Tropical Animal Health and Production, 32 (2000) 51–61

The Feeding of Leaf Meal of *Calliandra calothyrsus* to Laying Hens

R.T. Paterson*, R.L. Roothaert and E. Kiruiro
National Agroforestry Research Project, KARI Regional Research Centre, PO Box 27, Embu, Kenya
**Correspondence and present address: Natural Resources Institute (NRI), Central Avenue, Chatham Maritime, Kent, ME4 4TB, UK*

Paterson, R.T., Roothaert, R.L. and Kiruiro, E., 2000. The feeding of leaf meal of *Calliandra calothyrsus* to laying hens. *Tropical Animal Health and Production*, **32(1)**, 51–61

ABSTRACT

A 67-day feeding experiment was conducted to study the effects of inclusion of 5%, 7.5% or 10% leaf meal of *Calliandra calothyrsus* (calliandra) in the diets of laying hens on feed intake, egg production, egg weights, yolk colour and the birds' weights. While no significant effects were seen on either egg numbers or egg size, feed intake increased and the efficiency of feed utilization decreased with increasing inclusion of the foliage. Absolute initial and final body weights did not show significant treatment differences but live weight changes over the course of the experiments were statistically significant, weight gains decreasing with increasing calliandra levels. The strength of colour of the yolks increased within 3 days of offering the calliandra, irrespective of the level of inclusion. The persistence of the colour change after withdrawal of the leaf meal ranged from 3 days at the 5% inclusion to over 10 days at the 10% level. While it may be possible to include calliandra leaf meal in poultry rations along with other, local, low-cost components, there would appear to be little advantage in using it in conjunction with commercial layers meal at levels higher than those necessary to provide the desired pigmentation level in the yolks (5% or less).

Keywords: Calliandra calothyrsus, egg, leaf meal, nutrition, poultry

INTRODUCTION

In the rural areas of Kenya, the poultry industry is dominated by large numbers of small-scale producers. In recent times, with the liberalization of the economy, commercial feed prices have increased faster than the purchasing power of the general populace, resulting in a falling demand for poultry products. Because of this, some producers of both eggs and poultry meat have been unable to stay in business, while others have tried to reduce their costs by using less commercial feed. Although official statistics are lacking, both live and dressed chickens have become noticeably smaller and less plentiful in rural markets.

Until recently, feed producers tended to use yellow maize as the basis for commercial rations. Poor seasons in 1993 and 1994 led to large imports of maize for both human and animal consumption, much of which was white maize. The inclusion of this in layers' meal led to a marked deterioration in the colour of egg yolks. While there is no

price premium, consumers show a marked preference for strongly coloured egg yolks. Furthermore, there may be nutritional implications to yolk colour, since the level of pigmentation is correlated with the presence of vitamin precursors (CDA, 1977). It was suggested that the use of high-protein tree fodder in poultry rations might reduce feeding costs and provide sufficient pigment to make the eggs more attractive and nutritious for the consumers.

Calliandra calothyrsus (calliandra) grows well in the areas of high agricultural potential in East Africa, at altitudes of 1500–2000 m (e.g. O'Neill, 1995), where it is attracting attention as a source of protein for feeding to dairy cattle (Paterson *et al.*, 1996). Leaf meal of this species has been successfully incorporated at levels of 5% in poultry rations in Indonesia (NRC, 1983), where it proved useful as a source of dietary pigmentation for egg production (Tangendjaja *et al.*, 1992). It was therefore necessary to test the efficiency of the fodder source within local, small-scale production systems.

MATERIALS AND METHODS

The work was conducted in a small-scale, commercial battery operation located in a closed room without artificial lighting. It had a capacity of 160 birds, kept two to a cage in banks of five cages (10 birds), feeding from a communal feed trough. The smallest possible unit for feeding experiments was therefore the bank of five cages. The banks were arranged four to a stand, such that each stand could represent a complete replicate of four treatments.

