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IMPACT OF USING CASSAVA ROOT MEAL AND DIFFERENT COLORING AGENTS ON LAYING HEN PERFORMANCE AND EGG YOLK COLOR

A. A.Ghazalah[1]; M. O. Abd-Elsamee[1]. and H. A. H. AbdEl-Halim[2]

[1]Anim. Prod. Dep. Fac. of Agric. Cairo Univ. Giza, Egypt.

[2]Anim. Prod. Res. Inst. Agric. Res. Center, Minis. Of Agric. Dokki, Giza, Egypt.

Corresponding author: M. O. Abd-Elsamee; E mail: mamdouh20466@yahoo.com

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ABSTRACT: In this study, 180 Lohman laying hens 50 weeks of age were randomly distributed into 5 groups each has 36 hens in 4 replicates to evaluate the impact of using cassava root meal (CRM) and different coloring agents on laying hen performance, egg quality, egg yolk color and economical efficiency. The 1st diet was mainly formulated from yellow corn as a major source of xanthophylls for egg yolk color and served as the control. In the 2nd diet, CRM replaced yellow corn at 50% without coloring agents. Three more diets were mainly formulated from diet 2 by adding 2% corn gluten meal, 2.5% potato veins (as a natural source of xanthophylls) or 0.2% canthaxanthin (as synthetic source of xanthophylls) to contain the same amount of xanthophylls as the control diet (12 mg / kg).The overall results showed that there were no significant differences in average values of egg production and feed conversion ratio due to dietary treatments. While, egg weight and feed intake values were significantly decreased with feeding laying hen on diets containing CRM either alone or with adding different sources of xanthophylls compared to those of the control diet. Also, there were no significant differences in average values of egg quality (shape index, shell thickness, Hugh units, egg total lipids and egg cholesterol) due to dietary CRM or using different sources of xanthophylls compared to control diet. While, the egg yolk color score were significantly improved in laying hens fed diet incorporated with either corn gluten meal, potato veins or canthaxanthin compared to laying hen fed diet containing only CRM. Results showed that the average values of economical efficiency were improved due to feeding laying hen on diets containing CRM either alone or with adding different sources of xanthophylls. It could be concluded that, cassava root meal could be used with adding different sources of xanthophylls to save about 50% of yellow corn in laying hen diets without any detrimental effect on laying hen performance, egg yolk color and economical efficiency of egg production during summer season.

Key words : Laying hen - cassava root meal - coloring agents - egg yolk color

INTRODUCTION

Yellow corn is a commonly used as a major source of energy and egg yolk coloring agent in commercial laying hen diets. While, because of increasing both the amounts of yellow corn grains used for producing ethanol and the competition between human and livestock for cereals such as yellow corn , resulting in high cost of the cereal grains and consequently high prices of poultry diets and poultry products. Therefore, it is necessary to look for cheaper sources of feed ingredients which can replace for yellow corn to reduce the cost of poultry diets and products. Cassava, tapioca or yucca *(Manihot esculenta)* is one of those energy sources which can be used in poultry diets. The world cassava production was 280 million ton in 2017, which represents a steady increase in production over previous years. Furthermore, the world price for cassava root was 51$/ ton, while the world price for corn was 153$/ton (FAO, 2017). The average values of metabolizable energy (ME) for cassava root meal (CRM) were varied from 3140 to 3470 kcal/kg (Agwunobi and Okeke, 2000 and Chauynarong et al., 2009). Many authors, Oladunjoye et al. (2010); Anaeto and Adighibe (2011); Aderemi et al. (2012); Oyewumi (2013) and Diarra and Devi (2015) showed that yellow corn could be replaced with CRM up to 50% in laying hen diets without detrimental effect on laying hen performance. On the other hand, the absence of carotenoids in CRM is a major factor limiting its use in laying hen diets due to decrease of egg yolk color score being the expressive sensory factor for consumers. In study conducted by Saparattan et al. (2005), they observed that diets with maize or CRM had similar effects on laying rate and egg quality, but egg yolk color score was lowered in layers fed on CRM diet. Also, Yin et al. (2014) found that egg yolk became progressively whiter when CRM increased from 25 to 50% of laying hen diets. However, they showed that the defect in CRM diets can easily be corrected by addition of either natural or synthetic carotenoids. In this respect, Subarna et al. (2006) and Panait et al. (2016) suggested that corn gluten meal could be used in laying hen diets up to 5% as a natural source of yellow pigmentation for egg yolk. Also, Kaya and Yildirim (2011) concluded that egg yolk color improved with using dried potato veins in laying hen diets as a source of natural pigment for egg yolk color. While, Marounek et al. (2015) and Spada et al. (2016) reported that the addition of synthetic carotenoids such as canthaxanthin or apo-ester to laying hen diets improved egg yolk color.

