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Full Length Article

The Effect of Dried Sweet Potato (*Ipomea batatas*) Vines on Egg Yolk Color and some Egg Yield Parameters

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ABSTRACT

Effects of dried vines powder of sweet potato cultivars 'Hatay Beyazı', 'Hatay Kırmızı' and 'Beauregard' on egg yolk color were determined in layers aged 44-52 week. In this study, 176 layers were equally divided into 11 groups including negative control (no pigments), positive control (commercial layer diet) and three sweet potato varieties with three doses (3 x 3) at 15, 20, 25 mg/kg total xanthophylls. The internal and external quality characteristics of the Monday and Thursday eggs were recorded. Egg yolk score were classified by visual with Roche Color Fan (RCF) and Minolta refractometer. Egg production, feed intake, live weight and feed conversion ratio were calculated weekly. The highest RCF value 3.96 was obtained from those fed with 'Hatay Kırmızı'. The greatest *a* and *b* values were recovered at the 25 mg/kg dose of 'Hatay Kırmızı' compared to the other sources. In conclusion, to obtain the desired level of RCF values in the egg yolk, the dried vines powder of 'Hatay Kırmızı' having natural carotenoid content can be used as a natural pigmenter in layer diet.

Key Words: Egg yolk color; Natural colorant; Sweet potato; RCF value

INTRODUCTION

The color of the egg yolk is considered to be one of the important factors for egg consumption. Several researches indicate that the consumers select the eggs based on the egg yolk color (Lipstein, 1989; Fletcher, 1999). Layers cannot produce pigments; thus they need to be fed by the coloring pigments.

The desired egg yolk color is produced by caroteneoids such as carotenes and xanthophylls. The caroteneoids having oxygen atoms are called as xanthophylls (such as lutein & zeaxanthine), while the ones without oxygen are called carotene (such as α, β-carotene & lycopene). Caroteneoid pigmentation has two important factors: the storage ability of the pigment in the egg yolk; and the wave length of the pigment. Lutein, zeaxanthine and apo-esther are caroteneoids, which are in yellow having wavelength of 445-450 nm; whereas, canthaxanthine and citranaxanthin are in red and have wavelength of 468-470 nm.

Corn, *Zea mays* L., which is used up to 60% in compound feed is a natural source of caroteneoids. When the feed or the natural pigmenting are not adequate, the feeds are supported by synthetic pigments such as canthaxanthine, citranaxanthin and β-apo-8-Carotenoic Acid Ethyl Esther (ACAEE).

The consumers have adopted preferences towards the natural products recently. In the same lines, poultry researchers focused on the natural pigmenting for the egg yolk. Flours or extracts of alfalfa, marigold, red pepper, lycopene, orange peel, spirulina have been experimented on layers and quail feeding with varying results (Kırkpınar & Erkek, 1999; Lorenz, 1999; Santos-Bocanegra *et al*., 2004; Şamlı *et al*., 2005; Hasin *et al*., 2006; Şahin *et al*., 2008).

Sweet potato (*Ipomea batatas* L.) is also a source of natural pigment. The tubers of sweet potatoes are rich in β-carotene, while the foliage is rich in xanthophylls. Thus, sweet potato is not only important food for human but also for poultry.

The amount of carotene in the sweet potato considerably depends on the tuber cultivars and locations (Çalışkan *et al*., 2007). For example, the average of the carotene of 17 local clones from Taiwan was 0.400 mg/100 g; while the cultivars from American and Philippines had the averages of 24.8 and 11.45 mg/100 g in fresh material, respectively (Woolfe, 1992).

The absorption of caroteneoids is dependent on several factors such as fat (Jayarajan *et al*., 1980; Han *et al*., 1987) and vitamin contents of the feed (Surai *et al*., 1998; Surai & Sparks, 2001), layers genotype (Jensen *et al*., 1998) and sex (Hinton *et al*., 1973). The polarities of the caroteneoids have also been reported to affect the absorption (Na *et al*., 2004).

The egg yolk accumulates less than 1% of β-carotene, 7% of Zeaxanthine and 34% ACAEE (Roche, 1988). This indicates the polarity order of β-carotene < Zeaxanthine < ACAEE. Na *et al.* (2004) studied the effects of the polarity

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of caroteneoids on the absorption and storage and reported that the canthaxanthine and ACAEE had 3-5 and 9-11 folds higher effect compared to β-carotene. The same study reported that the layers fed by β-carotene failed to have desirable colors on egg yolk, while layers fed by canthaxanthine and ACAEE had adequate pigmentation on their egg yolks.

