Meal of cassava foliage as pigment of diets with cassava meal and oil of African oil palm for laying hens

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Twenty-eight White Leghorn laying hens, of the Cuban commercial hybrid L-33, were used for eight weeks within the laying peak (36 to 43 weeks of age), to evaluate the meal of root of cassava (*Manihot esculenta* Crantz) and the crude oil of African oil palm (*Elaeis guineensis* J.) as pigments of the egg yolks, out of their incorporation to the diet of laying hens during the laying peak. The birds were allocated in individual cages, with 108 g of feed/bird/d, water *ad libitum*, and 16 h of light. Analysis of variance was performed, according to one-way design with two treatments and fourteen repetitions (one cage with one hen). The treatments consisted of two diets (I- cassava meal + African palm oil, II- cassava meal + African oil palm + 2.5 % of cassava foliage meal). The viability was of 100 % in all the treatments. No differences were found for laying (91.59 and 90.10 %), which surpassed the potential of this hybrid during the laying peak (90 %), feed conversion/egg (118 and 120 g of feed/egg), mass of egg produced (3071 and 3027 g/bird) and mass conversion (1.98 and 2.00). The pigmentation of the egg yolk was doubled, by adding 2.5 % of meal of cassava foliage to the diets (3 and 6 in the scale of Roche). It was likeable to enhance the pigmentation of the egg yolk and reduce the feeding costs of the laying hens, when including 2.5 % of meal of cassava foliage to diets where the cassava meal and the oil of the African oil palm are basic sources of starch and lipids for the laying hens.

Key words: *eggs, cassava, pigmentation*.

Angola is a great producer of cassava and oil of the African oil palm (UCV 1985, MINADEP of Angola 2007, FAO 2010 and FAOSTAT 2011), besides being traditionally an importer of corn and soybean oil (FAO 2010).

Zacarías and Valdivié (2011) substituted, totally and successfully, corn by meal of cassava root, and soybean oil by that of the African oil palm in laying hen diets during the laying peak, not changing the productive performance of the hens. With these substitutions they reduced the feeding costs and the pigmentation of the egg yolk, according to the scale of Roche, starting from six, in the diets of corn + soybean oil, and up to three, in those of meal of cassava root + oil of the African oil palm.

In accord with Mc Dowell *et al*. (1974) and Rosero (2002), the meal of the cassava foliage, when fresh and having between 1.5 and 6 months of elaboration, provides important indices of CP (19.5 to 15 %). In these conditions, the feeding costs are reduced, up to some extent, when substituting small amounts of soybean cake or other protein sources that are expensive in the market in laying hens by meal of cassava foliage (Valdivié *et al*. 2010). Nevertheless, when the cassava foliage grows older, at 9 months of age, it can have, approximately, 13 % of CP. One year after sowing, it can have between 8 and 11 % of CP, and between 4 and 5 % at 22 months.

From the nutritional point of view, the principal limitation of this meal in poultry feeding is its low content of ME (5768.4 to 7093.5 MJ of ME birds/kg) (Buitrago 1990 and do Santos *et al*. 2009). When using high levels of this foliage, its content of CF, tannins, and maybe cyanhydric acid, may affect the performance of the birds (Buitrago 2009).

The cassava foliage is rich in carotenoid pigments, thus, it is appropriate to pigment the egg yolks, the legs, the skin, and the peak of the birds, when used at 2 to 6 % in diets of laying hens and other birds (Flores 1998, Buitrago *et al*. 2001, Buitrago 2009 and Valdivié *et al*. 2010).

This research was performed to enhance the pigmentation of the egg yolk and reduce the feeding costs in laying hens, when including 2.5 % of meal of cassava foliage in diets where the cassava meal and the oil from the African oil palm are basic sources of starch and lipids for laying hens within the laying peak.