Therefore, this work was planned to study the effect of using cassava root meal and different coloring agents on laying hen performance and egg yolk color.

MATERIALS AND METHODS

The present work was conducted in the Agricultural Experimental Station, Faculty of Agriculture, Cairo University. A total number of 180 Lohman laying hens 50 weeks of age were used to evaluate the impact of using cassava root meal (CRM) and different coloring agents on laying hen performance, egg quality, egg yolk color and economical efficiency of egg production. Hens were kept in previously cleaned and fumigated cages of wire floored batteries in an open system house under similar conditions of management. Laying hens were randomly distributed into 5 groups, each containing 36 birds in 4 replicates. Each of the 5 groups were given one of the following 5 isonitrogenous (17%) and isocaloric (2700 ME kcal/kg) diets according to the strain recommended guide for 12 weeks experimental period. The 1st diet was mainly formulated from yellow corn as a major source of xanthophylls for egg yolk color and served as the control. In the 2nd diet, CRM replaced yellow corn to 50% without using coloring agent. Then, three diets were mainly formulated from diet 2 by adding 2 % corn gluten meal, 2.5 % potato veins (as a natural source of xanthophylls) or 0.2% canthaxanthin (as synthetic source of xanthophylls) to represent the treatments No. 3, 4 and 5, respectively. The three diets contained the same amount of xanthophylls as the control (12 mg / kg diet). The level of the pigment sources based upon its content of the xanthophylls (22 mg / kg for yellow corn, 300 mg / kg for corn gluten, 240 mg/ kg for potato veins and 3000 mg / kg for canthaxanthin).The determination of xanthophylls were carried out according to the method reported by Holden (1965). The determined chemical composition of CRM used in this experiment was: 11.5 , 4.5 , 0.7 , 7.5 , 5.2 and 70.6% for moisture, CP , EE , CF , ash and NFE, respectively. Therefore, ME was 3230 kcal/kg as calculated by the following equation:

ME= 53+ 38 (CP + 2.25EE + 1.1NFE) according to Scott et al. (1976).

The experimental diets and their chemical composition are presented in Table (1). Water and feed (in mash form) were offered ad-libitum allover the experimental period with 16 hours light/ day regimen.

During the experimental period, records of feed intake, egg production and egg weight were used to calculate the values of feed conversion ratio (FCR) according to the following equation : FCR = (FI / EP X EW) X 100

Where: FI = feed intake (g) , EP = egg production (%) , EW = egg weight (g)

Every four weeks, twenty eggs from each treatment were randomly taken for testing their quality as indicated by shape index, shell thickness (by using a dial pipe gauge), Haugh units (calculated by using the HU formula based on the height of albumen and egg weight according to Eisen et al., 1962), egg total lipids (determined by the method of Folch et al., 1957), egg total cholesterol (determined by the method of Caurohami et al., 1959) and yolk color (measured according to Roch yolk color fan). The data obtained were statistically analyzed by using MSTAT-C (1989) procedure with One-way analysis. Duncan's multiple range test was used to detect any significant differences among the experimental means (Duncan,1955). Significance was defined as $P<0.05$. The experimental model used was:

$Y_{ij} = \mu + T_i + e_{ij}$

Where : Yij = an observation,
μ = the overall mean

Ti = Effect of treatments, i (1 to 5),
eij= Experimental error.

Finally, all treatments were economically evaluated by calculating the net revenue per unit of total feed cost.

RESULTS AND DISCUSSION

Laying hen performance:

Effect of dietary treatments on laying hen performance is shown in Table (2). Results show that the average values of egg production were not affected when laying hens were fed diets contained

CRM either alone or with adding different sources of xanthophylls compared to those of the control diet. This result is confirmed by Diarra and Devi (2015) who indicated that yellow corn could be replaced with CRM up to 50% in laying hen diets without detrimental effect on laying hen performance.