The birds were routinely fed on a commercial layers meal with a nominal analysis of 12% moisture (maximum); 15% crude protein (minimum); 6% crude fibre (maximum); 2–6% crude fat; and 4% acid-insoluble ash (maximum). The calcium concentration was in the range 2.8–3.7%, with minimum levels of phosphorus and of copper, manganese and zinc of 0.4% and 5, 50 and 50 ppm, respectively. All the birds had permanent access to fresh water. A total of 12 banks arranged on three stands (120 birds) were used for the experiments, the remaining birds being held in reserve. The birds were Rhode Island Red hybrids that had hatched in July 1993. They were therefore old birds that had been laying for about 14 months (since February–March 1994) at the start of the work. They were slaughtered in December 1995, at the end of their productive lives. An initial, short-term observation trial was conducted to estimate the background variation between the banks and to determine the range of inclusion levels to be tested in the longer-term experiment to follow.

Initial trial

A single lot of a commercial layers' meal was used. The bags of meal were emptied and thoroughly mixed to ensure uniformity of the basal ration. The calliandra foliage was harvested as regrowth of 2–3 months from mature trees maintained as a hedgerow at the KARI Regional Research Centre, Embu. Calliandra grown under these conditions routinely has a crude protein content in excess of 25% (dry matter basis). The site

characteristics (O'Neill, 1995) were as follows: altitude 1480 m; annual rainfall in 1994–95, 1448 mm in two wet seasons; soils of humic nitisols with moderate to high fertility. Sufficient foliage was harvested at one time for the whole trial. It was air-dried in the shade to a moisture content of about 12%, when the leaflets readily fell from the petioles. The leaflets were passed through a laboratory mill to form a leaf meal. This was again thoroughly mixed. Four rations were then prepared, using the air-dry materials as follows: (1) control, 100% commercial meal; (2) 5% calliandra and 95% commercial meal; (3) 10% calliandra and 90% commercial meal; (4) 15% calliandra and 85% commercial meal. The feed was weighed into separate bags of 1.00 kg each for ease of handling and to prevent any possible separation of the components prior to feeding.

To determine the background differences between the three stands (12 banks) selected for the trial, the birds were all fed on the control diet for a period of 2 weeks (the uniformity period), during which the quantities of feed added and refused were recorded at the same time each day, together with egg production. No adaptation period was thought to be necessary, as this control ration was the same meal that the birds were used to consuming. At the conclusion of this period, the banks in each of the three stands were assigned at random to the four diets, resulting in three replicates of four treatments, arranged in a randomized block design. This preliminary trial ran for 2 weeks, after which all the birds returned to the commercial ration without calliandra. At the conclusion of each 2-week period, the weight of eggs produced from each bank was recorded for a single day and the eggs were randomly sampled for assessment of yolk colour by the use of a Roche yolk colour fan.

The experiment

The experiment started 2 weeks after the conclusion of the preliminary trial. As before, sufficient rations were prepared at one time to last for the whole of the planned experimental period. The sources of the basal ration and of the calliandra were as before, although, in view of the previous results, the inclusion levels of calliandra were changed to 0, 5%, 7.5% and 10% in treatments 1 to 4 respectively. The randomization of the treatments in each stand was also changed to minimize any possible cumulative effects of feeding calliandra. As before, the amounts of feed offered and refused and the numbers of eggs laid were recorded on a daily basis. Average egg weight and yolk colour were determined weekly, and the birds were weighed fortnightly. The experiment ran for 67 days.

The experiment consisted of three replicates of four treatments arranged in a randomized block design and the data were subjected to an analysis of variance. In the eighth week, one bird in each of the control, 7.5% and 10% calliandra treatments fell sick for reasons that could not be determined but which appeared to have nothing to do with the rations. They were humanely slaughtered to prevent suffering. For the remaining days of the experiment, the results from the affected banks were adjusted to account for the missing birds.

