

PERFORMANCE OF LAYERS FED TOASTED, BOILED OR BOILED AND SOAKED CASTOR OIL SEED MEAL (*R. COMMUNIS*)

RESPUESTA PRODUCTIVA DE PONEDORAS ALIMENTADAS CON HARINA DE SEMILLA DE RICINO (*R. COMMUNIS*), TOSTADA, COCIDA Y COCIDA Y HÚMEDA

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ADDITIONAL KEYWORDS

Egg quality. Layers. Processing. Ricin.

PALABRAS CLAVE ADICIONALES

Calidad de huevo. Ponedoras. Procesamiento. Ricino.

SUMMARY

A feeding trial was conducted to investigate the response of Isa Brown laying hens to three different methods of processing castor oil seed meals (CSM); toasting, boiling and boiling-and-soaking for using as total substitute for soybean meal. Two hundred, 75-week old laying birds were randomly assigned to four experimental diets in a completely randomized design experiment. The control diet (CD) contained 19.10 % soybean; the proportion of soybean in the CD (T_1) was replaced completely with toasted, boiled and boiled-and-soaked castor oil seed meal in diets T_2 , T_3 and T_4 respectively. Chemical analysis showed that treatment methods did not have any significant ($p > 0.05$) effect on the dry matter (DM), crude fibre (CF), ether extract (EE), ash, nitrogen free extract (NFE) and gross energy of the meal. However, the crude protein value of the toasted meal (24.55 %) decreased ($p < 0.05$) significantly as compared to the other two treatment methods. Toasted method also retain significantly ($p < 0.05$) higher level of ricin value (0.21 mg/100 g) when compared to boiling (0.09 mg/100 g) and boiling-and-soaking (0.03 mg/100 g). Birds on the control diet, T_3 and T_4 had numerically ($p > 0.05$) similar values of final live weight, weight gain, feed conversion ratio and hen day production that were significantly ($p < 0.05$) favorable than birds on T_2 . Birds on T_2 also had significantly ($p < 0.05$) depressed liver weight (2.11 %) as compared to birds on the control diet (2.87 %). Haemoglobin (Hb) values also showed a significant decrease ($p < 0.05$) in birds on T_2 (2.23

g/dL) than that of birds on the control (10.67 g/dL), T_3 (10.11 g/dL) and T_4 (10.35 g/dL). Birds on T_2 equally had a significantly ($p < 0.05$) decreased RBC (154.33×10^3) in relation to the control diet (288.02×10^3). The egg quality parameters were not significantly ($p > 0.05$) affected by the test ingredient apart from promoting lighter egg yolk coloration. The study showed that boiled and boiled-and-soaked CSM can totally replace soybean meal in layers diet without any adverse effect on egg production, external and internal egg qualities, except encouragement of lighter yolk coloration. Boiling-and-soaking however, as a processing method had no special advantage in terms of egg production parameters and egg quality parameters, hence the additional task of soaking after boiling was unnecessary. Boiling of castor oil seed for 40 minutes is therefore preferred among the treatment methods. As an industrial waste, CSM incorporation in layer diets as a feed ingredient especially for large scale operations would results in substantial cost savings.

RESUMEN

Un ensayo de alimentación fue realizado para investigar la respuesta de gallinas ponedoras Isa Brown a tres métodos diferentes de procesamiento de las semillas de ricino (CSM); que son tostado, hervido y hervido humedecido para usarlos como sustitutos totales de la harina de soja. Doscientas gallinas ponedoras de 75 semanas

