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**ВЛИЯНИЕ НАТУРАЛЬНЫХ
И СИНТЕТИЧЕСКИХ КАРОТИНОИДОВ
НА РАЗВИТИЕ ЦВЕТА ЯИЧНОГО ЖЕЛТКА**

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Аннотация: Это исследование было направлено на оценку добавления натуральных (морковь и тыква) и синтетических каротиноидов (кантаксантин и сложный эфир апо-каротиноидов) для выявления влияния на цвет желтка и сенсорное восприятие яиц. Кормление проводилось в течение 28 дней с использованием 80 несушек кросса Хай-Лайн белый в возрасте 53 недели. Три обработки каротиноидами включали морковь, тыкву и синтетику, которые использовали в качестве кормовой добавки. В качестве контроля использовали коммерчески полноценный корм для несушек. Каждая обработка включала три уровня концентрации с 2-мя повторами. На каждую повторность выделяли по четыре птицы. Обработка моркови и тыквы содержала в концентрации 5 г, 10 г и 15 г / день / курицу с кормом для несушки. Для синтетической комбинации кантаксантина (Cantthapllus®10%) и сложного эфира апо-каротиноидов (ApoEplus®10%) использовались следующие концентрации: 0,003:0,0025г, 0,0035:0,003г и 0,004:0,0035г / день / курицу. Производительность кладки и качество яиц оценивали ежедневно. Цвет яичного желтка измеряли визуально с помощью шкалы Roche yolk color fan (RYCF). В течение экспериментального периода цвет яичного желтка постепенно увеличивался. Максимальные значения RYCF-9 и RYCF -7 были получены при употреблении 15 г / день / курицу моркови и тыквы после 23 дня кормления соответственно, и затем они были стабильными. Цвет яичного желтка RYCF-13 был получен в течение 22

дней с комбинацией синтетического кантаксантина и сложного эфира апокаротиноидов 0,004: 0,0035 г / день на курицу. Наблюдалась значительная разница ($P < 0,05$) между обработкой морковью, тыквой и синтетической обработкой с контрольной обработкой по проявлению цвета яичного желтка и органолептическим свойствам. Более высокая общая приемлемость была получена при синтетической обработке. Опрос потребителей показал, что 50% потребителей предпочитают RYCP-14 цвет яичного желтка. Более эффективной и действенной обработкой была синтетическая обработка, которая больше применима к индустрии несущек, а для органических несущек морковь была лучшей обработкой из средств обработки натуральными каротиноидами.

Ключевые слова: Кросс Хай-Лайн белый, Цвет яичного желтка, Морковь и тыква, Каротиноид, Кантксантин, Апокаротиноид.

EFFECT OF NATURAL AND SYNTHETIC CAROTINOIDS ON EGG YOLK COLOR DEVELOPMENT

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Abstract: From the viewpoint of consumers, great emphasis is placed on the color of egg yolk. Layers cannot synthesize the pigments and thus the feed mixtures are the source of pigments. This study was aimed to evaluate the addition of natural (carrot and pumpkin) and synthetic carotenoids (canthaxanthin and Apo-carotenoid ester) to detect the effects on yolk color and sensory perception of eggs. Feeding trail was conducted 28 days of period by using 53 weeks of age, 80 Hy-Line white layers. Three carotenoid treatments were consisted with carrot, pumpkin and synthetic which were used as a feed additive. Commercially available layer feed was used as a control. Each three treatment was consisted with three concentration levels with 2 replicates. 4 birds were allocated for each replicate. Carrot and pumpkin treatment contained 5 g/ day/hen, 10 g/day/hen and 15 g/day/hen concentration with layer feed. For synthetic combination of canthaxanthin (Cantthapllus@10%) and Apo-carotenoid ester (ApoEplus@10%) were used with following concentrations 0.003:0.0025 g/day/hen, 0.0035:0.003 g/day/hen and 0.004:0.0035 g/day/hen. Laying

performance and egg quality characteristics was assessed daily. Egg yolk color was measured visually by the Roche yolk color fan (RYCF). Egg yolk color was gradually increased within the experimental period. Maximum RYCF -9 and RYCF -7 were obtained by 15 g/day/hen of carrot and pumpkin after 23 days of feeding respectively and then it was steady. Egg yolk color RYCF-13 and stability within 22 days was obtained with the combination of synthetic canthaxanthin and Apo-carotenoid ester 0.004:0.0035 g/day/hen. There was a significant difference ($P<0.05$) between carrot, pumpkin and synthetic treatment with control treatment on egg yolk color development and organoleptic properties. Higher overall acceptability was obtained by the synthetic treatment. Consumer survey indicated that 50% consumers preferred RYCF-14 egg yolk color. The more efficient and effective treatment was the synthetic treatment which is more applicable to layer industry and for organic layers carrot was the best treatment out of natural carotenoid treatments.