Data in Table (2) shows that egg weight values significantly decreased (P<0.05) with fed laying hen diets containing CRM either alone or with adding different sources of xanthophylls compared with those of the control group. This may be due to the low levels of both fat and fatty acids contents in CRM. This result is confirmed by Mwambilwa (2015) .

Results in Table (2) illustrated de clear that feed intake values significantly decreased (P<0.05) with feeding hens on diet contained CRM compared to that of the control diet. The reduction in feed intake with using dietary CRM may be due to the unpalatability of CRM for its powdery nature (Mwambilwa, 2015). The average values of feed conversion ratio (FCR) are shown in Table (2). The best FCR (2.33) was observed for the control diet (T1), while the worst value (2.44) was recorded for laying hens fed diet containing CRM with potato veins (T4). However, there were no significant differences for FCR values due to dietary treatments.

Egg quality:

The effect of experimental treatments on egg quality is shown in Table (3). Results show that the average values of shape index, shell thickness, Hugh units, egg total lipids and egg cholesterol were almost constant for all treatments and there were no significant differences among treatments due to feeding laying hens on diets containing CRM either alone or with adding different sources of xanthophylls compared to control diet. These results are in harmony with Oladunjoye et al. (2010) and Oyewumi (2013) who indicated that there were no significant differences in shell thickness values due to replacing 50% of maize with CRM in laying hen diets. Also, Yin et al. (2014) and Ghazalah and Abd-Elsamee (2017) found that egg total lipids and egg cholesterol did not significantly differ with feeding laying hen on diets containing 50% CRM.

Results in Table (3) observed that the egg yolk color score was lowered (P<0.05) significantly with feeding hens on CRM diet without pigmentation source and it can not be accepted by the consumers. This result is confirmed by Saparattan et al.(2005) and Yin et al.(2014). Accordingly, because of the egg yolk color is considered one of the important factors for egg consumption and the consumers select based on the yolk color hence, it was very important to enrich the dietary CRM by a natural or synthetic source of xanthophylls. Data in Table (3) show that comparing with control diet, the egg yolk color score was significantly decreased (P<0.05) with adding potato veins, while there were no significant differences due to adding either corn gluten meal or canthaxanthin. These results are in a good harmony with those obtained by Kaya and Yildirim (2011) and Panait et al. (2016) who found that yellow corn and corn gluten meal contain large amounts of zeaxanthin which is one of the best pigmenting compounds and produce eggs with a deep orange color. While, the main pigmenting compound of potato veins is lutein, which is not an effective as the zeaxanthin compound. Also, Marounek et al. (2015) and Spada et al. (2016) found that the addition of synthetic carotenoids such as canthaxanthin or apo-ester to laying hen diets improved egg yolk color.

Economical efficiency:

Data presented in Table (4) shows that the economical efficiency and money return per hen at the end of experimental period as affected by different dietary treatments. Generally, egg production and feeding cost are the most important factors which involved in the achievement of maximum efficiency of egg production. Data showed that feeding laying hens on diets contained 50 % CRM as substitution of yellow corn either alone or with adding different sources of xanthophylls improved both net revenue, economical efficiency and relative economical efficiency values compared to those of the control diet. These results coincided with those obtained by Ghazalah et al. (2009); Mwambilwa (2015) and Ghazalah and Abd-Elsamee (2017) who found that using CRM at 50 % replacement of yellow corn in laying hen diets improved the average values of economical efficiency parameters.

IN CONCLUSION

cassava root meal could be used safely to replace up to 50 % of yellow corn in laying hen diets with adding different sources of xanthophylls to improve both laying hen performance, egg yolk color and economical efficiency of egg production.

Table (1): Composition and calculated analysis of the experimental diets.

