Use of Dried Carrot Meal (DCM) in Laying Hen Diet for Egg Yolk Pigmentation

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ABSTRACT : Dried carrot meal (DCM) prepared from fresh carrot was found to be a good source of xanthophyll (54 mg/kg) and morderate source of protein (188.3 g/kg) and energy (2,510 kcal/kg) with low level of fibre (80 g/kg). DM, EE and NFE content of DCM were 895, 35 and 661.7 g/kg respectively. The ingredient was used in laying hen diet to evaluate its pigmenting value for egg yolk. Thirty-two laying hens from Starcross strain were divided into four groups and fed four different diets: a control diet containing 62% ground wheat, a corn-based diet (50% ground yellow corn), control + 4% DCM and control + 8% DCM. Use of DCM at 8% level in layer mash significantly improved yolk colour at 3rd, 6th and 9th week of supplementation in comparison with wheat-based control diet. This improvement was statististically similar to that obtained from yellow corn-based diet.

DCM at 4% level also improved yolk colour score. Wheat-based diet significantly increased feed consumption compared to yellow corn and diet supplied with 8% DCM. Body weight gain, egg production, feed conversion were not significantly affected due to dietary addition of DCM and no mortality was observed during 63-day experimental period. Further works on DCM are suggested.
(Key Words: DCM, Diet, Egg-Yolk, Pigmentation, Xanthophyll, Yolk Colour, Internal Characteristices, Laying Performance)

INTRODUCTION

Proper pigmentation of egg yolk is important for consumers' satisfaction. Consumers all over the world usually prefer yolk colour ranging from golden-yellow to orange i.e. midway to high on the Roche Yolk Colour (RYC) fan. Yolk colour is also important in the manufacture of egg products such as liquid, frozen, and dried whole egg and separated components (Bartov and Bornstein, 1974; Johnson et al., 1980). Thus both industries and the consumers of fresh eggs want well coloured yolk.

Karunajeewa (1984) suggested that British consumers would accept much paler yolk colour than their stated preference but would reject very dark yolks (13 or more on the RYC fan). Although the addition of synthetic pigment is allowed in several items of human food such as margarine, fruit juice, cheese etc, some countries do not allow it in poultry diet or in egg products. For instance, the use of canthaxanthin in poultry feeds is prohibited in the U. S. A. (Fletcher and Halloran, 1981).

The colour of egg yolk is produced by oxycarotenoids, commonly known as xanthophyll pigment, derived from hen's feed. Yellow corn, in addition to energy source, also supplies xanthophyll pigment for chicken. It contains 20-25 mg xanthophyll/kg (Scott et al., 1968) which can produce yolks with colour score ranging from 6.5 to 7 on RYC fan if fed to laying birds at 50% dietary levels where it constitutes the only source of xanthophyll (Saha, 1995). Korane et al. (1992) reported a yolk score of 4.6 when birds were fed a diet containing 55% corn where 2% lucerne was included as additional source of carotenoids. In countries like Bangladesh, where the production of yellow corn is very limited, wheat is the only grain usually considered by the poultry producers in diet formulation. Wheat-based diet usually fails to produce eggs with standard yolk colour (colour score 1 to 2 on RYC fan; Saha, 1995). On the other hand, use of synthetic pigment in the diet increases feed cost.

Pale egg yolks resulting from feeding wheat-based diets to layers is one of the problems of egg-laying farms in Bangladesh. Many consumers believe that eggs with pale yolks are neither tasty nor nutritious. Yolk pigmentation results primarily from xanthophyll, a non-nutritive factor having no contribution to taste. But the

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attitude of the consumers is a matter of concern to egg producers. There is a limited production of yellow corn and synthetic carotenoids are scarce, expensive and not normally used. Thus it seemed worthwhile to search for natural colouring ingredients that could produce the same yolk colour as a diet containing 50% yellow corn.

Dried carrot meal (DCM) which contains approximately three times more xanthophyll than yellow corn (65 vs 20-25 mg/kg, Scott et al., 1968), could be a source of yellow pigment to colour egg yolk. The present study was therefore undertaken to determine the proximate components and xanthophyll concentration of DCM and to evaluate its effects on egg yolk pigmentation, other internal egg characteristics and laying performance.

MATERIALS AND METHODS

Preparation of DCM

Fresh carrots were manually cut into small pieces, sun-dried for 22 hours, and later oven-dried at 105℃ for another 8 hours. The dried carrots were cooled at room temperature and ground by a mechanical grinder (SKJOLD, SAEBY-DENMARK, Model No. 20). The fine carrot powder thus prepared and denominated as DCM.