Kaya and Yıldırım (2009) studied the possibility of feeding layers by tubers and foliage of the sweet potato having β-carotene, lutein and zeaxanthine. They added dried tubers and vines of sweet potato to compound feeds with the ratios of 1, 2, 3 and 4%. Although dried sweet potato tubers did not result in the good pigmentation on the egg yolk, 3% dried vines treatment resulted in up to 5.8 RCF.

This previous study led the design of the present experiment, where three doses of the three sweet potato cultivars having lutein, zeaxanthine and total xanthophylls contents were tested in basal and commercial layer diets to see the possible impact on egg yolk color.

MATERIALS AND METHODS

The study was conducted at the Mustafa Kemal University, Agricultural Research and Implementation Center, Poultry Unit for eight weeks. The layers were kept in cages (50 × 50 cm) individually. Prior to study, the experimental layers were fed by control feeding having no pigments. At the beginning of the experiments, the layers were randomly allocated into the cages. Each unit had 16 hybrid layers (Super Nick), which were 44 week-old. The experiments had following treatments: (a) negative control (basal diet having no pigments); (b) positive control (layer diet corn-soya based and having commercial pigments; Canthaxanthin 1500 mg/kg & ACAEE 500 mg/kg); (c) tree sweet potato cultivars [‘Beauregard’ (B), Hatay Beyazı’ (HB) and ‘Hatay Kırmızı’ (HK)] with three supplemental doses (15, 20 & 25 mg/kg total xanthophyll). Thus, the experiment had the total of 11 treatments by using 176 layers. The layers were fed freely without water restrictions. The experimental unit was illuminated 16 h.

The sweet potato vines were harvested at 120th days of transplanting. The vines were dried at 65°C for 48 h. Then, the dried material was ground to be added to the compound feed. The ground material was kept on the bags placed in the jars and dark and 4°C until given to the layers.

The dry matter (DM), crude protein (CP), ether extract (EE), ash and crude fiber (CF) contents of the dried foliage and other materials which were used as feed were determined by the methods of AOAC (1990) and presented in Table I. Total xanthophylls contents of the compound feed and dried sweet potato vines was determined by spectrophotometric method (Shimadzu UV-1700 spectrophotometer), while lutein and zeaxanthine contents were determined by Liquid Chromatography/Mass Spectrometer at TÜBİTAK-ATAL and presented in Table II. As natural pigmenting compound, the dried foliages of B, HB and ‘HK’ were used at the rates of 15, 20 and 25 mg/kg total xanthophylls, respectively (Table III).

In the experiment, several factors such as daily feed intake (FI), change in the live weight (LW), feed conversion ratio (FCR), egg yield ratio (EYR), egg weight (EW), internal (thick albumen & yolk height, yolk width, albumen & yolk index, albumen length & width, flesh & blood stain, Haugh Unit) and external (egg weight, specific gravity, egg width & length, egg shape index, eggshell thickness) egg quality parameters were determined.

The eggs were weighed by a scale sensitive to 0.01 g. The width and length were measured by a digital compass, egg yolk and white height were measured by a tripod micrometer, and eggshell thicknesses were measured by a micrometer. Eggshell thickness was determined on the three different regions of the dried eggshell. The specific gravity of the eggs was determined by solution method.

The external and internal egg parameters were calculated by following equations (Nesheim *et al*., 1979):

$$\text{Haugh Unit} = 100 \times \log (H+7.57-1.7W^{0.37})$$

Where; H=Thick albumen height (mm), W=Egg weight (g).

Feed consumption and the changes in live weight were monitored weekly. Feed conversion ratios were calculated by dividing the egg weight by the feed intake.

To determine the effect of the dried sweet potato vines, the eggs were collected twice a week. In each case, three eggs were analyzed form each experimental unit. Visual evaluation was conducted using Roche Color Fan (RCF) in 1–15 scales (Vuilleumier, 1969). The color measurements were also conducted using *L, a* and *b* values using a Minolta chromo meter (CR 300, Minolta-Japan).

