Research Article

Production of Pigment Enriched Desi Chicken Eggs by Feeding of *Tagetes erecta* Petals

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Abstract | The present study was carried out with an aim of enriching desi chicken egg with carotenoid pigment and to improve its colour of consumers' preference. A total of 96 adult Nicobari fowls at the age of 30 weeks were subjected to four dietary treatments consisting of 1 (T-1), 2 (T-2), and 3 (T-3) g marigold dried petal powder per day per hen and control (c). The mean egg production parameters, egg quality characters and reproductive trait were recorded for 120 days. Marigold feeding to Nicobari fowl up to 3 g did not show any adverse effect on the palatability of feed, egg production performance, egg weight, egg mass output, hatchability and feed efficiency. Significant ($P<0.05$) improvement in the Roch yolk colour score from 4 to 8 reflected the enrichment of caroteinoid pigments in egg yolk. Feeding of dried Marigold petals up to 3 g per hen per day as supplemental feed additive for rural poultry could enrich carotenoid pigments in desi eggs and thereby could improve yolk colour of consumer's preference under semi-intensive system of management to meet the growing demand and changing consumers need for enriched poultry production.

Keywords | Feeding of Marigold petals, Nicobari fowl, Improved egg yolk colour, Carotenoid enrichment in yolk

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INTRODUCTION

Designer egg is a technology to exploit products beyond their traditional food value and is the enrichment of egg retaining their nutritional, functional and sensory qualities. In the past decade, enrichment of any food products is gaining importance among health conscious consumers to promote their health. Growing role of human nutritionists led to convergence of consumer, Government and scientists' attention on superior quality of poultry products. Further, research priority in poultry nutrition has been diversified into the field of enriching or fortifying eggs with certain nutrients of consumer's choice at pre-oviposition and pre-slaughter stage itself based on the basic concept that eggs accumulate nutrients if hens are subject to dietary and nutritional manipulations (Sujatha and Narahari, 2011).

Eggs are the acceptable and best vehicles to incorporate consumer health beneficial nutrients. Recent trend in fortification of poultry products is enrichment with natural antioxidants through herbal feed additives since consumer's preferences for natural organic products in their food are increasing (Cho et al., 2013). In Andaman & Nicobar Islands, backyard

poultry eggs meet out more than 60 per cent of rural requirements of rural people for eggs. Desi laying chicken are generally able to consume grasses and other greens that are rich in carotenoid pigments. Therefore desi eggs are always of acceptable yolk colour and are comparatively more preferred by consumers.

Recent past in these Islands, with due concern for housing of rural poultry, backyard free range system is being shifted to rearing of poultry with supplemental feeding inside poultry shelters. Hence, the chance for accessibility to grasses is declining and desi chickens started failing to produce eggs with standard egg yolk colour. Further, backyard poultry farmers face problems in better hatchability at field level due to lack of cold storage before natural hatching using broody hens. Carotenoid pigments are potent natural antioxidants (Cho et al., 2013). Since the usage of synthetic pigment in the feeding of rural poultry is highly impossible by the rural poultry keepers, natural carotenoid source should be of ideal choice as pigmenting agents for egg yolk. Marigold is frequently used by rural women in many occasions like as festivals and day to day worships. Used marigold and orange skin become useless and just thrown to dustbins. Researchers (Ferdaus et al., 2008; Karadas et al., 2006; Lokaewmanee et al., 2010) reported that marigold petal meal and its residue are good sources of xanthophylls to be used in layer diets as egg yolk pigmenting agents. Moreover, lutein the rich content of marigold is an excellent natural pigment to reduce the macular degeneration and cataracts, major causes for deterioration of sight in elder people (Karadas et al., 2006). There is growing demand for carotenoid-enriched products. Eggs are good source for enrichment with lutein which in turn capable of increasing the concentration of this pigment in human plasma (Lokaewmanee et al., 2010; Mansoori et al., 2008).