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fueron aleatoriamente asignadas a 4 dietas experimentales en un diseño completamente al azar. La dieta control (CD) contenía 19,1 % de soja; la proporción de soja en la CD (T1) fue sustituida completamente con harina de semilla de ricino, tostada, hervida y humedecida en las dietas T2, T3 y T4 respectivamente. Los análisis químicos demostraron que los métodos aplicados no tuvieron efectos significativos sobre la materia seca, fibra bruta, extracto etéreo, cenizas, extracto no nitrogenado y energía bruta de la harina. Sin embargo, la proteína bruta de la harina tostada (24,55 %) disminuyó ($p < 0,05$) en comparación con los otros 2 tratamientos. El método de tostado mantuvo significativamente ($p < 0,05$) elevados valores de ricina (0,21 mg/100 g) comparado al hervido (0,09 mg/100 g) y el procedimiento de hervido y humidificación (0,03 mg/100 g). Las aves de las dietas control, T3 y T4 determinaron valores numericamente similares del peso vivo final, ganancia de peso, conversión alimenticia y producción diaria por gallina que fueron significativamente ($p < 0,05$) favorables respecto a las aves del T2. Las aves del T2 tuvieron también un peso del hígado (2,11 %) menor ($p < 0,05$) que las de la dieta control (2,87 %). La hemoglobina también demostró un descenso significativo en las aves del T2 (2,23 g/dL) respecto a las de la dieta control (10,67 g/dL), T₃ (10,11 g/dL) y T₄ (10,35 g/dL). Igualmente las aves del T2 tuvieron valores inferiores de RBC ($154,33 \times 10^3$) en relación con la dieta control ($288,02 \times 10^3$). Los parámetros de calidad del huevo no fueron afectados por los ingredientes probados aparte de la coloración de la yema. El estudio demostró que la CSM hervida o hervida y humedecida puede reemplazar totalmente a la harina de soja en la dieta de ponedoras sin ningún efecto adverso sobre la producción de huevos, calidad interna y externa, salvo una coloración más clara de la yema. El hervido y humedecido sin embargo, no tiene especial ventaja como método de tratamiento en términos de producción y calidad de huevos, por lo que la tarea adicional de humedecer después del hervido es innecesaria. El hervido de la semilla de ricino durante 40 minutos, es por ello, preferible a los otros métodos. Como residuo industrial la incorporación de CSM en la dieta de ponedoras como ingrediente alimenticio, especialmente en operaciones a gran escala puede dar lugar a considerables ahorros de costes.

INTRODUCTION

In Nigeria, one of the major problems facing the livestock industry is that of increasing unavailability of the conventional feedstuffs. The competition between humans and monogastrics for these grains has further hiked prices, thereby threatening the potential for increasing animal protein production, which is in short supply (Bawa *et al.*, 2007). This has led to the search for alternative feedstuffs for animal production. Such alternatives according to Oyebiyi *et al.* (2007) should of necessity be available all year round; easy to be procured and processed, if need be, into usable forms and must have a comparable cost advantage over the conventional feedstuffs.

One of such important but lesser known plant protein sources is the castor oil seed (*Ricinus communis*). The seeds are obtained from the castor tree, an evergreen herbaceous or semi woody long shrub or small tree that gets up to 40ft (12 m) tall and 15ft (4.6 m) in diameter (Weedfact, 2003), widely distributed in Tropical Africa, in India and Temperate regions (FAO, 1997). In Nigeria, castor oil bean is distributed in a number of the Southern States including Nsukka, Awka, Anambra, Bendel, Imo and Cross River States (Okorie *et al.*, 1985 and Rehman, 1999). The raw seed is high in protein 32.80 to 40.00 % (Okorie *et al.*, 1985; Nsa and Ukachukwu, 2009), with an ideal amino acid profile that is moderately high in cystine, methionine, tryptophan and isoleucine (Harnold, 2002).

The seeds, leaves and stems of castor plant are poisonous to people, animals and insects due to the toxic protein known as ricin, a phytotoxin believed to have cytostatic and cytotoxic effects in the cells and exhibits antitrypsin action as in some legumes (Clarke and Clarke, 1975). Castor oil bean also has agglutinating property. The agglutination is believed to be due to RCA (*Ricinus communis agglutinin*). However, poisoning caused by ingestion is only due

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to ricin, as RCA does not affect red blood cells unless given intravenously (Vietta and Thorpe, 1991).

Autoclaving, cooking or boiling, steam heating, infra-ray cooking, extrusion cooking, toasting, salt-bed roasting and radio frequency dielectric heating methods have been employed in detoxifying castor oil seeds (Raghavan *et al.*, 1974; Borchers *et al.*, 1972; Gustafson *et al.*, 1971; Waldroup and Hazen, 1978; Udedibie *et al.*, 1996; IFSP, 1988). Some of these treatments are locally adaptable by farmers and feed millers in Nigeria since they do not involve sophisticated equipment or huge capital investment (Ukachukwu and Obioha, 1997). These include cooking, soaking and boiling.