The experiments were designed as a factorial experiment with two factors (3 x 4) and the data were subjected to the GLM procedure of SPSS statistical software (Release 10.1). The significant means were separated by Duncan’s Multiple Range Test at 5% within the same software.

RESULTS

The results of the treatments are presented in Table IV. Daily feed intake was affected by treatments ($P < 0.01$) and varied between 105.11-118.11 g. In ‘Beauregard’ and ‘Hatay Beyazı’ cultivars, the daily feed intake decreased with the increases in the doses; while this was increased with the increased dose in ‘Hatay Kırmızı’ cultivar.

The egg production varied between 90.95-94.08% among the treatments. However, the differences among the treatments were not significant ($P > 0.05$). When the live weight at the end of the experiment values were considered, the differences among the treatments (the means varied between 1441.62 g to 1610.50 g) were not significant ($P > 0.05$). The treatments were not significant for feed conversion, while the best feed efficiency was obtained as 15 mg/kg with ‘Hatay Kırmızı’ cultivar.

Table I: Nutrition values of feed ingredient used in the experiment

Feed ingredients	DM (%)	OM (%)	Ash (%)	CP (%)	EE (%)	CF (%)
Wheat	89.71	87.85	1.86	12.05	2.01	2.60
Millet	88.46	86.46	2.00	8.64	4.44	11.00
Soybean meal	87.94	82.18	5.76	47.53	0.97	5.15
Full-fat soybean	92.63	87.83	4.80	33.06	38.64	6.20
Wheat Bran	88.76	84.63	4.13	15.28	4.05	12.80
Hatay Beyazı	95.28	85.57	9.71	23.48	3.34	27.00
Hatay Kırmızı	92.20	77.32	14.88	18.01	3.63	28.00
Beauregard	95.31	82.52	12.79	12.23	2.89	25.00
Compound feed	90.58	79.87	10.71	17.48	6.09	5.79

DM (%); Dry Matter, OM (%); Organic Matter, CP (%); Crude Protein, EE (%); Ether Extract and CF (%); Crude Fiber

Table II: Lutein, zeaxanthine and total xanthophyll contents of the pigmenting materials used in the experiment

Material	Lutein (mg/kg)	Zeaxanthine (mg/kg)	Total xanthophyll (mg/kg)
Compound feed	nd[1]	nd	nd
Hatay Beyazı	207.02	23.53	1161.00
Hatay Kırmızı	245.26	34.71	1465.00
Beauregard	182.44	33.26	503.70

[1]Not detected.

The results regarding the external and internal parameters of the eggs are given in Table V. The sweet potato cultivars differed significantly for the egg weight (EW), egg shape index (ESI), albumen index (AI), Haugh Unit (HU) ($P < 0.01$), and eggshell thickness (EST) ($P < 0.05$). There was no difference ($P > 0.05$) in the eggshell weight (ESW), eggshell ratio (ESR) and yolk index (YI) among the treatments.

The egg yolk color differed significantly ($P < 0.01$) among different treatments. The greatest RCF averages reached to that of positive control. The negative control, having no pigmenting compound, has the average of 1.24 RCF. Among the sweet potato cultivar and doses, the greatest RCF (3.96) was averaged on 20 mg/kg xanthophylls dose of 'Hatay Kırmızı' cultivar.

The *L* value of the negative control group was greatest (64.37) and the lowest in positive control group (59.15) with the greatest RCF. The 15 mg/kg doses of the cultivars (62.92, 64.40 & 64.26) were also higher than the higher doses. The greatest mean for *a* which was showing the redness of the egg yolk was in 'Hatay Kırmızı' treatments (6.23, 6.50 & 6.60 with the doses of 15, 20 & 25 mg/kg total xanthophylls, respectively). Similarly, 'Hatay Kırmızı' treatments had the greatest *b* values as well (25.54, 27.93 & 27.97 with the doses of 15, 20 & 25 mg/kg total xanthophylls, respectively).

DISCUSSION

'Hatay Kırmızı' supplemental group decreased feed intake, this might be attributed to the higher organic matter of the leaves of 'Hatay Kırmızı' and its lower crude ash and cellulose content compared to the other potato cultivars. There was no incidence of anorexia and hyperphagia in experimental Super Nick layers. Each hen consumed feed as much as written in its management guide, approximately 100-110 g per day. The obtained shape index in the current experiment was 72.70-74.58, which were close to standard shape index for eggs as reported by Şenköylü (1991).