Chemical analyses

The proximate components of DCM and other feed ingredients were determined by following the procedures of A.O.A.C. (1970). Xanthophyll concentration in DCM and egg yolk were determined by the method of Quackenbush et al. (1970). Metabolizable energy (ME) of feed ingredients was calculated by substituting values of proximate components in the formula suggested by Janssen and Terpstra (1972).

Diet formulation

Four isocaloric and isonitrogenous diets with adequate amounts of Ca, total P were prepared as follows: a control diet containing 62% ground wheat, a corn-based diet (50% ground yellow corn), control + 4% DCM and control + 8% DCM. The requirements of ME, CP, Ca toatal P and lysine of all layer diets were satisfied very closely to those recommended by NRC (1994). Vitamin mineral-premix (Embavit-L) and extra vitamin C (L-ascorbic acid) were incorporated into all diets according to the manufacturer's instructions. Table 1 shows the

Table 1. Composition of the experimental diets

Ingredients	Amount in dietary treatment groups (%)			
	Control	Corn	4% DCM	8% DCM
Wheat (crushed)	62	–	62	62
Maize (crushed)	–	50	–	–
Rice polish	11.5	25	8	4
Sesame oil cake	4.5	4	4	4
Full fat soybean	9.5	8.5	9.5	9.5
Fish meal	4	4	4	4
DCM	0	0	4	8
Oystershell	5.5	5.5	5.5	5.5
Bone meal	2.5	2.5	2.5	2.5
Common salt	0.5	0.5	0.5	0.5
Vitamin mineral premix	+	+	+	+
Chemical Composition:				
DM	92.16	90.13	92.2	92.2
ME kcal/kg	2,710	2,696	2,711	2,711
CP (%)	16.2	17.5	16.2	16.4
Lysine (%)	0.77	0.68	0.75	0.73
Methionine (%)	0.27	0.29	0.25	0.24
Fat (%)	5.4	7.9	5.1	4.6
CF (%)	4.4	5.4	3.9	3.8

* Embavit-L added@2.5 g/kg manufactured by Rhone Poulenc Bangladesh Ltd. Each 2.5 kg premix contained: Vitamin A, 12,000,000 IU; Vitamin D_3 2,500,000 IU; Vitamin E, 20 g; Vitamin K_3, 4 g; Vitamin B_1, 1.5 g; Vitamin B_2, 5 g; Vitamin B_6, 4 g; Nicotinic acid, 30 g; Pantothenic acid, 10 g; Vitamin B_{12}, 10 mg; Folic acid, 0.5 g; Biotin, 50 mg; Cobalt, 0.3 g; Copper, 6 g; Iron, 24 g; Iodine, 0.6 g; Manganese, 48 g; Zinc, 40 g; Selenium, 120 mg; DL-Methionine, 50 g; Choline chloride, 250 g; L-lysine, 30 g.

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Birds, their housing, feeding, husbandry and routine procedures

Thirty-two 51-week old brown-feathered commercial layers (Starcross) were caged individually in 3 tiered laying cages in an open-sided house. The birds were placed in a pen measuring 610 × 536 × 240 cm with provision for adequate ventilation. Birds were randomly allocated in cages, each cage being 42.7 × 58.5 × 42.7 cm. Each layer was considered as an experimental unit.

Following acclimatization for a week on the control diet, four diet groups, each of 8 hens, were fed these experimental diets for 63 days providing identical care and management. The birds had free access to feed and water at all times. A constant photo period of 16 h light/8 h dark was used throughout the study period. Feeders and waterers were cleaned daily. Strict hygienic measures were taken during the experimental period. House temperature was recorded twice daily, once in the morning and again in the afternoon. Feed intake was recorded from the amount supplied at the beginning of the week and amount retained at the end of week. Egg production was recorded daily.

Eggs were weighed every day in the afternoon immediately after collection. Necessary calculations were done to determine body weight gain, feed consumption, hen-day egg production and feed conversion ratio. During 3rd, 6th and 9th weeks of study, yolk colour score from 32 eggs (one from each hen) was recorded by comparing with a RYC fan (F. Hoffman-La Roche Ltd).

Measurement of internal egg quality characteristics

Albumen indices, Haugh units and yolk indices were determined. The height and diameter of yolk and albumen were measured from three different parts by a micrometer (Ames micrometer) and a slide calipers repectively. The average values of three readings for height and diameter were substituted for calculating yolk and albumen index. Haugh unit was determined by adjusting egg weight and albumen height in an Egg Quality Scale (Ogawa Seiki Co Ltd, Tokyo, Japan). The separation of yolk and albumen from each other following breakage of eggs and the measurements of their weights and DM were in accordance with the proceduress described by Chowdhury (1988).