Materials and Methods

The experiment was performed in the poultry facilities of the Institute of Animal Science, in the Mayabeque province, Cuba. Twenty-eight White Leghorn laying hens, of the hybrid L-33, of 36 weeks of age, were used during the laying peak, with 90 % laying or more, according to the recommendations of Caballero (1982).

The birds were allocated in two treatments consisting of two diets: I) control with meal of cassava root as basic source of energy + 2.5 % of oil of the African oil palm; II) addition of 2.5 % of meal of the cassava foliage of five months of establishment (table 1).

The chemical analyses of the raw material were performed in the Center of Tropical Roots and Starches (CERAT) of the UNESP, in Sao Paulo, Brazil. The meal of cassava root contained 87.79 % of DM; 2.19 % of CP; 0.47 % of EE; 72.81 % of starch; 5.26 %

Table 1. Composition of the diets, contributions and prices

Ingredients	Cassava meal + 2.5 % African palm oil	Cassava meal + 2.5 % African palm oil + 2.5 meal of cassava foliage
Meal of cassava root	52.89	51.63
Soybean cake	32.74	31.51
Meal of cassava foliage	-	2.50
Crude oil of African oil palm	2.50	2.50
Premixture of vit. and minerals	1.00	1.00
Monocalcium phosphate	1.23	1.32
Calcium carbonate	9.05	8.94
Common salt	0.25	0.25
DL-methionine	0.31	0.32
BHT	0.01	0.01
Coline chloride	0.02	0.02
Crude protein	15.71	15.71
ME, MJ/kg	10836.06	10713.03
Calcium, %	3.83	3.83
Available phosphorus, %	0.36	0.36
Lysine, %	0.91	0.91
Methionine + cystine, %	0.77	0.77
Threonine, %	0.55	0.53
Tryptophan, %	0.19	0.19
Crude fiber, %	5.00	5.00
Cost USD/t	302.15	296.89

USD-United States dollars

of simple sugars, and 10.7 ppm of cyanhydric acid. The meal of cassava foliage, cut at five months of sowing, contained 89.35 % of DM, 15.23 % of CP; 2.54 % of EE; 1.21 % of starch; 1.03 % of simple sugars; and 1.81 ppm of cyanhydric acid.

DM, CP, EE and starch were determined according to AOAC (2000). The simple sugars (glucose, sucrose, and fructose) were prepared according to Hurst *et al*. (1979) and they were injected in HPLC equipment (VarianProStar 220/230/240 Pump). The figure of 12958 MJ was selected out of the quality table of the meal of cassava root, described by Bernal *et al*. (2010). The high content of starch (72. 81 %) of the meal was considered.

The ME was estimated for the oil of the African oil palm (36855.1 M J) and for the meal of cassava foliage (6186.4 MJ), according to the values of Rostagno *et al*. (2005) and according to average of Hutagalung (1976) and Buitrago (1990), respectively.

The hens were allocated in individual cages, of 40 cm x 40 cm, with two nipple drinkers guaranteeing water *ad libitum*, and a linear feeder of 40 cm of length, receiving 108 g of feedstuff /bird/d. They were supplied 16 h of light. Table1 shows the daily amount of nutrients and ME given to the hens in 108 g of feedstuff.

Analysis of variance was performed, according to completely randomized design, with two treatments and 14 repetitions (individual cage with one hen). The birds had two weeks of adaptation to the diets (34 and 35 weeks of age), in agreement with Caballero (1982). Lately, they were eight weeks (56 d) in experimentation.

The indicators daily intake (feedstuff, nutrients and ME) and individual liveweight (at 36 and 43 weeks of age); daily egg production and individual egg weight (once weekly); broken eggs (daily), eggs covered with a soft membrane (daily), eggs with double yolk (daily); and pigmentation of the yolk of 12 eggs (33, 38, and 44 weeks of age) with the Roche yolk color fan were measured. At 33 weeks, the pigmentation of the eggs had the value of 6 in the yolk of all the eggs, according to the scale of the Roche color fan. These elements permitted calculating the mass of eggs/bird and the mass conversion of feedstuff consumed/egg produced.