The possibility of using castor oil bean meal as a feeding stuff has shown no adverse effect or pathological changes in rats, guinea pigs, sheep, cows and birds fed up to 20 % detoxified castor oil bean meal (Nsa *et al.*, 2010).

Though thermal treatments is a very successful method of detoxifying or inactivating ricin, researches showed that steaming of castor seeds for 15 minutes was unsuccessful as witnessed by the 95 % mortality among the fed chicks. Chicks fed diets with 40 % autoclaved castor pomace left some residue of toxic substance, but when washed with water, HCl or Ethanol, satisfactory result was obtained (Okomato *et al.*, 1965). Autoclaving of allergen isolated from ricin for one hour eliminated the toxin completely, implying that, direct boiling destroys and eliminates ricin in castor seeds (Poliankoff, 1980). Okorie *et al.* (1985) showed that ricin components can be destroyed by roasting the bean at 140 °C for 20 minutes.

The nutritive composition and digestibility of a dehulled castor seed are said to improve when heated longer in steam (Clemens and Vern, 1965). However, excessive thermal treatment reduces the nutrient content of the seed either through denaturation or solubilisation and subsequent

leaching (Ukachukwu and Obioha, 1997, Nsa and Ukachukwu, 2009). Earlier report showed that amino acid value of toasted seed could worsen with excessive heat treatment while autoclaving was shown to destroy cystein (D'Mello *et al.*, 1985).

Unlike broiler and rabbit production, there is little information on complete replacement of soybean meal with castor oil seed meal in layer feeds. The present study is therefore designed to investigate the extent to which locally adaptable thermal processing methods can improve the nutritive value of castor oil bean in egg production, egg quality parameters, haematological and serum chemistry of laying birds.

MATERIALS AND METHODS

The study was conducted at the Poultry Unit of the Department of Animal Science Research and Teaching Farm, University of Calabar, Nigeria. Castor oil bean seeds and other feed ingredients used for the study were bought from Ogoja local Markets in Cross River State of South-South Nigeria.

PROCESSING OF CASTOR OIL BEAN SEEDS

The large mottled variety of castor bean seeds were used for this study. The undecorticated seeds were divided into three portions. One lot was subjected to boiling for 40 minutes as described by Ani and Okorie (2006), the other by 30 minutes boiling followed by soaking for 48 hours, while the last lot was toasted for 30 minutes as described by Nsa and Ukachukwu (2009).

Boiled seeds (40 minutes). Water was brought to boiling at 100 °C before the castor seeds were poured in. Boiling continued at 100-105 °C for 40 minutes. At the end of boiling water was drained off. The seeds were then thinly spread out on a concrete floor and sun dried for 5 days. The dry seeds were ground in hammer mill, defatted and stored in air tight bag.

Boiled (30 minutes) and soaked (48

hours) seeds. Seeds were poured into boiling water and allowed to boil for 30 minutes. Water was then drained off, followed by soaking in water that was 5 times the volume of the seeds for 48 hours. Decanting and drying followed the same procedure.

Toasted seeds (30 minutes). Sand was poured into a drum and made to attain a temperature of 140°C using firewood before introducing the seeds. Turning was carried out frequently. At the end of 30 minutes, sand was immediately sifted out by means of a sieve and the seeds spread out to cool.

Analysis. Equal samples in each batch of the processed castor seed meals (CSM) were collected, ground and bottled in airtight containers for chemical analyses (Nsa *et al.*, 2010).

Determination of proximate composition of the sample was by AOAC (1995) procedure, employing the micro-Kjeldahl method for crude protein (CP) and Soxhlet extraction method for ether extract (EE). Nitrogen free extract was determined by difference. The gross energy of the samples was assayed using the adiabatic oxygen bomb calorimetric technique.

Ricin was extracted and isolated by method similar to that of Mise *et al.* (1971). The potent ricin component was extracted from the ground castor seed meal with methanol under reflux for 24 hours.