Statistical analyses

Data for yolk colour, laying performance and egg quality characteristics were analysed as a completely randomized design and least significant difference tests were applied to the means. Statistical treatments of data were performed by MSTAT statisical packaged programme in a microcomputer.

RESULTS AND DISCUSSION

Chemical composition of DCM

The proximate analysis showed that DCM contained 89.5% DM, 18.83% CP, 3.5% EE, 8% CF, 66.17% NFE and 3.5% Ash. It appears that the CP and EE values were more or less similar to those reported for dehydrated alfalfa (DA), but CF was one-third of the value reported by Austic & Nesheim (1990). The NFE value was more than double and ash content was one third of DA (Janssen and Terpstra, 1972) and ME content was found to be 2,510 kcal/kg. This value, although higher than for DA (1,580 kcal/kg; Austic & Nesheim, 1990) was logical because DCM contains less fibre and more NFE in comparison with DA.

The total xanthophyll content in DCM was 54 mg/kg which was slightly lower than the value reported by Scott et al. (1968). Lower xanthophyll value in the current study probably resulted from some deterioration due to processing and storage. The reduction in the concentrations of carotenoids in feed ingredients due to processing techniques and storage procedures is well established (Chandra et al., 1978; Karunajeewa et al., 1984).

Effect on yolk colour

The effect of DCM on yolk colour in comparison with wheat or corn based diet is shown in table 2. Use of DCM at 8% level in layer mash significantly improved yolk colour at 3rd, 6th and 9th week of supplementation in comparison with wheat based-diet. DCM at 4% level also improved yolk colour score but this improvement was only significant in the 6th week. Similarly, 8% DCM showed higher yolk colour values over those of 4% DCM, the data differed significantly in the 6th week. In this study, the effect of week of measurement was not tested.

The yolk colour score obtained by feeding 50% yellow corn in this study (4.1 to 4.8) was lower than the values reported previously by Saha (1995). Korane et al. (1992) although fed slightly higher amounts of yellw corn (55%), found yolk colour score of 4.6, a value close to the result of the present study. Ross and Dominy (1990) reported 4.9 from laying quails fed 44.34% yellow corn plus 3% dehydrated alfalfa. Recently, a number of workers reported improvement in the pigmentation of egg yolk from feeding diets containing various carotenoids feed ingredients; eg; blue green algae (Ross and Dominy,

Table 2. Effects of feeding DCM to layers on yolk colour score

Weeks of feeding	Control diet (wheat-based)	Yellow corn based diet	4% DCM	8% DCM	SEM	Level of significance
3rd	1.87[b]	4.12[a]	3.12[ab]	3.69[a]	0.0299	* = $p < 0.05$
6th	1.62[c]	4.81[a]	3.00[b]	4.31[a]	0.4378	** = $p < 0.01$
9th	2.25[c]	4.75[a]	3.10[bc]	3.87[ab]	0.3241	** = $p < 0.01$

Values within each row not having one letter in common differ significantly.

1990; Anderson et al., 1991); elodea and hydrilla (McDowell et al., 1990); algae meal (Lipstein et al., 1980); microalgal biomass (Gouveia et al., 1996); duckweed (Haustein et al., 1990; Akhter, 1995). Most of the authors reported higher yolk colour score than those obtained by feeding DCM in the present study. This variation was probably due to differences in the nature and concentrations of carotenoids of the feed ingredients in addition to some losses due to processing techniques and storage of DCM.

Effects on other internal characteristics of eggs

Data on other internal quality characteristics are presented in table 3. The albumen indices, Haugh units (HU), yolk indices were quite satisfactory in all diet groups. During the 6th and 9th week of DCM supplementation, there were no significant differences in albumen weight, albumen DM, albumen index and Haugh