Research demonstrates that carotenoid absorption in the human intestine is increased when consumed with lipids, suggesting that eggs are good delivery system for carotenoids (Amar et al., 2013). Carotenoids from egg yolk are more bio-available compared to spinach or pigment supplements. In a study, where hens fed with diets containing yellow xanthophylls extracted from *Tagetes* recorded the improvement in Roch yolk Colour Score up to 11.7 (Ferdaus et al., 2008; Karadas et al., 2006; Lokaewmanee et al., 2010). Similarly, Marigold feed additives fed to quails enhanced the enrichment of total carotenoids in quail eggs (Karadas et al., 2006).

Most of the findings are based on the extract from marigold flower, but very little information is available on direct feeding of marigold as feed additive. Therefore, a study was conducted by using marigold as a feed supplement for natural pigmenting source in the feed of rural poultry to improve the pigmenting ability of desi egg yolk, enhance the nutritive value of desi eggs and increase its hatchability.

MATERIALS AND METHODS

Ethical Approval

The experiment was conducted after the permission of Institutional Animal Ethics Committee.

Experimental Design

A total of 96 laying pullets of Nicobari fowl, the indigenous native poultry of these Islands belonging to same hatch were selected at 30 weeks of age. Marigold flower (*Tagetes erectus*) were collected, shade dried and subjected to proximate analysis for nutrient contents. Hens were assigned to three dietary treatments where in the same basal diet (Table 1) was supplemented with dried marigold petals at inclusion levels of 1, 2, and 3 g per bird per day respectively as marked as T-1, T-2, T-3 and one group was kept as control (c) without supplementation of marigold. Each group was replicated into three with 24 birds (20 female + 4 male) in each replicate. Experiment was conducted for 120 days. Fresh water and mash feed was fed *ad libitum* throughout the experimental period. The birds were reared during a photoperiod of 12 hours and an additional artificial light was provided for 4 hours to make total lighting period to 16 hours daily. Birds in all treatment groups were provided with identical care and management throughout the experimental period. Strict hygienic measures and sanitation programme were taken during this period.

Production Data

Egg production was recorded daily (replication wise) and the eggs were weighed every day in the afternoon immediately after collection and thereafter change in feed consumption, feed efficiency, hen-day egg production, hen-housed egg production and egg mass output were determined. 15 numbers of eggs from each treatment were collected and stored at room

temperature for 7 days. After incubation period of 21 days, hatchability was assessed.

Egg Quality Characteristics

Egg quality characteristics were measured for the egg laid by birds of different dietary groups. Two eggs from each replication were collected during the 3rd week of the experimental period. Egg width and length were measured by using slide calipers. The egg was then carefully broken on a glass plate to measure both internal and external quality characteristics. The internal egg quality characteristics were determined by estimating the albumen weight, albumen index, Haugh unit, yolk weight and yolk index. The external egg quality characteristics were measured by estimating the egg shape index, shell thickness and per cent shell. The intensity of egg yolk colour was scored using Roch Yolk Colour Fan.

Data was analyzed as per complete randomized design in the SAS system (2002).

RESULTS

Chemical composition of Marigold Petals

The dried marigold petals had nutrient profile of Dry matter (15%), Crude protein (11.5%), Crude fat (8.25%) and Ash (6.45%).

Production performance

The mean egg production parameters, both internal and external egg quality characteristics and Roch yolk colour score of dietary treatments are shown in table 2, 3 and 4, respectively. Hen day and hen housed egg production, egg weight, egg mass, feed intake and feed efficiency were not adversely affected by feeding of marigold. Layers fed with marigold recorded comparatively higher egg production, egg weight, egg mass, better feed efficiency and yolk percent; but the differences observed in means were found to be statistically non-significant as compared to control. Similarly, egg quality characteristics of marigold fed and control groups showed no significant differences between means of the three treatments and control group; however, it was found that Roch yolk colour score in Nicobari fowl fed with various levels of marigold powder showed significant (P<0.05) differences between the means. It was noticed that the mean of Roch yolk color score of all marigold fed groups (8) was significantly higher than the control (4).