EXPERIMENTAL BIRDS: MANAGEMENT AND DIET

Two hundred (200), 75 week old Isa Brown strain laying birds from a commercial farm in Cross River State were used for the study. The birds were weighed and randomly allotted to the four treatment groups of 50 birds each with five replicates of 10 birds each. They were managed intensively in a two-tiered battery caged unit. Two birds were housed in each compartment of the cage measuring 30x38x48 cm. Coccidial and bacterial treatments that served as part of the birds routine management continued within the period with the administration of

wormazine. The experiment lasted for 10 weeks, with 2 weeks serving as a stabilization period.

Four experimental diets were formulated (**table I**) in such a way that soybean meal was replaced by each of toasted, boiled, boiled-and-soaked CSM denoted as T₂, T₃ and T₄ respectively, while T₁ was the control. The crude protein (%) and metabolisable energy (kcal/kg) contents of the feed were within the recommended range (NRC, 1994). Feed and water were given to the birds *ad libitum*.

EXPERIMENTAL DESIGN AND DATA COLLECTION

The experiment was designed to be a completely randomized design and lasted for 10 weeks. Individual birds were weighed at the commencement of the experiment, and subsequently weighed weekly. Feed consumption was measured by calculating the difference in the quantity of feed offered daily and the quantity left. Egg weight was recorded daily while the mean hen day production (HDP) was computed weekly from the production records. The HDP was calculated as number of eggs produced/ number of hens x number of days x 100. Birds were closely observed for mortality to effect adjustment in feed calculation.

Egg quality characteristics were determined from two freshly laid eggs, free of cracks, from each replicate using the following parameters; egg weight, yolk weight, albumin weight, shell weight, albumin height, shell thickness, yolk thickness, yolk height, yolk width, yolk index, haugh unit and yolk colour.

Egg weight and albumin height were used to compute the haugh unit using the simple formula of Haugh (1937).

Albumin height (mm) was taken as the height of the thick white of the chalazae at a point about the midway between the inner and outer circumference of thick white with tripod micrometer (P6085 spherometer) having an accuracy of 0.01 mm.

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Yolk weight (g) was obtained by separating the yolk from the albumen using a plastic egg separator and thereafter weighed with the use of electronic sensitive weighing balance. The yolk width (cm) was measured around the widest horizontal circumference using vernier caliper. Yolk colour was graded with the Hoffman-la-Roche, with yolk colour intensity from pale yellow (Score 1) to deep orange (Score 15).

Blood samples from 2 birds per replicate at the 10th week of the experiment were collected through the wing vein into ethylene diamine tetra-acetate (EDTA) bottles for haematological studies; packed cell volume (PCV), haemoglobin concentration (Hb) and red blood cell counts (RBC) were determined using Wintrob's microhaematocrit, colorimetry cyanomethaemoglobin method and improved Neubauer

Table 1. Composition of layer diets containing toasted, boiled and boiled-and- soaked processing methods of castor oil seed meal (CSM). (Composición de las dietas de las ponedoras a base de semilla de ricino (CSM) tostada, hervida, y hervida y humedecida).

	Control diet	Toasted	Boiled	Boiled- soaked
Ingredients (%)				
Maize	52.00	52.00	52.00	52.00
Wheat offal	16.50	16.50	16.50	16.50
CSM	0	19.10	19.10	19.10
Soy bean meal	19.10	0	0	0
Fish meal	2.0	2.0	2.0	2.0
Bone meal	3.00	3.00	3.00	3.00
Oyster shell	6.50	6.50	6.50	6.50
Salt	0.35	0.35	0.35	0.35
Methionine	0.15	0.15	0.15	0.15
Lysine	0.15	0.15	0.15	0.15
Vit./min. Premix ¹	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated analysis (%)				
Crude protein	16.25	15.18	15.90	15.45
Ether extract	2.83	2.90	2.96	3.13
ME(kcal/kg) ²	2558.05	2571.43	2593.12	2612.19
Calcium	3.58	3.56	3.55	3.51
Total phosphorus	0.86	0.86	0.85	0.83
Determined analysis (%)				
Crude protein	16.31	15.11	15.04	14.98
Ether extract	2.34	2.41	2.48	2.60
Crude fibre	5.98	6.11	6.33	6.60
ME(kcal/kg)	2550.00	2568.19	2571.45	2579.10
Calcium	3.67	3.61	3.55	3.42
Total phosphorus	0.88	0.88	0.85	0.81

¹Trace minerals for kg⁻¹ diet contain: Mn 40 g; Fe 20 g; Zn 18 g; Cu 0.8 g; Co 0.09 g and Se 0.04 g. The vitamins for each kg contain: Vit. A 5 000 000 i.u.; Vit D3 1 100 000 i.u.; Vit K 0.8 g; Vit B12 8.0 g; Folic acid 0.4 g; Biotin 0.02 g; Vit C 10.0 g; Cholin chloride 120.0 g; Zinc bacitracin 8.0 g; Methionine 80.0 g; Avatec 36.0 g.