RESULTS

In the initial, uniformity period, the birds in the second of the three replicates consumed the most feed ($p < 0.05$), but this appeared to be related to physical position within the poultry house, rather than to treatment. Unlike the other two replicates, this stand of banks faced a wall without windows or doors. It might therefore have been less influenced by direct sunlight or by disturbance from humans by virtue of its location. The absence of production differences indicated acceptable uniformity between the banks. The feed consumed, eggs produced, feed efficiency (eggs per unit of feed) and egg size as determined in both the uniformity period and the preliminary trial are shown in Table I.

TABLE I
Preliminary studies. Daily feed intake (kg), egg production (number), feed efficiency (eggs/kg of feed) and average egg weight (g). Means over 3 banks of 10 chickens fed varying levels of dried leaf meal of *Calliandra calothyrsus* (calliandra)

	Uniformity period[a]		Trial period		
Week number	1	2	3	4	SED[b]
Feed consumed (kg/10 birds per day)					
Commercial meal	1.30	1.43	1.40	1.46	
5% calliandra	1.38	1.43	1.40	1.51	0.039
10% calliandra	1.36	1.48	1.43	1.46	
15% calliandra	1.39	1.45	1.40	1.47	
Eggs produced (total from 10 birds/day)					
Commercial meal	6.5	6.7	6.4	6.8	
5% calliandra	6.9	7.5	7.4	7.7	0.35
10% calliandra	7.0	7.1	6.4	6.1	
15% calliandra	6.4	7.4	6.8	5.9	
Eggs produced per kg of feed					
Commercial meal	4.97	4.94	5.10	4.62	
5% calliandra	4.69	5.23	4.75	5.11	0.347
10% calliandra	4.57	5.31	4.47	4.85	
15% calliandra	4.66	5.08	4.17	4.04	
Average egg weight (g)					
Commercial meal		62		66	
5% calliandra		70		67	3.1
10% calliandra		65		71	
15% calliandra		67		67	

[a]For a uniformity period of 2 weeks the birds were fed on their normal rations to determine existing background differences between banks. In weeks 3 and 4, the experimental rations were fed

[b]SED, standard error of the difference between treatment means within weeks

By the conclusion of the preliminary trial, the yolk colour from the controls was rated at 2 on the Roche yolk colour fan (an unattractive, pale yellow), while the yolks from the groups on the calliandra treatments were rated at 6 (yellow-orange), 10 (dark orange-yellow) and 12 (excessively deep orange) respectively for the 5%, 10% and 15% inclusion levels.

For the main experiment, the weekly data for feed consumption, egg production, feed efficiency and egg weights, and fortnighly bird weights are shown graphically in Figures 1–5, while the averages over the whole of the experiment are presented in Table II.

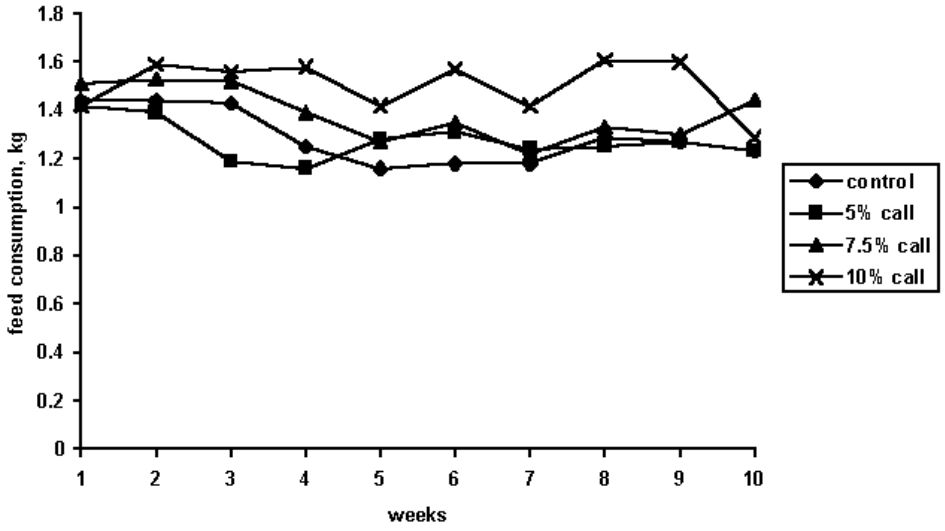

Figure 1. Daily feed consumption (kg) per bank of 10 birds (averaged over one week)