Table 1: Composition of basal diet

Ingredient composition	Per cent
Maize	61
Soya bean cake	20.9
Dry fish	8
Sunflower cake	5.5
Rapeseed cake	2
Calcite powder	0.2
Di Calcium Phosphate	0.04
DL-Methionine	0.01
Satlt	0.01
PHTASE 5000 IU	100 g
Cholin chloride	500 g
Vitamin mixture	1kg
Trace mineral mixture	1kg
Liver tonic	1kg
NSP enzymes	500 g
Shell grits	75gm
Nutrient Composition	
ME, kcal/kg	2560
Crude protein %	18
Calcium %	3.82
Salt %	0.42

Reproduction performance

The mean hatchability and day old chick weight (Figure 1)recorded in marigold supplemented groups did not significantly (P>0.05) differ from control group. The difference found in the mean of hatchability per cent and day old chick weight in treatment groups was 10% higher than the control group; but the difference was non-significant.

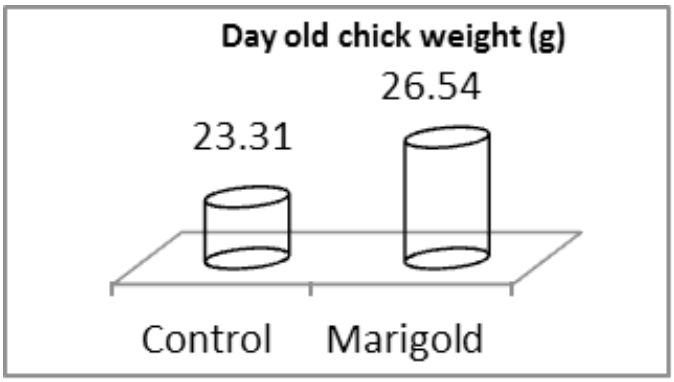

Figure 1: Day old chick weight (g)

Table 2: Mean production traits of Marigold feeding in Nicobari fowl

Production traits	Control C	1% Marigold T_1	2% Marigold T_2	3% Marigold T_1
Hen Day Egg Production % NS	48.00± 23.18	48.53±34.16	49.53±26.13	49.84±31.18
Total no of eggs per bird (180 d) NS	86	87	87	88
Egg weight (g) NS	47.94±0.66	46.80±0.52	48.25± 0.44	50.34± 0.62
Egg mass (g/hen/day) NS	23.01±1.66	22.73±2.13	23.89±1.91	25.09±2.13
Yolk percentage NS	32.14	32.66	33.60	34.97
Feed intake (g/bird/day) NS	91.84±3.12	89.56±9.18	89.46±2.43	88.93±5.34
Feed efficiency per doz eggs NS	2.30±6.30	2.22±5.10	2.17±7.27	2.06±7.43
Feed efficiency /egg mass NS	3.99±4.87	3.94±2.39	3.74±6.69	3.40±9.11
Livability % NS	100	100	100	100

Table 3: Mean egg quality traits of Marigold feeding in Nicobari fowl

Egg quality traits	Control C	1% Marigold T_1	2% Marigold T_2	3% Marigold T_1
Shell thickness (mm)NS	0.32	0.34	0.33	0.33
Shell per centNS	10.06	12.37	11.19	10.05
Yolk per centNS	32.14	32.66	33.60	34.97
Yolk Index NS	0.45	0.47	0.46	0.46
Albumen IndexNS	0.09	0.07	0.08	0.08
Haugh unitNS	100.5	100.6	101.2	101.0
Albumin per cent NS	57.78	53.26	55.20	49.96

Table 4. Mean Roch yolk color score of marigold

Treatments	Roch Yolk color score
C (Control)	4.33
T_1 (1% Marigold)	7
T_2 (2% Marigold)	7
T_3 (3% Marigold)	8

Economics of Marigold feeding

Egg production cost increased maximum by Rs.2.70 per egg; spontaneously farm rate of enriched country egg would be higher.