²Metabolisable energy was calculated using Ponzenga (1985) formula, [ME(kcal/kg)= 37 (% CP)+81.8 (% EE)+35.5 (% NFE)].

haemocytometer, respectively (Lamb, 1991). Three birds per treatment were sacrificed and the following organs weighed; liver, kidney, heart and pancreas as described by Udedibie *et al.* (1996).

STATISTICAL ANALYSIS

All data were subjected to one - way analysis of variance (ANOVA) for CRD. Differences between the treatment means were separated using Duncan's Multiple Range Test as outlined by Daniel (1991).

RESULTS AND DISCUSSION

The gross composition of experimental diets is presented in **table I**. While the proximate composition, gross energy and ricin content of toasted, boiled and boiled-and-soaked castor seed meals are presented in **table II**. Among the treatment methods, only toasting brought about Significant ($p < 0.05$) differences in crude protein (% CP) and ricin content of the meal. Other chemical components namely dry matter, crude fiber, ether extract, ash, nitrogen free-extract and gross energy were not affected by processing methods. The crude protein content

of the toasted meal (24.55 %) was significantly ($p < 0.05$) lower than both boiled seed meal (28.33 %) and boiled-and-soaked seed meal (26.43 %). The lower level of crude protein in toasted meal could be attributed to the dry heat which quickens the denaturation, complex bond forming with other nutrients especially carbohydrate and subsequent solubilisation of protein due to excessive heat treatment (Nsa, 2008). However, Values obtained from all the treatment methods were higher than the 21.80, 22.50 and 22.39 percent crude protein levels reported for raw kidney bean, lima bean and pigeon pea respectively (Oyenuga, 1968; Okorie *et al.*, 1985; Apata and Ologhobo, 1994; Ukachukwu and Obioha, 1997; Ukotebi, 2002). Nsa and Ukachukwu (2009) have shown that the crude protein value of castor oil seed meal ranks with those of green seed, bambara, groundnut seed, *Mucuna cochinenensis*, *Milletia obanensis*, but lower than that of groundnut and soybean seed meal which is the richest in crude protein value among the legume species (Ene-Obong and Carnovale, 1992; Apata and Ologhobo, 1994). This indicates that all the treatment methods retain adequate protein level as a good concentrate source for livestock feeds. The ricin content of the toasted meal (0.21 mg/100 g) was significantly higher than the boiled seed meal (0.09 mg/100 g) and boiled-and-soaked seed meal (0.03 %). This observation was in consonance with earlier findings by Okorie *et al.* (1985), where wet treatment was more effective in ricin reduction than dry heat treatment.

The response of laying birds to total replacement of soybean meal with three different methods of processed castor oil seed meals is presented in **table III**. There was no significant ($p > 0.05$) difference in the mean daily feed intake (MDFI) of birds across the treatment groups. This indicates that there was no inhibition in the consumption of any of the diets. Any differences observed in other performance parameters could

Table II. Proximate composition, gross energy and ricin content of processed castor oil seed meal (% DM basis). (Composición, energía bruta y contenido de ricina de semilla de ricino procesada (%MS).

	Toasted	Boiled	Boiled- soaked	SEM
Dry matter	87.69	84.15	82.11	7.03
Crude protein	24.55 ^b	28.33 ^a	26.43 ^{ab}	2.99
Crude fibre	21.67	19.88	18.43	2.16
Ether extract	17.56	17.21	17.11	0.54
Ash	4.35	4.12	4.02	0.17
NFE	31.87	30.46	34.01	4.88
Gross energy ¹	4.01	3.98	3.88	0.16
Ricin (mg/100 g)	0.21 ^a	0.09 ^b	0.03 ^b	0.02

Means on the same row with different superscripts are significantly different ($p < 0.05$). ¹kcal/g.