A pre-experiment average yolk colour rating of 3.3 on the Roche colour fan increased to 4.3 after one week of feeding the control diet, a difference that is probably due to chance variation between feed batches. By this time, the ratings had increased to 7.7, 9.7 and 10.3 for the 5%, 7.5% and 10% calliandra treatments, respectively. After 2 weeks of feeding, the colours stabilized at 9.0, 9.0 and 11.0, respectively for the three calliandra treatments.

At the conclusion of the experiment, the birds returned to the ration that they had been eating before it started. The yolk colour ratings of the eggs from the birds on the calliandra treatments fell steadily after withdrawal of the tree leaf meal, reaching the value for the controls (average 3.3 on the Roche colour fan), within 3, 10 and 14 days for the 5%, 7.5% and 10% calliandra treatments, respectively.

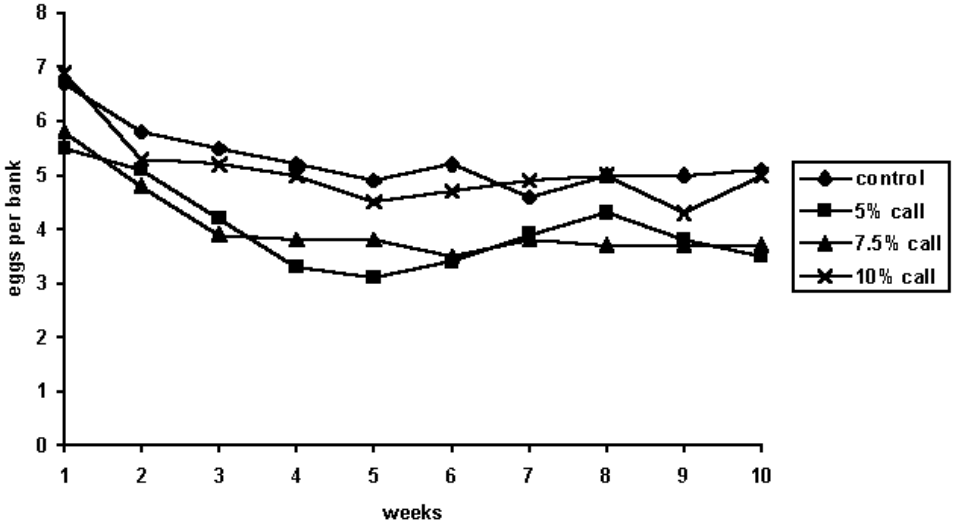

Figure 2. Daily egg yield per bank of 10 birds (averaged over one week)

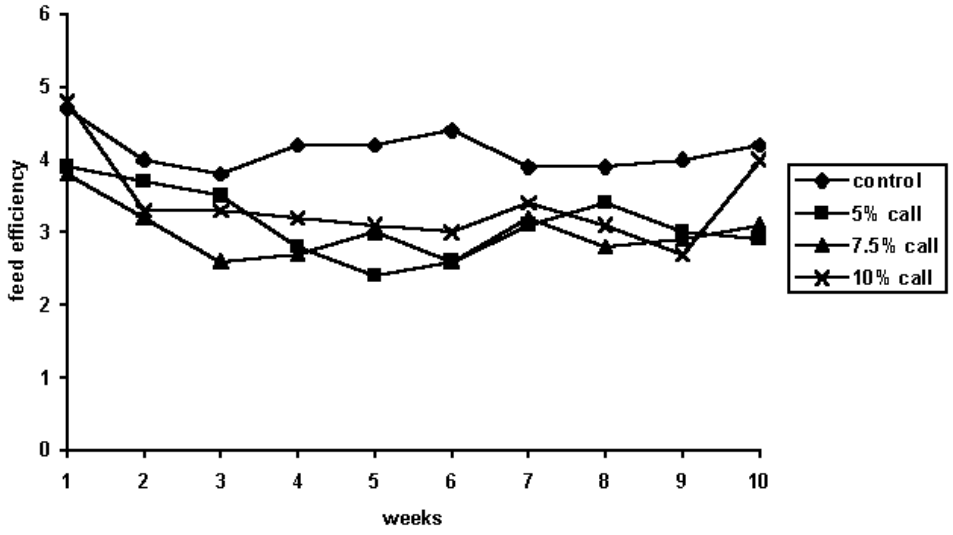

Figure 3. Weekly feed efficiency (eggs/kg of feed consumed)