Ingredients	Treatments				
	T1 Cont.	**T2**	**T3**	**T4**	**T5**
Yellow corn	54.0	27.0	27.0	27.0	27.0
Cassava root meal	-	27.0	27.0	27.0	27.0
Soybean meal (44%)	26.0	30.0	28.0	29.0	30.0
Wheat bran	6.70	2.68	3.00	1.18	2.48
Cotton seed oil	2.50	2.50	2.20	2.50	2.50
Di-Ca Phosphate	2.00	2.00	2.00	2.00	2.00
Limestone	8.00	8.00	8.00	8.00	8.00
NaCl	0.40	0.40	0.40	0.40	0.40
Vit. & Min. Premix *	0.30	0.30	0.30	0.30	0.30
DL-methionine	0.10	0.12	0.10	0.12	0.12
Corn gluten meal (60%)	-	-	2.00	-	-
Potato Veins	-	-	-	2.50	-
Canthaxanthin	-	-	-	-	0.20
Total	100.0	100.0	100.0	100.0	100.0
Calculated analysis **					
CP %	17.0	17.0	17.0	17.0	17.0
ME cal/ kg	2700	2700	2700	2700	2700
Ca %	3.60	3.60	3.60	3.60	3.60
Avi. P %	0.50	0.50	0.50	0.50	0.50
EE %	4.50	3.60	3.60	2.50	2.50
CF %	3.10	4.20	4.20	5.20	5.20
Lys. %	0.92	0.95	0.95	0.95	0.95
Meth. %	0.38	0.38	0.38	0.38	0.38
Meth. + Cys. %	0.67	0.64	0.65	0.64	0.64
Xanthophyll (mg/kg)	12.0	6.0	12.0	12.0	12.0
Price/ Ton (LE)	5200	4900	4970	4820	4930

*Supplies per kg diet: Vit. A 12000 IU, Vit. D_3 2000 IU, Vit. E 10 mg, Vit. K_3 2 mg, Vit. B_1 1 mg, Vit. B_2 4 mg, Vit. B_6 1.5 mg, Vit. B_{12} 10 mg, Pantothenic acid 10 mg, Nicotinic acid 20 mg, Folic acid 1 mg, Biotin 0.05 mg, Choline chloride 500 mg, Copper 10 mg, Iodine 1 mg, Manganese 55 mg, Zinc 55 mg, Selenium 0.1 mg and Iron 30 mg.

** According to NRC, 1994.

Table (2): Effect of dietary treatments on laying hen performance.

Treatments	Parameters			
	Egg Production (%)	**Egg Weight (g)**	**Feed Intake (g/h/d)**	**FCR**
T1(Cont.)	73.1	62.5^{a}	108.8^{a}	2.38
T2	72.8	58.9^{b}	103.3^{b}	2.41
T3	72.7	59.2^{b}	104.5^{b}	2.43
T4	71.9	58.5^{b}	102.8^{b}	2.44
T5	72.9	58.8^{b}	103.9^{b}	2.42
LSD	1.70	1.40	2.50	0.08

a, b, Means in each column bearing the same superscripts are not significantly different (P<0.05).
T1= Control , T2= 50% CRM , T3= 50% CRM with corn gluten meal,
T4= 50% CRM with dried potato veins and T5=50% CRM with canthaxanthin

Table (3): Effect of dietary treatments on egg quality.

Treatments	Parameters					
	Shape index	**Shell Thick. (mm)**	**HU**	**Egg total lipids (mg/g)**	**Egg cholest. (mg/g)**	**Egg yolk color**
T1(Cont.)	74.4	38.5	84.1	10.2	5.2	9.3^{a}
T2	74.7	37.9	83.9	10.3	5.3	4.7^{c}
T3	74.8	37.8	83.7	10.6	5.5	8.8^{ab}
T4	73.9	37.6	84.3	10.2	5.3	7.5^{b}
T5	74.6	38.3	84.6	10.3	5.8	8.7^{ab}
LSD	2.50	2.10	1.50	1.30	1.20	1.5

a, b, Means in each column bearing the same superscripts are not significantly different (P<0.05).
T1= Control , T2= 50% CRM , T3= 50% CRM with corn gluten meal,
T4= 50% CRM with dried potato veins and T5=50% CRM with canthaxanthin

Table (4): Effect of dietary treatments on economical efficiency.

Treatments	FI / hen (kg)	Price/ kg feed (LE)	Fed cost / hen (LE)	Egg No./ hen	Total revenue (LE)[a]	Net revenue (LE)[b]	E.E[c]	REE[d] (%)
T1(Cont.)	9.14	5.20	47.53	61.4	76.75	29.22	0.61	100
T2	8.68	4.90	42.53	61.1	76.37	33.84	0.79	129
T3	8.78	4.97	43.63	61.1	76.37	32.74	0.75	123
T4	8.63	4.82	41.59	60.4	75.50	33.91	0.81	133
T5	8.73	4.93	43.03	61.2	76.50	33.47	0.78	128

a) Assuming that the selling price of one egg is 1.25 LE.
b) Total revenue – feed cost.
c) Net revenue per unit feed cost.
d) Assuming that the E.E of the control diet = 100.
T1= Control , T2= 50% CRM , T3= 50% CRM with corn gluten meal,
T4= 50% CRM with dried potato veins and T5=50% CRM with canthaxanth