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therefore only arise from the utilization of the diets.

Significantly better average weight gains (AWG) and average final weight (AFW) were achieved for birds on the control diets, which did not show any significant ($p < 0.05$) difference with birds on diets containing boiled (T_3) and boiled-and-soaked castor seed meal (T_4). Birds on diet containing toasted castor oil seed meal however, had depressed average live weight (ALW) (1.65 kg) and AWG (4.22 g). The depressed AWG and FLW of birds on T_2 could be due to high residue of ricin. It could be recalled that of all the three treatment methods (**table II**), the level of ricin was highest in the toasted sample. Ricin has been found by Nsa *et al.* (2010) to be growth depressant. The mean feed conversion ratio were significantly different ($p < 0.05$) with birds on treatment diets T_1 , T_3 and T_4 having similar and better ($p < 0.05$) feed conversion than birds on T_2 . This result shows that birds on T_3 were poor

converters of feed to dozen of egg, this might be due to the high residue of ricin in the toasted meal. Nsa (2008) reported decrease in egg production as ricin content in laying birds diet increased. The improved performance of the birds on diets containing other test ingredients other than toasted seed meal, suggested enhanced nutritive value which encouraged better utilization by laying birds and could be attributed to the better detoxification of the meal (**table II**), similar observations were recorded by Udedibie and Mba (1994); Amaefule and Obioha (1998); Finks *et al.* (1992); Ukachukwu and Anugwa (1995); Nsa *et al.* (2010) for pigeon pea, pigeon pea, cowpea, soybean and castor oil seed respectively.

The Hen Day Production of birds on the control was significantly better than those on the toasted meal but was similar with birds on the boiled and boiled-and-soaked meals could be due to the poor utilization of the toasted CSM by laying birds. Generally,

Table III. Effect of boiling, boiling-and-soaking and toasting as processing methods of castor oil seed meal in diet on egg production and egg quality of pullets. (Efecto del uso de semilla de ricino (CSM) tostada, hervida, y hervida y humedecida sobre la producción y calidad de los huevos).

	Control diet	Toasted	Boiled	Boiled- soaked	SEM
Initial weight (kg/bird)	1.78	1.77	1.77	1.78	0.14
Final weight (kg/bird)	1.88 ^a	1.65 ^b	1.83 ^a	1.84 ^a	0.18
Feed intake (g/bird/day)	142.15	133.24	139.56	140.11	7.61
Feed conversion (kg/doz.egg)	2.31 ^b	2.89 ^a	2.45 ^b	2.38 ^b	0.17
Hen day production %	69.02 ^a	51.50 ^b	63.89 ^a	64.43 ^a	2.11
Mortality	0.5	1.0	0.5	1.0	0.02
Egg weight (g)	58.14	54.12	56.97	57.13	6.11
Albumin height (mm)	7.98	7.79	7.81	7.65	0.78
Albumin weight (g)	35.60	34.78	34.86	35.13	1.88
Haugh unit (H.U.)	89.22	88.34	89.06	89.14	11.44
Shell thickness (mm)	0.34	0.34	0.34	0.33	0.01
Shell weight (g)	6.92	6.86	6.88	6.84	0.77
Yolk/albumin ratio	0.43	0.41	0.42	0.42	0.01
Yolk weight (g)	15.28	15.12	15.14	15.19	3.21
Yolk colour	9.72 ^a	4.12 ^b	5.47 ^b	5.33 ^b	0.99

Means on the same row with different superscript differ significantly ($p < 0.05$).

the values obtained for yolk weight, shell thickness in all the treatment diets including the control were similar to the observation of Odunsi *et al.* (2002); Ezieshie *et al.* (2001); Adeniji and Balogun (2002); Olayeni *et al.* (2007). This was expected since all the birds were mature and of the same age. This agreed with the findings by Abdullah *et al.* (2003) who reported that the age of the hen strongly influenced the egg size and the proportion of its components. Although, Egg thickness is a good indicator of shell strength and is important in the handling and marketing of eggs to minimize breakage. It therefore appears that the processed Castor oil seed meal were not lacking in nutrients (minerals and vitamins) directly involved in the formation of a strong shell, and these are mainly calcium, phosphorus, magnesium, chlorine, potassium and vitamins (Wal-droup and Hazen, 1978).