Table 3. Internal quality characteristics of egg from layers fed corn or DCM

Variables	Week of supplementation	Control diet	50% Corn	4% DCM	8% DCM	SEM	Level of significance
Albumen wt. (g)	3rd	35.64[b]	39.41[a]	35.15[b]	34.18[b]	0.6538	*
	6th	35.26	37.16	35.94	36.92	0.3467	NS
	9th	37.92	39.61	35.51	37.43	0.4307	NS
Albumen DM (%)	3rd	13.68[a]	12.98[ab]	13.61[a]	12.75[b]	0.1410	**
	6th	13.02	13.02	12.90	12.75	0.0394	NS
	9th	12.33	12.70	12.40	12.56	0.0513	NS
Albumen index	3rd	0.10[b]	0.12[a]	0.12[a]	0.10[b]	0.0039	**
	6th	0.10	0.12	0.12	0.10	0.0033	NS
	9th	0.10	0.12	0.11	0.10	0.0029	NS
Haugh unit	3rd	82.06[b]	91.23[a]	90.18[a]	82.98[b]	1.4519	**
	6th	83.86	89.88	90.48	83.65	1.1432	NS
	9th	82.79	88.84	87.81	83.50	0.9291	NS
Fresh yolk wt. (g)	3rd	16.98	15.81	15.88	15.76	0.1790	NS
	6th	17.14	15.80	15.92	16.41	0.1855	NS
	9th	18.29[a]	15.68[b]	16.14[b]	16.18[b]	0.3583	**
Yolk DM (%)	3rd	51.73	52.02	51.36	51.99	0.0934	NS
	6th	51.32	51.42	51.47	51.27	0.0420	NS
	9th	51.16[ab]	50.79[b]	51.37[a]	51.49[a]	0.0934	**
Yolk index	3rd	0.35	0.37	0.37	0.35	0.0042	NS
	6th	0.35	0.38	0.38	0.37	0.0059	NS
	9th	0.37	0.37	0.38	0.37	0.0013	NS

Values within each row not having one letter in common differ significantly.
(** = $p < 0.01$; * = $p < 0.05$; NS = Nonsignificant).

unit values. During the 3rd week of supplementation, albumen weight of eggs from DCM supplemented groups did not differ significantly from wheat-based diet although all values differed significantly from the higher values obtained from corn-based diet. Of course, albumen DM was found to be comparable among corn and DCM based diets in the same week, suggesting that higher albumen weight in yellow corn-based diet was probably due to higher water content. HU values were significantly higher in corn-based and DCM based diets in the 3rd week. Although some variations in albumen quality were observed only during 3rd week of DCM supplementation, the data for all traits throughout the experimental period were found to correspond good quality eggs and therefore quite acceptable. There was no significant variation in fresh yolk weight during 3rd and 6th week but during 9th week, yolk weight was significantly reduced in corn-based and DCM based diets in comparison with wheat-based diet. This was probably due to variation in water content since the yolk DM content of wheat-based diet did not differ significantly from other test diets. Yolk index did not differ significantly between diets supplemented or not. Like albumen quality, the data on yolk quality characteristics resembled those which are usually found for good quality yolks.

Laying performance

The laying performance data are presented in table 4. Body weight gain, egg production, egg weight, feed conversion ratio and liveability of layers fed DCM did not differ significantly in hens that receiving wheat and yellow corn-based diets. Birds which received higher level of DCM consumed significantly less feed than those kept on wheat based diet, but this result was comparable to yellow corn-based diet. Decreases in body weight gain and feed consumption in yellow corn-based and 8% DCM containing diets might be attributed to low dietary concentrations of lysine. There was no mortality during the experimental period. All performance data obtained due to feeding DCM found to be satisfactory and acceptable, even though the bird's age was above 52 weeks. The results on laying performance suggest that the use of DCM in laying diet has no detrimental effects on laying performance.

Table 4. Laying performance of birds fed diets containing corn or DCM (63 days)

Variables	Control diet (wheat based diet)	50% yellow corn	4% DCM	8% DCM	SEM	level of significance
Body weight gain (g/bird)	8.85	6.97	8.72	4.04	0.6848	NS
Egg production hen- day (%)	60.72	63.62	62.14	65.18	0.6092	NS
Egg weight (g)	64.14	63.45	61.52	62.19	0.3631	NS
Feed consumption (g/day)	123.45[a]	110.07[b]	114.52[ab]	106.09[b]	2.2862	** = $p < 0.01$
Feed conversion ratio	3.19	2.77	2.99	2.75	0.0636	NS
Livability (%)	100	100	100	100	–	NS

Values within each row not having one letter in common differ significantly.

CONCLUSIONS AND FUTURE WORKS

The *in vivo* effect of DCM on laying performance and egg quality characteristics, specially yolk pigmenting ability of DCM on Starcross layers kept laying for 63 days under conventional conditions strongly suggests that DCM can be used in laying hen diet for egg yolk pigmentation where possible and available at a reasonable cost.