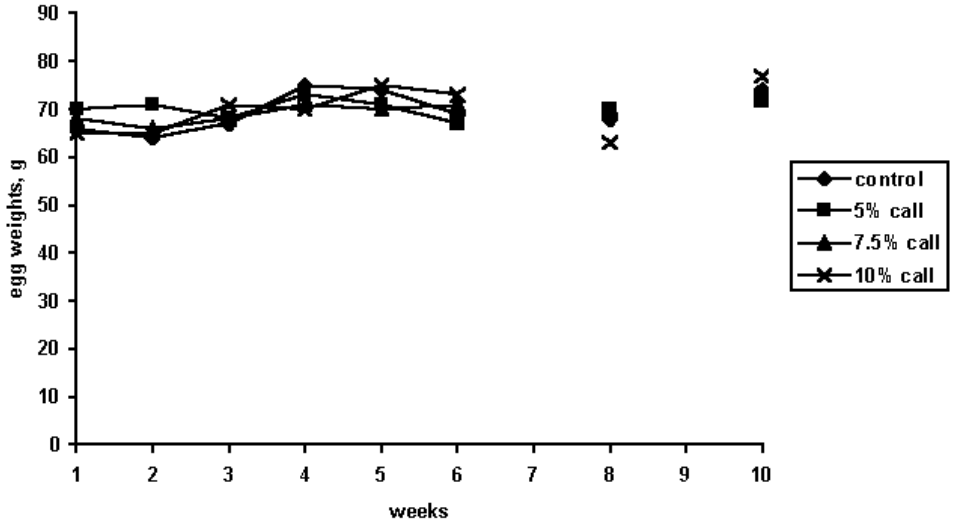

Figure 4. Average egg weights (g), sampled weekly. Note: data not presented in weeks 7 and 9 owing to incomplete sampling

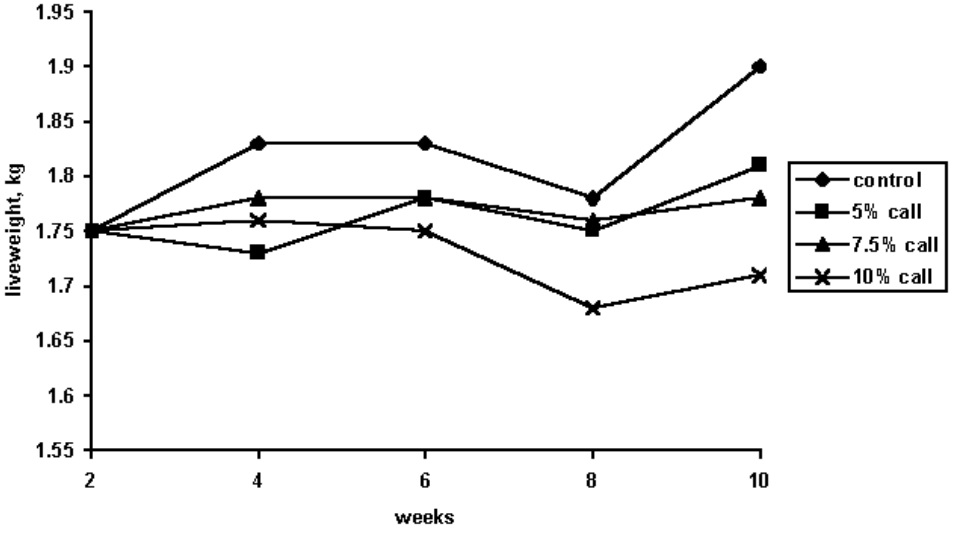

Figure 5. Average bird live weights (kg) from weighing at fortnightly intervals

TABLE II
Main experiment. Daily feed intake (kg), egg production (number), feed efficiency (eggs/kg of feed), average egg weight (g) and overall average live weight changes (g). Means over 67 days from 3 banks of 10 chickens fed varying levels of dried calliandra leaf meal