The results obtained from the external qualities of eggs and some internal qualities such as egg weight, albumin weight, yolk albumen ratio and yolk weight were expected since all the birds were mature and of the same age. The yolk colour however, was

affected significantly ($p < 0.05$) by the CSM. Apart from the Control Diet, all other diets with castor oil seed meal encouraged lighter egg yolk colour. This observation was contrary to the reports of Okorie *et al.* (1985) who reported the raw castor oil seed to be high in carotene (7-15 mg/kg) a range that is higher than values obtained for other oil seeds. So one should have expected the yolk colour to even be higher with diets with Castor oil seed meal, since pigmented ingredients, especially xanthophylls, cause dark orange yolk and lesser pigmented feed gives a relatively light yellow yolk. However, toasting, cooking and soaking of the seeds might have affected the carotene level of the castor oil seed meal. The haugh unit showed no significant changes ($p > 0.05$) but however seems to be a bit lower for birds on diet with toasted castor oil seed meal (88.34). Haugh unit is one of the most important parameters for determining the quality of an egg. According to the United States Department of Agriculture (USDA), a haugh unit score of 72 and above (Score AA) is acceptable and connotes freshness in egg (Card and Nesheim, 1972). It could be deduced from

Table IV. Effect of toasting, boiling and boiling-and-soaking as processing methods of castor oil seed meal on carcass characteristics and haematological indices of pullets. (Efecto del uso de semilla de ricino (CSM) tostada, hervida, y hervida y humedecida sobre las características de la canal e índices hematológicos de las aves).

	Control diet	Toasted	Boiled	Boiled- soaked	SEM
Dressed weight(kg)	1.12	0.84	1.05	1.07	0.02
Dressing percentage	59.76	51.09	57.59	58.23	1.06
Kidney (%)	0.71	0.65	0.71	0.68	0.01
Spleen (%)	0.11	0.15	0.13	0.13	0.01
Liver (%)	2.87 ^a	2.11 ^b	2.65 ^{ab}	2.77 ^{ab}	0.19
Pancreas (%)	0.39	0.51	0.44	0.40	0.08
Heart (%)	0.73	0.65	0.61	0.67	0.14
Lungs (%)	0.71	0.73	0.68	0.66	0.03
Hb(g/dl)	10.67 ^a	2.23 ^b	10.11 ^a	10.35 ^a	1.01
RBC(x103)	288.02 ^a	154.33 ^b	245.11 ^{ab}	251.54 ^{ab}	5.43
PCV (%)	39.12	35.77	36.08	31.31	2.77

Means on the same row with different superscript differ significantly ($p < 0.05$).

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the results that laying birds could tolerate complete replacement of soybean meal with processed castor oil seed meal without sacrificing freshness of egg.

Among the internal organs (**table IV**) only the liver was significantly ($p < 0.05$) affected by diet with toasted castor oil seed meal. Birds fed diet containing toasted CSM had a depressed liver weight when compared with birds on other diets. This confirms the claim that liver may be the primary target organ of anti-nutritional factor(s). It could be recalled that of all the three thermal treatments (**table II**), the ricin level was highest in the toasted sample.

Layers (**table IV**) on the toasted castor seed meal recorded significantly ($p < 0.05$) lower haemoglobin (Hb) and red blood cells (RBC). The control diet produced birds with higher Hb, RBC and PCV levels though not significantly different than birds on the

boiled and boiled-and-soaked CSM. The lower level of RBC and Hb on toasted CSM was expected because of the relative high level of ricin (**table II**) which is a form of hemagglutinin.

CONCLUSION

CSM either boiled for 40 minutes or boiled for 30 minutes followed by soaking for 48 hours can totally replace soybean meal in diets for laying hens without any detrimental effect on egg production, external and internal egg qualities. However, soaking after boiling did not add any advantage to boiling alone in any of the above parameters. In order to improve yolk coloration diet with CSM should be supplemented with pigmented materials. Complete replacement of soybean meal with 40 minutes boiled CSM in laying bird's diet as a feed ingredient would result in substantial cost savings.

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