The economic analysis was conducted by the difference in the prices of the feeds consumed by the birds, which was the only variation between treatments. The prices in USD/t for the economic analysis were: meal of cassava root (195), soybean oil (1316), oil of the African oil palm (422), soybean cake (430), meal of cassava foliage (58.3), premixture (1649), monocalcium phosphate (578), DL-methionine (5716), L-lysine (2676) BHT (1906), coline chloride (1259), calcium carbonate

(56) and common salt (360).

Results and Discussion

The viability was of 100 % in the two treatments, which proves that the utilization of meal of cassava root, as basic source of starch and energy, together with the oil of the African oil palm, as basic lipid source, with 2.5 % of meal of cassava foliage or without it, does not provoke deaths in laying hens. This conclusion has been supported by the works of Cruz *et al*. (2006), dos Santos *et al*. (2009) and Valdivié *et al*. (2010). This high viability was related to the low content of anti-nutritional substances in the meal of cassava root (10.7 ppm of cyanhydric acid) and in the meal of cassava foliage (1.81ppm of cyanhydric acid) used in this experiment.

Table 2 shows that the feedstuff intake was of 108 g/bird/d, because the birds were given the same amount all the days and they ingested it without any leftover. Thus, the hens had in all the treatments the same intake of crude protein (16.97 g of CP/bird/d), methionine + cystine (832 mg/bird/d), lysine (983 mg/bird/d), calcium (4.14g/bird/d) and available phosphorus (389 mg/bird/d). According to Rostagno *et al*. (2005), Hy Line (2006) and UECAN (2010), the needs for these nutrients is fulfilled with these intakes.

The ME content of the diets was reduced only to 12.54 MJ/bird/d using the meal of cassava foliage, thereby increasing the content of plant oil of the feedstuff formula for not increasing its cost, when substituting totally corn by the meal of cassava root (table 2).

The daily needs of ME for White Leghorn laying hens are of 1195.4 to 1195.5 MJ of EME/bird/d, according to Hy-Line (2006). Thus, there are no harms to the laying or the egg quality with intakes of 1170.4 to 1157.9 MJ/bird/d (table 2).

The egg production during the eight weeks of the laying peak did not differ significantly between treatments (table 3), and it surpassed the 90 % of the laying throughout the experiment. This indicates that the diets permitted the Cuban L-33 layers to express or surpass the maximum laying indicated for this hybrid during the laying peak (90 %), according to reports of the UECAN (2010).

These results were in accordance with those of Temperton and Dudley (1941), Pillai *et al*. (1968), Enrique and Ross (1972), Hamid and Jalaludin (1972), Montilla *et al*. (1973), Muller *et al*. (1974), Eshiet and Ademosun (1976), Khajarern*et al*. (1979), Tewe and Egbunique (1992), Ávila (1996), Tewe and Bokanga (2001), Cruz *et al*. (2006) and Do Santos *et al*. (2009). These authors used, in their diets, sources of lipids that reduced the powder effect, and the intake was not impaired. Besides, there was use of cassava meal with high starch content (rich in ME) and low contribution of cyanhydric acid.

The egg weight did not differ between treatments (table 3) and it was found within the adequate range for the weight of the eggs commercialized in Cuba. Also, there were not significant differences either between treatments for the feed intake and the egg production. Therefore, it is obvious that no differences were found between treatments for the mass of eggs produced, the feedstuff consumed/egg, and the mass conversion.

The indicators of feed conversion can be classified as excellent, because an expense of only 118 to 120 g of feed/egg produced is quite attractive for any egg producing farm. This feed efficiency supports the nutritional quality of these feeding systems, where the meal of cassava root and the oil of the African oil palm substitute the cereals and the traditional plant oils.