'Hatay Kırmızı' had the higher amount of xanthophyll, lutein and zeaksantin compared to those of the other cultivars according to chemical analysis. For this reason, the higher RCF values were obtained in 'Hatay Kırmızı' supplemented hen eggs.

The required egg colour density is controlled both by the dietary concentration of yellow (lutein, zeaksantin & apo-ester) and red pigmentors (cantaxhantin, citranaxhantin & capsanthin) (Chen & Yang, 1992; Lai *et al*., 1996). Yolk egg yellow pigmentation are affected by many factors such as animal health and physiology, dietary factors, feed production and product characteristics with the ability to storage xanthophylls (Baker & Gunther, 2004). For example, cantaxhantin attributed to red pigmentation is stored in egg yolk about its 40-50%, while citranaxhantin stores only its 10-20% (Schoner *et al*., 1990), also capsantin is stored by 16% in yolk (Hamilton, 1992).

The accretion of natural pigmentors is quite lower than synthetic ones (Marusich & Bauernfeind, 1981; Karunajeewa *et al*., 1984; Hencken, 1992). Lutein and zeaxhantin is stored in egg yolk only by 12-20% (Anonymous, 2009).

According to the above literature, the current natural pigment sources potato leaves with lower doses 15, 20 and 25 mg/kg were not sufficient to form egg yolk colour since their storage ability in yolk is quite lower than synthetic ones. This may be due to low xanthophyll contents in potatoes leaves pointing to need of additional pigmentors. In positive control diet, for example, dietary maize supplies sufficient background yellow pigmentation so that additional colouring agents will increase the degree of colouring from yellow to dark red (Anonymous, 2009).

The current findings showed that potato leaves had sufficient yellow pigments in order to built up background yellow formation but these are not enough to increase the tone of colouring from yellow to dark-red based on b and RCF values.

In conclusion, results of the present study revealed that: (a) the dried foliage of the sweet potato can be used to improve egg yolk color without affecting layer health, egg quality and production performances; (b) 15, 20 and 25 mg/kg total xanthophyll treatments tested in this experiment were considerably lower than the high limit of European Union Regulation (70/524/EEC), 80 mg/kg total xanthophylls (Breithaupt, 2007); (c) to reach the desirable yellow/red color of the egg yolk feeding the dried sweet potato foliage, the layer diet should be enriched by a more powerful natural pigment such as red pepper.

Table III: The contents of the compound feeds used in the experiment

Cultivar		Beauregard			Hatay Beyazı			Hatay Kırmızı		
Raw material/Dose[1]	**Control**	**15**	**20**	**25**	**15**	**20**	**25**	**15**	**20**	**25**
Wheat	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Millet	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00
Wheat bran	5.25	3.28	2.28	0.29	3.96	3.53	3.10	4.23	3.89	3.55
Soybean meal	14.00	13.00	13.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Full-fat soybean	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Beauregard (B)	---	2.97	3.97	4.96	---	---	---	---	---	---
Hatay Beyazı (HB)	---	---	---	---	1.29	1.72	2.15	---	---	---
Hatay Kırmızı (HK)	---	---	---	---	---	---	---	1.02	1.36	1.70
Vegetable oil	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Limestone	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
DCP	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Mineral[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100	100	100	100	100	100
Energy, ME (kcal/kg)[3]	2765	2716	2703	2700	2748	2743	2737	2752	2748	2743
CP %[4]	17.20	16.78	16.75	17.05	17.00	16.94	16.87	17.04	16.99	16.94
CF %[4]	6.30	6.74	6.87	6.91	6.50	6.56	6.63	6.45	6.50	6.54
Tot. xanthophyll. (mg/kg)[3]	0	15	20	25	15	20	25	15	20	25

[1]1 kg of vitamin has 7.500.000 IU Vit. A, 2.500.000 IU Vit. D_3, 50.000 mg Vit. E, 2.500 mg Vit. K_3. 1.500 mg B_1, 4.000 mg B_2, 2.500 mg B_6, 10 mg B_{12}, 25.000 mg, Vit. C, 35.000 mg Niacin, 10.000 mg Ca-D-Pantotenat, 100 mg Biotin and 1.000 mg Folic acid
[2]1 kg of mineral has 8.000 mg Cu, 80.000 mg Fe, 100.000 mg Mn, 200 mg Co, 1.000 mg I, 80.000 mg Zn, and 150 mg Se
[3]Values obtained from the calculations
[4]Values obtained from the analyses
[1]Doses are in mg/kg

