassa* is not cellulolytic fungus and therefore, it does not produce high levels of cellulose enzymes. Moreover, the chitin from the mycelium of *Neurospora crassa* also contributes to the high crude fiber levels.

Another approach for increasing the carotenoid levels in feed is through the extraction from yellow-orange flowers and tubers. Marigold (*Tagetes erecta*) is an ornamental plant with yellow and orange flowers that contains 1079.50 μg g^{-1} carotenoids, 232.34 μg g^{-1} β-carotene and 652.34 μg g^{-1} xanthophyll[3]. Karadas *et al.*[7] investigated the effects of lucerne concentrate, tomato powder and marigold extract as feed additives for quails and found that the mixture increased yolk pigmentation and carotenoid levels in eggs.

In this study, carotenoids were extracted from marigold flower to generate Marigold Flower Extract (MFE). The aim of this study was to assess the effect of MFE as a feed additive on quail production performance and egg quality.

MATERIALS AND METHODS

Poultry: This study used 207 week old *Coturnix coturnix japonica* quail.

Marigold flower extract preparation: Marigold Flower Extract (MFE) was prepared by drying and grinding marigold flower until it became a powder. The MFE was extracted using 90% ethanol and then dried and milled.

Experimental design: The experiment was performed in a completely randomized design using increasing concentrations of MFE (0, 5, 10 and 15 ppm) as a feed additive. Each treatment was repeated five times.

Feed formulation: The poultry feed was formulated with 20% CP to provide 2800 kcal kg^{-1} Metabolic Energy (ME). The nutrients and ME of the formulated feed are shown in Table 1.

Variables: The measured variables were feed consumption (g $head^{-1}$ day^{-1}), quail-day production (%), egg weight (g $bird^{-1}$), egg mass production (g $head^{-1}$ day^{-1}) and feed conversion.

Data analysis: The data were statistically analyzed using the analysis of variance of a Completely Randomized Design (CRD). The differences among treatments were determined using Least Significant Difference (LSD) testing.

Table 1: Nutrient and metabolic energy from the diet formulation

Ingredients	Formulation (%)
Yellow corn	50.00
Rice bran	8.00
Soybean meal	14.50
Bone meal	4.00
Concentrated 126	20.00
$CaCO_3$	3.00
Topmix	0.50
Total	100.00
Nutrient and energy contents	
Crude protein (%)	20.23
Ether extract (%)	3.63
Crude fiber (%)	3.84
Ca (%)	3.73
P (%)	0.84
Lysine (%)	1.15
Methionine (%)	0.56
ME (kcal kg^{-1})	2800.35

ME: Metabolic energy, Ca: Calcium, P: Phosphorus

Table 2: Effects of marigold flower extract as a feed additive on the production performance of laying quail

Treatments	Feed consumption (g bird^{-1} day^{-1})	Hen-day production	Egg weight (g egg^{-1})	Egg mass production (g bird^{-1} day^{-1})	Feed conversion
A (0 ppm)	21.23^{b}	74.33^{b}	9.59	7.12^{b}	2.90^{a}
B (5 ppm)	21.54^{b}	76.24^{b}	9.66	7.30^{b}	2.86^{a}
C (10 ppm)	21.88^{b}	78.67^{b}	9.69	7.60^{b}	2.82^{a}
D (15 ppm)	22.03^{a}	80.69^{a}	9.75	7.89^{a}	2.79^{b}
SE	0.11	1.50	0.18	0.09	0.19

$^{a-d}$Different superscripts within column are significantly different (p<0.05), SE: Standard error of the mean

RESULTS

The effects of treatments on the production performances of *Coturnix coturnix japonica* laying quails are provided in Table 2.

Feed consumption: The feed consumption of *Coturnix coturnix japonica* laying quails was affected (p<0.05) by the levels of MFE present in the diet. Increasing the level of MFE in the diet increased feed consumption in a range of 21.23-22.03 g bird^{-1} day^{-1}.

Hen-day egg production: The levels of MFE in the diet influenced (p<0.05) the hen-day egg production of *Coturnix coturnix japonica* quails. Increasing MFE levels in the basal diet increased the hen-day production by 74.33-80.69%.

Egg weight: The egg weight of *Coturnix coturnix japonica* laying quails was not affected (p>0.05) by the levels of MFE in the diets. The egg weight ranged from 9.59-9.75 g egg^{-1}.

Egg mass production: The egg mass production of *Coturnix coturnix japonica* laying quails was affected (p<0.05) by the levels of MFE in the diet. The egg mass production in this study ranged from 7.12-7.89 g bird^{-1} day^{-1}.

Feed conversion: The feed conversion ratio of *Coturnix coturnix japonica* laying quails was affected (p<0.05) by the levels of MFE in the diet. The feed conversion ratio in this study ranged from 2.79-2.90 g bird^{-1} day^{-1}. The effects of MFE as feed additive on the egg quality of *Coturnix coturnix japonica* quails were illustrated in Table 3.

Egg cholesterol: The levels of cholesterol in the eggs of *Coturnix coturnix japonica* quails were affected (p<0.05) by the levels of MFE in the diet. The egg cholesterol levels found in this study ranged 530.01-746.38 g/100 g.