At 38 and 43 weeks of age, the pigmentation of 6 in the scale of Roche was kept stable with the addition of 2.5 % of meal of the cassava foliage to the feedstuffs of meal of cassava root + oil of the African oil palm. However, when not adding the meal of the cassava foliage, the pigmentation of the egg yolk was reduced to 4, at 38 weeks of age, and to 3, at the 43 weeks of age. Thus, it was proved that in order to keep a pigmentation of 6 in the scale of Roche, the diets of cassava meal + oil of the African oil palm should be supplemented with

Table 2. Calculated intake of nutrients and metabolizable energy

Nutrient or metabolizable energy	53 % cassava meal + 2.5 % African palm tree oil	52 % cassava meal + 2.5 % African palm tree oil + 2.5 % cassava foliage meal
Feedstuff, g/bird/d	108.00	108.00
ME, g/bird/d	280.00	277.00
CP, g/bird/d	16.97	16.97
Methionine+Cystine mg/bird/d	832.00	832.00
Lysine, mg/bird/d	983.00	983.00
Threonine, mg/bird/d	594.00	572.00
Tryptophan, mg/bird/d	205.00	205.00
Calcium, g/bird/d	4.14	4.14
Phosphorous available, mg/bird/d	389.00	389.00

Table 3. Performance of the hens during 56 d of the laying peak

Indicators	53 % cassava meal + 2.5 % African palm tree oil	52 % cassava meal + 2.5 % African palm tree oil +2.5 % cassava foliage meal	SE ±
Viability, %	100.00	100.00	-
Laying, %	91.59	90.10	1.70
Feed intake, g/bird	6048.00	6048.00	0.00
Feedstuff g/egg	118.00	120.00	2.00
Egg weigth, g/egg	59.90	60.00	0.09
Egg mass, g/egg	3071.00	3027.00	56.00
Feedstuff consumed/mass of egg produced	1.98	2.00	0.04
Yolk pigmentation, (33 week)	6.00	6.00	-
Yolk pigmentation, (38 week)	4.00	6.00	-
Yolk pigmentation, (43 week)	3.00	6.00	-

2.5 % of meal of cassava foliage or any other effective source of carotenoid pigments.

The pigmenting properties of the meal of cassava foliage for the egg yolk had been previously noted by Augudu (1972), Flores (1998), Gill and Buitrago (2002), Do Santos *et al*. (2009) and Valdivié *et al*. (2010), when adding levels of 1.5 to 6 % to the diets of laying hens. These properties had been attributed to the high content of xanthofils of the cassava leaf (605 mg/kg of total xanthofils and 508 mg/kg of pigmenting xanthofils), whereas the corn grain contains only 25 mg of total xanthofils/kg (Gil and Buitrago 2002).

Table 4 shows the variation of the daily intake of raw materials of feedstuffs in the laying hens, when including the meal of cassava foliage. As a result, the intake of meal of cassava root, soybean cake and calcium carbonate was diminished, and the intake of monocalcium phosphate and DL- methionine was increased. This is beneficial, from the economic point of view, because the cost of the feed consumed per each hen during the 56 d of test was three cents cheaper in USD with the application of the treatment with meal of cassava root + oil of African oil palm + 2.5 % of meal of cassava foliage.

In order to maintain a pigmentation of 6 in the scale of Roche, the diets of cassava meal + oil of African oil palm should be supplemented with 2.5 % of meal of cassava foliage. This generates an additional economic effect, equivalent to a saving of 20 cents in USD/bird/year.

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Table 4. Intake of feedstuff raw material/bird every day and economic effect

Raw material	Cassava meal + 2.5% African palm tree oil	Cassava meal + 2.5% African palm tree oil +2,5% cassava foliage meal
Meal of cavassa, g/bird/d	57.12	55.76
Soybean cake, g/bird/d	35.36	34.03
Monocalcium phosphate, g/bird/d	1.33	1.43
Calcium carbonate, g/bird/d	9.77	9.66
DL-methionine, g/bird/d	0.33	0.35
Cost of the feed consumed in 56 d, USD/ave	1.83	1.80

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