Key words: Cross Hy-Line white, Egg yolk color, Carrot and pumpkin, Carotenoid, Canthaxanthin, Apo-carotenoid.

Introduction

Yolk color is the first parameter of yolk quality and generally ranks third amongst egg quality parameters, after freshness and eggshell quality [3, c.55]. In several countries, egg yolk color is an important factor for egg marketing because many consumers prefer a golden yellow to pale yellow color [5]. In Sri Lanka most of the market egg which are coming from egg producer's egg yolks was pale in color [4, c.209].

Post harvesting losses of fruits and vegetables in Sri Lanka is 30%-40% (Institute of Post Harvest Technology, Sri Lanka). This experiment is conducted to identify the way of utilizing the part of this waste effectively. Therefore the present study was conducted to determine the effect of carrot (*Daucus carota*), pumpkin (*Cucurbita maxima*), and combination of synthetic canthaxanthin and apo-carotenoid ester on development of egg yolk color. In order to achieve the main goal the following objectives were set.

- To compare the best treatment from natural (carrot and pumpkin) and synthetic carotenoids treatment which effect the egg yolk color development.
- To identify the best source and level of natural (carrot and pumpkin) carotenoid source for the egg yolk color development.

- To identify the best combination level of synthetic canthaxanthin and apo-ester for egg yolk color development.
- To identify the consumer satisfaction from different treatment towards the egg yolk color

Methodology

Field survey was conducted in order to identify the consumer preference towards egg yolk color using pre designed questionnaire with random sample of 100 consumers at Wennappuwa region, Sri Lanka.

The experiment was conducted using Complete Randomized Design. There were four treatments including Control. The samples (A total 80 Nos of Hy-line white layer hens with average weight 150 ± 25 g and age of 53 weeks) have been randomly undergone to following four treatments (Table 1).

Raw carrot and pumpkin was chopped in to 0.5 cm to 1 cm and air dry at room temperature to obtained dry form which prevent loss of carotenoid in sample. Synthetic canthaxanthin and apo carotenoid ester was obtained as dry powder form. According to table 1, different carotene treatment concentrations mixed with prima layer feed and fed. Eggs were collected during 8.00 am and 3.00 pm. The length of experimental was 28 days and after one week feed adaptation period egg was used to further evaluation (21 days).

Carrot and pumpkin concentrations was decided according to the carotene availability and Hy line white layer breed requirement. Carotene amount of mature raw pumpkin (*Cucurbita maxima*) is 3.16 mg/100g [6,]. Carotenoid content of raw carrot 82.716 $\mu\text{g/g}$ (8.22716 mg/100g) [2, c.374].

Table 1

Experimental design		
Treatment	concentration	Sample size(n)
Control (T1)	0	8
Carrot (T2)	5 g Day ⁻¹ Hen ⁻¹	8
	10 g Day ⁻¹ Hen ⁻¹	8
	15 g Day ⁻¹ Hen ⁻¹	8
	5 g Day ⁻¹ Hen ⁻¹	8
Pumpkin (T3)	10 g Day ⁻¹ Hen ⁻¹	8
	15 g Day ⁻¹ Hen ⁻¹	8
	0.003: 0.0025 g Day ⁻¹ Hen ⁻¹	8
Canthaxanthin:apocarotenoic ester	0.0035:0.003 g Day ⁻¹ Hen ⁻¹	8
	0.004:0.0035 g Day ⁻¹ Hen ⁻¹	8
Total		80

Synthetic canthaxanthin and Apo carotenoid ester concentration was decided according to the product guide line. Canthapllus®10% (Product code: 10101 4,4'-dioxo- β -carotene) and ApoEplus®10% (Product code: 10801 Ethyl 8'-apo- β -caroten-8'-oate) required dosage of Canthapllus®10% and ApoEplus®10% for layer feeds should be adjusted in according to the natural yellow xanthophylls content in feedstuffs and the desired coloration effect.

Daily feed requirement of Hy line white layer hens is 100 g (Hy line white guide 2016). According to decided value of different carotene treatment concentration mixed with prima layer feed and fed. Eggs were collected during 8.00 am and 3.00pm. The length of experimental was 28 days and after one week feed adaptation period egg was used to further evaluation (21 days).