Figure 2: Roch Yolk Color Fan (RYCF)

DISCUSSION

Chemical composition of Marigold powder

Proximate analysis of marigold revealed that it can be a potential feed additive after simple processing.

The values of chemical composition of marigold were found to be close to the values previously reported by Karadas et al. (2006). The Ether extract and xanthophyll content (149.67 mg/kg) was lower than the findings of Cho et al. (2013).

Table 5. Economics of Marigold feeding

Trial period: 6 months	1% Marigold T_1	2% Marigold T_2	3% Marigold T_1
Dry Marigold consumed (g)	180	360	540
Fresh marigold needed (kg)	1.2	2.4	3.6
Marigold cost (Rs.)	132	264	396
Extra eggs obtained per bird (no.)	1	3	7
Extra Cost from eggs (Rs.)	10	30	70
Extra chicks obtained (nos.)	2.5	4	5
Extra cost from chicks (Rs.)	37.5	60	75
Total extra cost spent on bird due to marigold feeding (Rs.)	84.5	174	251
Overhead cost per egg (Rs.)	0.97	1.96	2.7
Farm rate of enriched desi eggs (Rs.)	10.97	12	12.7

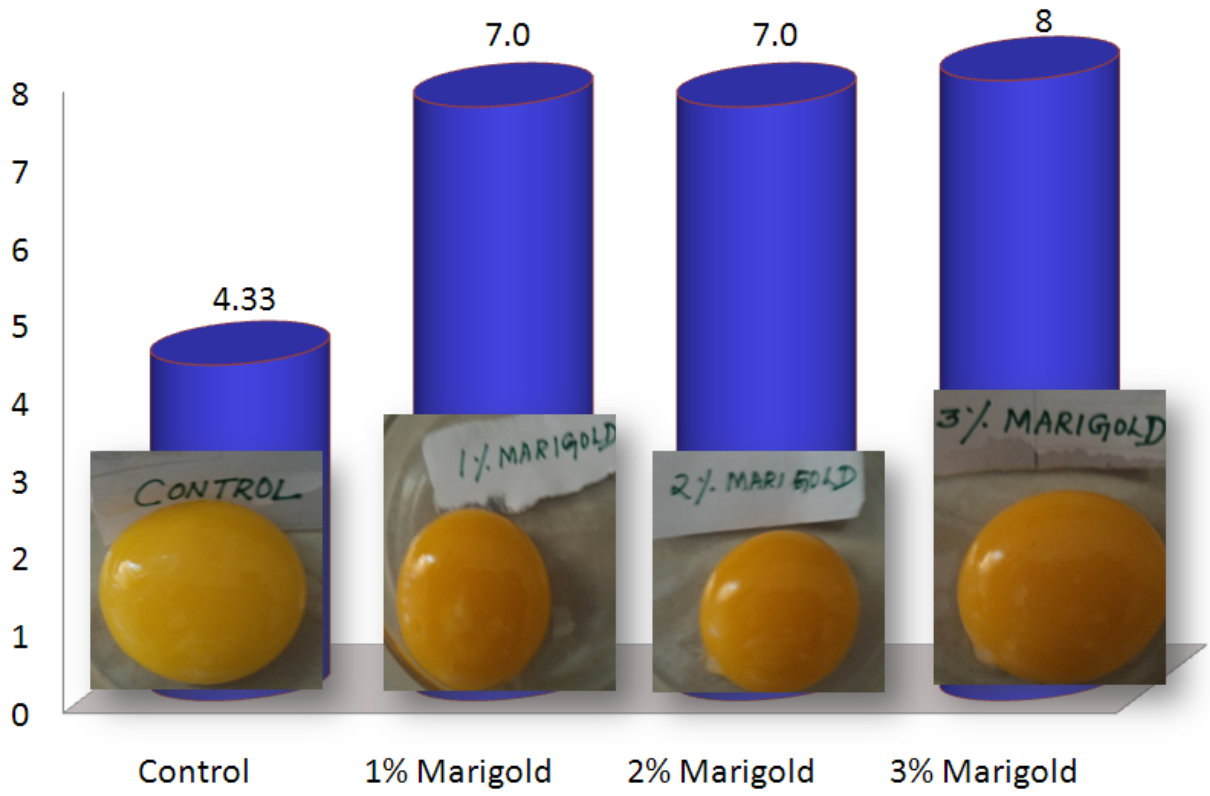

Figure 3: Effect of Marigold on Rock Yolk color score

Production performance

The similar non-significant difference in the means of production parameters observed in the present study was also reported by Ferdaus et al. (2008), Lokaewmanee et al. (2010), Mansoori et al. (2008), Cho et al. (2013) and Amar et al. (2013) who worked with carotenoid containing natural feed ingredients such as Paprika extract and marigold, tomato pomace and peel and marigold. Thus, the present result suggested that the use of 3 g marigold in the diet of laying pullets had no detrimental effect on the rate of egg production.

The mean feed consumption of various marigolds fed and control groups were close to each other and statistically non-significant. It indicated that the use of marigold up to 3 g could not affect the palatability of layer pullets and therefore feed intake was found

to be non-significant. Results on feed consumption agreed well with the results of Ferdaus et al. (2008), Lokaewmanee et al. (2010), Mansoori et al. (2008), Cho et al. (2013) and Amar et al. (2013) who reported that dietary inclusion of pigment rich herbs did not reduce the consumption of mixed feed.