Egg yolk color: The egg yolk color of *Coturnix coturnix japonica* quails was affected (p<0.05) by the levels of MFE in the diet. The egg yolk color in this study ranged from 6.20-8.68.

Table 3: Effects of marigold flower extract as feed additive on the egg quality of quail

Treatments	Egg cholesterol (g/100 g)	Egg yolk color
A (0 ppm)	746.38^{a}	6.20^{d}
B (5 ppm)	684.79^{b}	6.93^{c}
C (10 ppm)	593.22^{c}	7.87^{b}
D (15 ppm)	530.01^{d}	8.25^{a}
SE	2.11	0.68

$^{a-d}$Different superscripts within column are significantly different (p<0.05), SE: Standard error of the mean

DISCUSSION

Feed consumption and hen-day production increased when MFE was added to the diet of laying quail in this study (Range: 0-15 ppm), with the highest consumption being achieved with 15 ppm MFE additive. Poultry are known to prefer feed that is yellow or orange in color and the addition of MFE, which contains carotenoids, contributed to this effect[3,5]. The feed consumption range observed in this study with the addition of MFE additive (21.23-22.03 g head^{-1} day^{-1}) was in agreement with a study by Costa *et al.*[8], who found that the feed consumption of *Coturnix coturnix japonica* quail (6-13 weeks of age) supplemented with prebiotic and organic minerals ranged from 20.96-23.82 g head^{-1} day^{-1}. This feed consumption finding was also similar to the results of a study by Tuleun *et al.*[9], who showed that the feed consumption of *Coturnix coturnix japonica* quail was 21.23 g head^{-1} day^{-1} when fed 21% crude protein. However, this results were higher than those presented by Nataliyus *et al.*[10], who found that the feed consumption of *Coturnix coturnix japonica* quail (7-12 weeks age) ranged from 20.99-21.07 g head^{-1} day^{-1} when supplemented with *Leucaena leuchocepala* leaf in the diet.

The hen-day egg production of quail in this study was the highest for birds supplemented with 15 ppm MFE, which was likely due to the concomitant increase in feed consumption. High feed intake of laying quail increases the nutrient consumption, particularly protein intake and can increase egg production[11]. This findings in this study were similar to those by Tuleun *et al.*[9], who reported that hen-day egg production of *Coturnix coturnix japonica* quail ranged from

78.00-81.67%. However, the hen-day egg production observed in this study was lower than that observed by Costa *et al.*[8].

The average egg weight observed in our study was similar to that observed by Tuleun *et al.*[9], who observed that the egg weight average of *Coturnix coturnix japonica* quail fed a diet consisting of 20% crude protein was 9.75 g egg^{-1}. This result is also similar to the results obtained by Al-Daraji *et al.*[12] who reported that *Coturnix coturnix japonica* quail supplemented with up to 6% linseed in the diet produced an average egg weight ranging from 9.40-11.13 g egg^{-1}. In addition Vali *et al.*[13] reported that the average egg weight for 60-145 days old *Coturnix coturnix japonica* quail ranged from 8.20-13.56 g egg^{-1}.

It found that egg mass was influenced by MFE in the diet, which was a result of the increase egg production and egg weight. Costa *et al.*[8] found that the egg mass of *Coturnix coturnix japonica* quail ranged from 9.0-10.20 when fed prebiotic and organic minerals in the diet, which was a similar finding as this study.

The lowest feed conversion ratio observed in this study, which is defined as the ratio between feed intake and egg production[8], occurred with 15 ppm MFE supplementation in the diet. Feed conversion can be used as a surrogate marker of the egg production coefficient, whereby a smaller value indicates a more efficient use of feed to produce an egg. The average feed conversion ratio from this study was higher than that obtained by Nataliyus *et al.*[10], which ranged from 2.17-2.20 when quail were fed with diets containing *Leucaenaleu chocepala* leaf. This data were also slightly higher than those presented by Costa *et al.*[8] (Range: 2.50-2.70).

The lowest egg cholesterol levels were observed with 15 ppm MFE supplementation, which is likely associated with the increased carotenoid content. Beta-carotene can inhibit the action of the enzyme-CoA reductase Hydroksimetyl Glutaryl (HMG Co-A reductase), which play as role in the formation of mevalonate, thus inhibiting the synthesis of cholesterol[4]. This results indicated that 15 ppm MFE decreased egg cholesterol levels by 29.98%. It also found that this MFE supplementation resulted in a darker egg yolk color (redness). Gunawardana *et al.*[11] has reported that the color of the yolk is dependent on the carotenoid levels in the diet and this results are in agreement with those presented by Skrivan *et al.*[14].

CONCLUSION

Increasing MFE content in the diet of quail can improve the performance and egg quality. Providing MFE supplementation up to 15 ppm resulted in an increase in hen-day egg production by 80.69%, increase in egg weight to 9.75 g egg^{-1} and a feed conversion ratio of 2.79. In addition, the egg cholesterol level was reduced by 28.98% and the yolk color score increased by 33.06%.

SIGNIFICANCE STATEMENTS

This study is about the utilization of marigold flower extract as a feed additive to improve quail performance and egg quality. Marigold flower provides a source of carotenoids and poultry feed high in carotenoids has been shown to increase performance and egg yolk color as well as decrease egg cholesterol levels.

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