Table IV: The mean and significance (*P* values) of the experimental treatments

	Cultivar										
			Beauregard			Hatay Kırmızı			Hatay Beyazı		
Dose[1]	**C**	**Com.**	**15**	**20**	**25**	**15**	**20**	**25**	**15**	**20**	**25**
Initial LW	1534.87	1565.25	1558.62	1532.12	1504.87	1577.6	1535.62	1565.87	1578.75	1548.25	1541.5
Finish LW	1559.37ab[2]	1610.50a	1589.99a	1511.25ab	14441.62b	1549.86ab	1528.75ab	1579.25a	1556.00ab	1598.12a	1512.37ab
FI	108.15def*	114.88ab	118.11a	113.90ab	109.46cde	104.80f	114.36ab	115.35ab	112.83bc	112.38bcd	105.11ef
FCR	1.82ab	1.79b	1.98c	1.94bc	1.92bc	1.73a	1.86abc	1.98c	1.98c	1.85abc	1.83ab
EYR	94.08	92.29	93.08	91.96	91.74	92.85	93.52	91.4	91.18	93.52	90.95

C = Control, Com. = Commercial, Initial LW = Live weight at the beginning of the experiment (g), Finish LW = Live weight at the end of the experiment (g), FI = Daily feed intake (g), FCR = Feed conversion ratio, EYR = Egg yield ratio (%)
[1]Doses are in mg/kg
[2]Means presented by different letters are significantly different at 5%

Table V: The mean and significance (*P* values) of the egg quality parameters

	Cultivar										
			Beauregard			Hatay Kırmızı			Hatay Beyazı		
Parameter/Dose[1]	**C**	**Com.**	**15**	**20**	**25**	**15**	**20**	**25**	**15**	**20**	**25**
EW	62.56[2]bcde	64.97a	62.61bcde	62.36cde	61.49e	62.69bcd	63.66b	63.46bc	61.49e	63.16bcd	62.01de
SI	73.83bcd	72.96ef	74.04abc	74.40ab	74.58a	73.75bcd	73.36cdef	73.29def	74.23ab	73.44cde	72.70f
ESW	5.82b	6.12a	6.07a	6.03a	5.82b	5.98ab	6.06a	6.03a	5.96ab	6.03a	6.09a
ESR	9.28c	9.51bc	9.78a	9.74ab	9.51bc	9.58ab	9.67ab	9.51bc	9.59ab	9.65ab	9.81a
EST	0.39c	0.40ab	0.40ab	0.39abc	0.38c	0.39bc	0.40a	0.39abc	0.40ab	0.40ab	0.40ab
AI	2.02b	1.88c	2.07ab	2.18a	2.10ab	1.99bc	2.01b	1.87c	1.98bc	1.99bc	2.07ab
YI	41.04d	41.55bcd	41.18d	41.57bcd	42.40a	42.11abc	41.53bcd	41.45bcd	41.79abcd	41.74abcd	42.28ab
HU	79.10abcd	76.79de	79.90abc	81.30a	80.29ab	78.30abcd	79.02abcd	76.79de	78.35bcde	78.78abcd	80.01ab
RCF	1.24f	9.67a	3.13e	3.46d	3.47d	3.42d	3.96b	3.78bc	3.17e	3.45d	3.68c
L	64.37a	59.15d	62.92c	62.47d	63.19bc	64.40a	63.47abc	63.32abc	64.26a	64.20ab	63.47abc
a	4.79f	3.11g	6.12de	6.31bcd	6.20cd	6.23cd	6.50ab	6.60a	5.96e	6.40abc	6.50ab
b	18.09g	43.57a	25.03ef	26.22cde	26.31cde	25.54def	27.93b	27.97b	24.41f	26.78bcd	27.51bc

C = Control, Com. = Commercial, EW = Egg weight (g), SI = Shape index, ESW = Eggshell weight (g), ESR = Eggshell ratio (%), EST = Eggshell thickness (mm), AI = Albumen index, YI = Yolk index, HU = Haugh unit, RCF= Roche color fan, L= Hunter light value, a= redness, b= yellowness
[1]Doses are in mg/kg
[2]Means presented by different letters are significantly different at 5%

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