The mean weight of eggs laid by marigold fed and control groups and egg mass output were more or less similar and did not differ significantly. Lokaewmanee et al. (2010) reported non-significant difference in egg weight from feeding diets containing 0.1% paprika plus 0.1% marigold in the layer diet. This result also agreed well with Mansoori et al. (2008) and Amar et al. (2013) who also found non-significant differences among layers fed diets containing tomato pomace. Further, it is clear from this study that the inclusion of 3 g marigold in the diet of layer diet had no negative effect on egg weight. Due to non-significant difference in feed consumption, egg weight, egg mass and egg production, the differences in feed conversion ratios for egg numbers and egg mass of different dietary groups were not significant, though the most efficient utilizer of feed was those birds which received 3 g marigold and the lowest efficient group was the control group. Lokaewmanee et al. (2010) also found no significant difference in feed efficiency of laying hen fed with marigold along with paprika. Hence, it is inferred that feed supplementation of marigold petals up to 3 g in the diet of laying pullets did not influence feed conversion ratios at a negative rate. Slightly higher egg mass yield recorded by fowls fed with 3 g marigold as compared to other levels and control was probably a reflection of slightly higher egg production and egg weight of that group. Sujatha et al. (2013) also reported similar trends as the present study in egg mass output with supplementation of azolla meal.

All birds were healthy and there was no mortality in the present experiment, which was supported by Lokaewmanee et al. (2010), Mansoori et al. (2008), Cho et al. (2013) and Sujatha et al. (2013). This result clearly indicated that the use of marigold till 3 g in the diet had no detrimental effect on the health of laying birds.

It was found that shape, albumen and yolk index, shell, albumen and yolk percent and shell thickness of eggs laid by birds during experimental period of supplementation of marigold till 3 g level did not vary significantly ($P>0.05$). The various treatment groups in the diet as used in this study did not deteriorate the quality and physical composition of eggs except yolk color score. Previous experiments by Ferdaus et al. (2008), Lokaewmanee et al. (2010), Mansoori et al. (2008), Amar et al.(2013) and Sujatha et al. (2013) reported similar trend in the results for both albumen and yolk quality with tomato pomace and fresh azolla.