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الملخص العربى

آثر استخدام مسحوق جذور الكسافا والمواد الملونة المختلفة على الآداء الإنتاجى للدجاج البياض ولون الصفار

عبدالله على غزاله[1] ، ممدوح عمر عبدالسميع[1] ، حسن عبدالكريم حسن عبدالحليم[2]
[1] قسم الإنتاج الحيواني - كلية الزراعة – جامعة القاهرة – الجيزة – مصر.
[2] معهد بحوث الإنتاج الحيوانى - مركز البحوث الزراعية - وزارة الزراعة – الدقى – الجيزة - مصر.

فى هذه الدراسة تم استخدام عدد 180 دجاجة بياضة سلالة لوهمان عمر50 أسبوع تم تقسيمهم إلى 5 مجموعات تجريبية موزعة على أربعة مكررات وذلك لدراسة آثر استخدام مسحوق جذور الكسافا والمواد الملونة المختلفة على الآداء الإنتاجى للدجاج البياض وصفات جودة البيضة ولون الصفار وكذلك الكفاءة الاقتصادية لإنتاج البيض. تغذت المجموعة الأولى على عليقة مكونة فقط من الذرة الصفراء كمادة ملونة للصفار مع الأخذ فى الإعتبار أن هذه المجموعة تمثل مجموعة الكنترول. أما المجموعة الثانية تم تغذيتها على عليقة تحتوى على 50% من مسحوق جذور الكسافا كبديل للذرة الصفراء دون إضافة أى مواد ملونة. بينما تغذت المجموعة الثالثة على عليقة تحتوى على 50% من مسحوق جذور الكسافا مع اضافة 2% جلوتين ذرة (كملون طبيعى للصفار). كذلك تغذت المجموعة الرابعة على عليقة تحتوى على 50% من مسحوق جذور الكسافا مع اضافة 2.5% عرش بطاطس مجفف (كملون طبيعى للصفار). أما المجموعة الخامسة فتغذت على عليقة تحتوى على 50% من مسحوق جذور الكسافا مع اضافة 0.2% كانزانثين (كملون صناعى للصفار) وذلك للحصول على علائق تحتوى نفس كمية الزانثوفيل الموجودة فى عليقة الكنترول (12ملجم /كجم). تم تربية الطيور فى بطاريات تحت نفس الظروف من الرعاية طوال فترة التجربة التي استمرت لمدة 12 أسبوع مع تقديم الماء والغذاء بصفة مستمرة وكذلك توفير فترة 16 ساعة إضاءة يوميا.

أوضحت نتائج هذه التجربة عدم وجود فروق معنوية فى قيم إنتاج البيض أو معامل التحويل الغذائى نتيجة المعاملات المختلفة. بينما كان هناك انخفاض معنوى فى كل من قيم وزن البيضة والغذاء المأكول نتيجة استخدام مسحوق جذور الكسافا سواء كان بمفرده أو مع إضافة مصادر مختلفة للملونات وذلك مقارنة بالكنترول.

أيضا أظهرت النتائج عدم وجود فروق معنوية فى قيم صفات جودة البيضة مثل دليل الشكل، سمك القشرة ، وحدات هاوف ، الدهون الكلية والكوليسترول فى البيضة نتيجة المعاملات المختلفة . أما بالنسبة للون الصفار فقد تحسن معنويا عند إضافة أي من الملون الطبيعى أو الصناعى وذلك مقارنة بالعليقة المحتوية على مسحوق جذور الكسافا دون إضافة أى مواد ملونة.

كذلك بينت النتائج أن استخدام مسحوق جذور الكسافا سواء كان بمفرده أو مع إضافة المصادر المختلفة للملونات أدى إلى تحسن قيم الكفاءة الاقتصادية.

نستخلص من هذه الدراسة إمكانية استخدام مسحوق جذور الكسافا حتى مستوى 50% كبديل للذرة الصفراء في علائق الدجاج البياض مع إضافة مصادر مختلفة للمواد الملونة وذلك لتحسين الأداء الإنتاجي ولون الصفار والكفاءة الاقتصادية لإنتاج البيض.