Parameter	Control, no Call.	5% Call.	7.5% Call.	10% Call.	SED	CV (%)
Feed consumed, kg/10 birds/day	1.29	1.27	1.39	1.51	0.025	7.2
Eggs produced, total from 10 birds/day	5.5	4.1	4.2	5.2	0.19	15.6
Eggs produced per kg of feed consumed	4.24	3.20	3.01	3.51	0.141	16.0
Average egg weight (g)	69.8	70.3	69.4	69.8	1.67	8.3
Average live weight changes (g/bird)	143	53	23	–37	55.2	NA

Call., *Calliandra calothyrsus* leaf meal; SED, standard error of the difference between means; CV, coefficient of variation; NA, not applicable (CV is not a valid parameter where changes can be either positive or negative)

DISCUSSION

During the preliminary trial, there were no significant feed intake differences between the treatments. In terms of egg production, the 5% calliandra treatment appeared to give a slight increase in egg yield in comparison with the control, while 15% calliandra reduced the daily egg numbers, particularly during the second week ($p < 0.05$). Where efficiency of production was concerned, the high-calliandra treatment produced about one egg per unit of feed less than the 5% treatment ($p < 0.05$). The different diets had no significant effect on egg size. For all measured parameters, the coefficients of variation were uniformly low, falling between 4.8% and 9.0%.

The results using 5% or 10% calliandra appeared promising over the short-term. In view of the adverse effect of the high-calliandra (15%) treatment on both egg yield and yolk colour, the preliminary trial was terminated at this time, to minimize the financial losses by the commercial producer.

By the second week of calliandra feeding in the longer-term, main experiment, feed consumption in the high-calliandra (10%) treatment had increased by some 10–15% ($p < 0.01$) with respect to the control and this differential was maintained, or even increased, until the final week of the experiment (Figure 1). The average consumption by the birds in the 5% calliandra group was similar to that of the control, while the

7.5% group was intermediate (Table II). The feed intake of laying hens is inversely related to the energy content of the diet (Smith, 1990). Calliandra meal has a relatively high fibre content (Kaitho *et al.*, 1993), so increased inclusion of the leaf matter will reduce the digestible energy content of the diet, leading to a corresponding increase in feed intake.

Egg production fell in all treatments until the fifth week (Figure 2). Averaged over the whole of the period, egg production per bird was significantly lower in the 5% and 7.5% treatments than it was in the others (Table II).

The greatest effect was seen in feed efficiency (Figure 3). While the control remained above 4 eggs/kg of feed, except for a short period during the month of August (weeks 3–6) when maximum and minimum daily temperatures were only about 18–20°C and 10–14°C, respectively (Meteorological Department, Embu station), the two intermediate calliandra treatments were reduced to just below 3 eggs/kg at this time. The overall effect was highly significant (Table II). Egg production is adversely affected by both high and low ambient temperatures (e.g. CDA, 1977). A drop in both egg production and feed efficiency occurred when a range of tree leaf meals was fed to laying hens at levels of up to 20% of dietary dry matter (D'Mello, 1995). The reduction in egg production caused by the inclusion of *Leucaena leucocephala* in the diet was greater at 10°C than at 22°C (Vohra *et al.*, 1972), so there may have been a temperature × diet interaction during the coolest period in the present study.

Live weights (Figure 5) fell on the high-calliandra diet, particularly in the second month of feeding, resulting in small, but statistically significant, weight changes when measured over the duration of the experiment. The absence of a clear reduction in either egg size (Figure 4) or number (Figure 2) accompanying these weight changes suggests that body reserves were mobilized to maintain egg production. These trends are consistent with those found in the feeding of leaf meals from *L. leucocephala* and *Gliricidia sepium* to laying hens (D'Mello, 1995).