Yolk pigmentation had not been associated with changes in production as reported by Sujatha and Narahari (2011) and Rowgharni et al. (2006). In all three levels of dietary supplementation of marigold, the desirable yolk color score ranged from 7 to 8. Similar results had been observed by Lokaewmanee et al. (2010), Mansoori et al. (2008) and Amar et al.(2013) at evaluating pigments extracted from various natural pigment sources. The highly significant differences were found in yolk color scores between marigold and control dietary groups ($p<0.01$). Yolk color score of the eggs laid by birds fed with 3% marigold based diet was highest (8) of all marigold supplemented groups and differed significantly from control group (Figure 2 and 3). However, the yolk color scores did not differ significantly among all marigold supplemented groups. As per calculation based on feed intake, the daily supplemental xanthophyll intake varied from 0.845 to 0.597 mg xanthophyll from supplemental 3% marigold and control group respectively. Cho et al. (2013) also found that use of 4% marigold meal in the diet of laying pullets produced eggs with yolk color score 11.00 close to 30 mg synthetic pigment/kg diet. Similarly, Lokaewmanee et al. (2010) observed the improvement in Roche yolk color values by use of 0.1 % paprika plus 0.1% Marigold skin in the diet due to xanthophyll consumption present in the orange skin. The yolk color of paprika and marigold was higher than that of only paprika group because the birds on marigold combination group diet consumed more xanthophylls. Amar et al.(2013) also reported an improved yolk color value due to higher content of carotenoids in egg yolk produced from hens fed with 7% dried tomato peel dietary supplementation. On the other hand, Rowgharni et al. (2006) found 8.12 yolk color value at 20th day of dried Marigold flower dietary supplementation, which was similar to the values obtained for 3% marigold group supplementation at 3rd week in this study. The results of the present study were also agreed by Ferdaus et al. (2008) that dietary supplementation of 40 g of grounded Marigold

flower per kg diet improved the score of Roch yolk color fan. There was no significant difference found in the present study among the marigold supplemented groups. This result also agreed well with Amar et al.(2013), Mansoori et al. (2008), Cho et al. (2013) and Rowgharni et al. (2006) who also found non-significant differences among layers fed diets containing various levels of tomato pulp or tomato peel or marigold flower respectively. It is interesting to note that carrot meal and both Lemna and Wolffia species are also able to produce well colored yolks.

Reproductive performance

At backyard level, lower hatchability is the major constraint among many problems that rural poultry production faces. Rapid oxidation of egg yolk contents before incubation may be one of many reasons for this hatchability problem at backyard level. Hatchability was found to be 10% higher with marigold supplemented groups. The difference in the mean of hatchability was significantly ($P<0.05$) higher. The effect of potential antioxidant property of carotenoid pigments as reported by Karadas et al. (2006) that were transferred from maternal diet and rich in the egg yolk might have attributed to the improvement of hatchability. Higher day old hatch weight obtained was highly correlated with higher yolk percentage recorded with marigold supplementation.

Economics of Marigold feeding

The comparatively higher price of enriched desi eggs would be the major constraint for the middle class consumers; but still from quality point of view, the rate is affordable and the consumers are always ready to pay for premium quality. Further, nutritional security and health of rural farming community will be improved through consumption of these pigment enriched desi eggs produced by themselves at their level.

CONCLUSION AND RECOMMENDATION

Inclusion of dried marigold up to 3 g in the Nicobari fowl did not adversely affect the production performance and egg quality characteristics. Further, it was recorded that supplementation of marigold improved the hatchability and egg yolk colour. It is inferred that incorporation of marigold as a wholesome feed additive for desi birds under semi range system has beneficial effects on enrichment of caroteinoid pigments in egg yolk and improvement of color of desi chicken egg yolk that is most preferred by the health conscious consumers.

AUTHORS' CONTRIBUTIONS

All the authors contributed in various phases of this experiment *viz.*, conduction of experiment, guidance to conduct the research, scientific discussion and preparation of manuscript.

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