Performance evaluation

As a performance evaluation criteria feed intake, egg laying parentage, mortality of hens and weight gain were measured. For the evaluation of internal egg quality parameters yolk colour, yolk index, yolk ratio, albumen index, albumen ratio and shell parameters were evaluated. The pigmentation of the egg yolk was measured visually measured by using a Roche Yolk Colour Fan (RYCF) displaying a scale from 1 (pale yellow) to 15 (reddish orange). In order to compare the sensory properties with the different carotenoid treatments using 6-Point Hedonic Scale the sensory analysis were done by 30 untrained panel.

All the obtained data were statistically analyzed by Statistics Analysis Software 9.1 version. For the sensory data analysis Minitab 17 software is used and the data was analyzed using Friedman test.

Results and discussion

All the respondents in the selected group consumed egg. Nearly 95% of respondents were not consider about egg yolk color while buying from market and 5% of respondents was consider about egg yolk color while they buying eggs. Nearly, 66% of the respondents were considering about egg yolk color when they eating eggs and 34% were not. From all respondent 50 % was prefer orange color egg yolk, 16% were prefer yellow color egg yolk and 34% of like to pale yellow in color egg yolk (table 4). Similar results obtained by the researcher Bejaei *et al.* [1]n his studies on consumer perception of egg yolk colour.

Egg yolk color development

Egg yolk color was gradually increased with the time of feeding among three treatments

Carrot treatment

Figure 1. Egg yolk color development of different carrot concentration level treatments with time.

At the beginning egg yolk color gradually increased and it was reached a plateau after 23 days of feeding ($15\text{ g day}^{-1} \text{ hen}^{-1}$), which was sustained throughout the experiment (Fig.1). Saturation was reached and the color did not increase further. It was observed that the mean increment of egg yolk color are 5.33, 5.86 and 6.62 respectively with carrot application levels of 1g, 10g, and $15\text{ g day}^{-1} \text{ hen}^{-1}$. (Fig 4)

The increasing trend of egg yolk color with concentration of carrot can be further confirmed by the correlation analysis between concentration of carrot and egg yolk color development. There was a weak positive correlation ($R=0.27347$, $P=0.0019$) between carrot level and egg yolk color development.

Pumpkin treatment

There was an increasing trend of yolk color development of three treatment levels of pumpkin. Egg yolk color was obtained seedy after 19, 21 and 23 days of feeding for the levels of 5, 10 and $15\text{ g day}^{-1} \text{ hen}^{-1}$ respectively (Fig.2). It was found that the mean (5.24) of egg yolk color pumpkin $15\text{ g day}^{-1} \text{ hen}^{-1}$ is higher than the means for all other pumpkin concentration levels. ($p<0.05$). By increasing the level of concentration colour development increases. There was a weak positive correlation ($R=0.43768$, $P=0.001$) between pumpkin concentration level and egg yolk color development.

Figure 2. Egg yolk color development of different pumpkin concentration level treatments with time

Canthaxanthin: apocarotinoide ester treatment

Figure 3. Egg yolk color development of different concentration level of combination of synthetic canthaxanthin and apo-carotenoid ester treatments with time.

The interaction ($p < 0.05$) between a concentration of combination of synthetic canthaxanthin (CA) and apo carotenoid ester (AP) and time effect was observed, in the sense that there was a significant differences between concentration level and time (Fig.3). At the beginning of the experiment for all concentration of CA: AP,

rapid increment was observed in egg yolk color in first four days of egg analysis (from 8th day to 12th day) and it became steady in 12th day (Fig.3). The CA: AP 0.004:0.0035 g Day⁻¹Hen⁻¹ stabilized on 22nd day with the colour development of 13 RYCF scale.

Figure 4: Mean of egg yolk color for all treatment compared with control treatment

Mean (11.5853) of egg yolk color CA: AP 0.004:0.0035 g Day⁻¹Hen⁻¹ is higher than the means for all other concentration levels (Fig.4). Correlation analysis of concentration level of canthaxanthin (CA) and Apo carotinoide ester (AP) and egg yolk color development has a weak positive correlation ($R=0.2965$, $P=0.0008$).

Carrot treatment increase RYCF score 9 with inclusion of 15 g day⁻¹ hen⁻¹ within 23 days of feeding. Similarly 15 g day⁻¹ hen⁻¹ pumpkin treatment also increase egg yolk color RYCF score 7 within 23 days of feeding. Synthetic canthxanthin : apo-carotenoid ester 0.004:0.0035 g Day¹Hen⁻¹treatment was improved egg yolk color RYCF score 13 within 22 days of feeding

Conclusion

- Carrot is the best out of two different organic carotenoid treatments
- Synthetic treatment can be used for rapid and high level in yolk colour development comparing to all other treatments.

- Sensory attribute indicate that higher overall consumer acceptability and color was obtained by the combination of synthetic canthaxanthin and apo-carotenoid ester treatment. (results not given here)

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