In terms of production and feed cost, the results were not encouraging. The total feed consumption of the birds increased so that roughly the same amount of commercial feed was consumed, irrespective of the level of inclusion of calliandra. With no increase in either egg yield or size, and a slight depression in terms of body weight, there was no economic advantage to be gained from diluting the purchased feed with home-grown leaf meal, even though its high crude protein content (about 25%) might have been expected to increase productivity. The known, high levels of condensed tannins in the fodder (e.g. Kaitho *et al.*, 1993) may have reduced utilization, but D'Mello (1995) postulated that the poor digestibility and availability of nutrients resulting from the presence of a component with a high fibre content could explain the poor performance of poultry fed on leguminous leaf meals.

The colour of egg yolks is highly dependent on the content of pigment precursors in the feed (e.g. Smith, 1990). Calliandra was a ready and efficient source of pigment for egg yolks in Indonesia (Susana *et al.*, 1992; Tangendjaja *et al.*, 1992), where dietary inclusion levels of only 2% resulted in a desirable yolk colour. In commercial egg production, when the bulk of the ration is composed of purchased layers' meal, the only advantage from also feeding calliandra to laying hens would lie in its use as a source of pigment. In view of the persistence of the colour in egg yolks, it seems likely

that feeding either low levels of calliandra on a daily basis, or perhaps higher levels two or three times per week, would have the same effect.

Nevertheless, in view of the acceptability of the tree fodder and the lack of any obvious toxic effects over a period of almost 10 weeks, it might be possible to formulate low-cost poultry diets to utilize the high crude protein content of calliandra meal in conjunction with alternative sources of energy. However, as the tannins in the tree fodder might depress the digestibility of both protein and organic matter in the whole diet, further work is needed to evaluate calliandra in local diets for laying hens.

ACKNOWLEDGEMENTS

The active collaboration of the farm manager and staff at Don Bosco Technical Secondary School (Boys), Embu, Kenya; the technical assistance of Mr N. Murithi of KARI; and the support of the Director, KARI Regional Research Centre, Embu, are gratefully acknowledged. Statistical advice was provided by Richard Coe (ICRAF). The work was part of the activities financed by the Overseas Development Administration (ODA, now DFID) of the British Government through a project entitled 'Development and on-farm evaluation of agroforestry feeding systems'.

REFERENCES

CDA, 1977. *Eggs and Egg Products*, Publication 1498, revised 1977 by H.L. Orr and D.B. Murray (Canada Department of Agriculture (CDA), Ottawa)

D'Mello, J.P.F., 1995. Leguminous leaf meals in non-ruminant nutrition. In: J.P.F. D'Mello and C. Devendra (eds), *Tropical Legumes in Animal Nutrition*, (CAB International, Wallingford, UK)

Kaitho, R.J., Tamminga, S. and Bruchem, J., 1993. Rumen degradation and *in-vivo* digestibility of dried *Calliandra calothyrsus* leaves. *Animal Feed Science and Technology*, **43**, 19–30

NRC, 1983. *Calliandra: A Versatile Small Tree for the Humid Tropics*, (National Academy Press, Washington DC)

O'Neill, M. (compiler), 1995. *National Agroforestry Research Project KARI Regional Research Centre Embu Annual Report: March 1994–March 1995*, (AFRENA Report No. 92, International Centre for Research in Agroforestry (ICRAF), Nairobi)

Paterson, R.T., Roothaert, R.L., Nyaata, O.Z., Akyeampong, E. and Hove, L., 1996. Experience with *Calliandra calothyrsus* as a feed for livestock in Africa. In: Evans, D.O. (ed.), *International Workshop on the Genus Calliandra*, Proceedings of a workshop held in Bogor, Indonesia. *Forest Farm and Community Tree Research Reports* (Special Issue), (Winrock International, Morrilton, Arkansas, USA), 195–209