The current work was a preliminary study with DCM in layer nutrition. The results suggest flurther works with freeze-dried carrot meal for better yolk pigmentation since oven drying has been considered to be destructive of xanthophyll. Since, feed ingredients containing carotenoids do not always prove to be efficient pigmenting agents due to low percentage of utilizable carotenoid, the next logical step would be to determine the bioavailability of xanthophyll from freeze-dried carrot meal. In addition, amino acid analysis would be helpful to assess the protein quality of DCM.

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REFERENCES

Akhter, M. 1995. Effect of feeding duckweed (*Lemna minor*) meal on the laying performance and egg quality characteristics of chicken. M. Sc. (A. H.) in Poultry Science Thesis. Department of Poultry Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Anderson, D. W., C. Tang and E. Ross. 1991. The xantophylls of *Spirulina* and their effect on egg yolk pigmentation. Poultry Sci. 70:115-119.

A.O.A.C. 1970. Official Methods of Analysis. Association of Official Analytical Chemists, Washington D.C.

Austic, R. E. and M. C. Nesheim. 1990. Poultry Production. Lea and Febiger, 13th ed. Philadelphia.

Bartov, I. and S. Bornstein. 1974. Yolk colour as affected by diet. Proceedings of XV World's Poultry Congress. New Orleans. U. S. A. p. 245.

Chandra, S. S., P. Netke and B. S. Gupta. 1978. Studies on comparative utilization of xanthophylls from various natural sources for egg yolk pigmentation. Indian. J. Anim. Sci. 48:456-460.

Chowdhury, S. D. 1988. A method of partitioning egg components. Bangladesh. J. Anim. Sci. 17:93-97.

Fletcher, D. L. and H. R. Halloran. 1981. An evaluation of commercially available marigold concentrate and paprika oleresin on egg yolk pigmentation. Poultry Sci. 60:1846.

Gouveia, L., V. Veloso, A. Reis, H. Fernandes, J. Novais and J. Empis. 1996. *Chlorella vulgaris* used to colour egg yolk. J. Sci. Food Agric. 70:167-172.

Haustein, A. T., R. H. Gilman, P. W. Skillicorn, V. Vergara, V. Guevara and A. Gastanduy. 1990. Duckweed a useful strategy for feeding chickens, performance of layers fed with sewage-grown *Lemna* species. Poultry Sci. 69:1836-1844.

Janssen, Ir. W. M. M. A. and Drs. K. Terpstra. 1972. Feeding Values for Poultry. Spelderholt Centre for Poultry Research, Netherlands. Beekbergen. pp. 8-11.

Johnson, E. A., J. J. Lewis and C. R. Grau. 1980. Pigmentation of egg yolks with astaxanthin from the yeast *Phaffia rhodozyma*. Poultry Sci. 59:1777.

Karunajeewa, H., R. J. Hughes, M. W. McDonald and F. S. Shenstone. 1984. A review of factors influencing pigmentation of egg yolks. World's Poultry Sci. J. 40:52-65.

Korane, U. N., A. N. Sarag, R. D. Sadekar, A. R. Sirothia and D. N. Dharmadhikari. 1992. Effect of replacement of maize with prosomillet on egg yolk pigmentation and egg quality traits. Indian J. Poultry Sci. 27:144-146.

Lipstein, B., S. Hurwitz and S. Bornstein. 1980. The nutritional value of algae for poultry. Dried chlorella in layer diets. Br. Poult. Sci. 21:23-27.

McDowell, L. R., L. C. Lizama, J. E. Marion and C. J. Wilcox. 1990. Utilization of aquatic plants *Elodea canadensis* and *Hydrilla verticillata* in diets for laying hens. Poultry Sci. 69:673-678.

N. R. C. (National Research Council) 1994. Nutrient Requirements of Poultry 13th Revised Edn. National Academy Press, Washington D. C., U. S. A.

Quackenbush, F. W., M. A. Dyer and R. L. Smallidge. 1970. Analysis for carotenes and xanthophylls in dried plant materials. J. Assoc. Offic. Anal. Chem. 53:181-185.

Ross, E. and W. Dominy. 1990. The nutritional value of dehydrated blue-green algae (*Spirulina platensis*) for poultry. Poultry Sci. 69:794-800.

Saha, P. K. 1995. Use of two local varieties of corn as replacement for wheat in layer ration M. S. in Poultry Sci. Thesis. Department of Poultry Science, Bangladesh Agricultural University Mymensingh, Bangladesh.

Scott, M. L., I. Ascarelli and G. Olson. 1968. Studies of egg yolk pigmentation. Poultry Sci. 47:863-872.