Smith, A.J., 1990. *Poultry*, (The Tropical Agriculturalist Series. Macmillan, London, in cooperation with Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen)

Susana, I.W.R., Tangendjaja, B. and Wina, E., 1992. Pemanfaatan pigmen dari sumber alami: teknologi pembuatan aditif pigmen dan penyimpanannya [Use of pigment from natural sources: technology of manufacture and storage of additive pigment]. *Proceedings of a Conference on Livestock Agro-industry in Rural Areas, Bogor, Indonesia, 1992*, (Balai Penelitian Ternak, Indonesia), 569–575

Tangendjaja, B., Wina, E., Ibrahim, T. and Palmer, B., 1992. *Kaliandra (Calliandra calothyrsus) dan Pemanfaatannya [Calliandra and its Uses]* (Balai Penelitian Ternak, Indonesia, and the Australian Centre for International Agricultural Research (ACIAR))

Vohra, P., Herrick, R.B., Wilson, W.O. and Siopes, T.D., 1972. The use of ipil-ipil (*Leucaena leucocephala*) in the diets of laying chickens and laying quail. *The Philippine Agriculturalist*, **56**, 104–113

(Accepted: 4 March 1999)

Etude de l'alimentation de poules pondeuses avec des feuilles de *Calliandra calothyrsus*

Résumé – Une expérience fut menee pendant 67 jours en insérant 5; 7,7 ou 10% de feuilles de *Calliandra calothyrsus* dans l'alimentation de poules pondeuses pour établir son impact sur la prise de nourriture, la production d'oeufs, le poids des oeufs, la couleur du jaune et le poids des poules. Les résultats ne montrèrent aucun changement dans le nombre des oeufs ou leur taille, mais en revanche une augmentation de la prise de nourriture et une réduction de l'efficacité de la nourritre furent aussi observées. Il n'eut pas de variation entre les poids initiaux et finaux des animaux mais cependant les variations des poids au cours de l'expérience furent statistiquement différents; les gains de poids diminuant avec l'augmentation de l'apport en *C. calothyrsus*.

La couleur du jaune devint plus intense après 3 jours, quelque soit le taux de remplacement dans la nourriture. La couleur persista pendant 3 jours après l'arrêt de l'apport en *C. calothyrsus* à 5% et persista pendant 10 jours pour un remplacement à 10%. Bien que *C. calothyrsus* peut être introduite dans l'alimentation des poules avec d'autres repas commerciaux, les teneurs ne devraient pas dépasser 5% pour obtenir la coloration du jaune désirée.

La alimentación con hojas de *Calliandra calothyrsus* de gallinas ponedoras

Resumen – Se llevó a cabo un experimento de alimentación durante 67 días para estudiar los efectos de la inclusión de hojas de *Calliandra calothyrsus* (calliandra), en proporciones del 5, 7,7 o 10% en las dietas de gallinas ponedoras, sobre el volumen de ingestión, la producción de huevos, el peso de los huevos, el color de la yema y el peso de las aves. No se observó efecto sobre el número ni el tamaño de los huevos, sin embargó sí que se observó un incremento de la ingestión y una disminución de la eficiencia de utilización del alimento a medida que aumentaba la proporción de calliandra incluida. No se observaron diferencias entre tratamientos en los pesos inicial y final, pero la tasa de crecimiento fue estadísticamente menor cuanto mayor era la proporción de calliandra. La intensidad del color de la yema del huevo aumentó en sólo tres días de administrar calliandra, independientemente del nivel de ésta. La persistencia del color cambió tras la retirada de la calliandra en la dieta, siendo de tres días en las dietas al 5% y de hasta 10 días en las dietas al 10%. Sería posible incluir hojas de calliandra en la dieta de las aves junto con otros componentes locales de bajo coste, sin embargo, parece tener pocas ventajas cuando se utiliza incluida en dietas comerciales de ponedoras a niveles superiores a aquellos necesarios para conseguir la pigmentación deseada de la yema (5% o menos).