**Utilization of mulberry leaf meal (Morus alba) as protein supplement in diets for laying hens**

Riyadh Al-kirshi,1 Abdal Razak Alimon,1,2 Idrus Zulkifli,1 Awis Sazili,1,3 Mohamed Wan Zahari,4 Michel Ivan2
1Department of Animal Science, University Putra Malaysia, Serdang, Selangor, Malaysia
2Institute of Tropical Agriculture, University Putra Malaysia, Serdang, Malaysia
3Institute of Halal Products Research, University Putra Malaysia, Serdang, Malaysia
4Division of Livestock Production, MARDI Serdang, Selangor, Malaysia

**Abstract**

A 12-week feeding experiment was conducted to study the effects of inclusion of 0 (control; Diet A), 10% (Diet B), 15% (Diet C) and 20% (Diet D) of mulberry leaf meal (Morus alba) in the diet on production performance and egg quality of laying hens. Feeding mulberry leaf meal (MLM) reduced (P<0.05) the feed intake, egg production, egg weight and egg mass. However, feed conversion ratio was not affected (P>0.05). Shell weight and yolk weight were decreased (P<0.01), but shell thickness and albumen weight were not affected (P>0.05). Haugh units increased (P<0.001) as the level of MLM increased. Also, feeding MLM improved phosphorus, iron and calcium (Ca) in egg mass. Yolk color was measured using ColorFlex (Model CFLX-45/0 Hunter Associates Laboratories (HunterLab), Inc. Reston, Virginia, USA) that recorded 3 color coordinates (lightness L*, redness a* and yellowness b*) according to the CIE (1976) color system.

**Materials and methods**

Leaves from mulberry shrubs at four weeks re-growth were collected, stripped of their branches and sun-dried with frequent turning for 4-5 days. The sun-dried mulberry leaves were then hammer-milled to pass a 1 mm screen, and kept for future use in airtight plastic bags. Proximate analyses were carried out on the sun-dried mulberry leaf samples to determine: dry matter (DM), crude protein (CP), ether extract (EE), ash, crude fibre and calcium Ca) using standardized procedures of the Association of Official Analytical Chemists (AOAC, 1995). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) were analyzed according to Van Soest and Wine, (1967). Phosphorus (P) was determined according to Thomas et al. (1967). The chemical composition (% DM) of mulberry leaves at four weeks of age used in the present experiment is presented in Table 1.

One hundred and forty 26-week old Isa-Brown laying hens were obtained from a local commercial company and randomly transferred to individual wire cages (26 cm width x 46 cm length x 28 cm height). The cages were equipped with nipple drinkers and open trough feeders for each replicate. The birds were randomly allocated to four dietary treatments such that each treatment was replicated five times with 7 birds in each replicate. The diets (Table 2) were based on maize and soybean meal, and were formulated to meet the requirement of layers (NRC, 1994) with inclusion of mulberry leaf meal (MLM) at 0 (control; Diet A), 10% (Diet B), 15% (Diet C) and 20% (Diet D).

All diets were fed ad libitum in mash form to the laying hens during a 12-week experiment. Feed intake was recorded weekly, while egg production was recorded daily. Egg weight was determined weekly by weighing all collected eggs by replicate. Egg quality parameters were determined on four randomly selected eggs from each replicate at the end of each week (20 eggs per treatment per week). Feed conversion ratio (FCR) was calculated as g feed consumption per day per hen divided by egg mass per day per hen. Egg mass was calculated by multiplying egg weight by egg production. Haugh unit was determined according to Neshem et al. (1979). Yolk color was measured using ColorFlex (Model CFLX-45/0 Hunter Associates Laboratories (HunterLab), Inc. Reston, Virginia, USA) that recorded 3 color coordinates (lightness L*, redness a* and yellowness b*) according to the CIE (1976) color system.

**Statistical analysis**

Data were subjected to analysis of variance. Significant differences among treatments were determined by Duncan’s multiple-range test using SPSS (2006).
**Results and discussion**

Results demonstrated that increasing the MLM levels affected (P<0.05) laying hens’ performance (Table 3). Egg production was reduced from 90.7% to 79.8% as the MLM increased from 0 to 20%. The group fed 10% MLM did not differ (P>0.05) from the control as for egg production (89.2% vs. 90.7%). Feed intake, egg mass and egg weight were reduced (P<0.01) by the increased level of MLM. A decrease in feed intake as the level of mulberry increased may be due to both physical characteristics (semi-powdery nature and bulkiness) and unpalatable taste, which may affect the appetite of the birds. The present results are in agreement with Ravindran (1986), Lopez (1989), Udedibie (1998), Odunsi (2003) and Akande et al. (2007) who reported a reduction in feed intake with increased dietary leaf meals in the diets for broilers and laying hens. Increasing the fibre level from 3.04% to 5.80% by inclusion of 20% mulberry (Diet D) might be responsible for insufficient digestibility of nutrients, particularly protein and energy. This probably resulted in decreased (P<0.05) egg production and egg weight. Feed conversion ratio, however, was not affected by dietary treatments. Data with respect to egg quality (Table 4) indicated that only Haugh units were influenced by MLM levels. It was 91.1 in the group fed control diet (A). This is in agreement with the results of Machii (2000) and Narayana and Al-kirshi et al. (2007) who reported a reduction in egg quality with increased MLM. Birds fed diets containing MLM tended to produce eggs yolk with lower L* scores and the differences were significant at weeks 32 and 38 (Table 5).

The addition of MLM to the diets produced higher redness a* and yellowness b* values. This observation is in close agreement with the results of Machii (2000) and Narayana and Al-kirshi et al. (2007).

### Table 2. The ingredient and chemical composition of experimental diets.

| Ingredient         | Diet | Egg production, % | Feed intake, g/egg/day | Egg weight, g/egg | Egg mass, g/egg/day | Feed conversion ratio, g feed/g egg |
|--------------------|------|-------------------|------------------------|------------------|---------------------|-----------------------------------|
| Maize, %           | A    | 63.80             | 60.30                  | 58.30            | 57.00               |
| Soybean meal, %    | B    | 22.01             | 15.20                  | 12.00            | 8.60                |
| Mulberry, %        | C    | 10.00             | 15.00                  | 20.00            |
| Limestone, %       | D    | 7.90              | 7.43                   | 7.33             | 6.83                |
| Ash, %             |      |                   |                       |                  |                     |
| Crude fibre, %     |      |                   |                       |                  |                     |
| Neutral detergent fibre, % |      |                   |                       |                  |                     |
| Acid detergent fibre, % |      |                   |                       |                  |                     |
| Calcium, %         |      |                   |                       |                  |                     |
| Phosphorus, %      |      |                   |                       |                  |                     |
| Gross energy, MJ/kg|      | 17.60             |                       |                  |                     |
| Metabolized energy, MJ/kg |      | 7.60              |                       |                  |                     |

The values are the means of three samples.

### Table 3. Effects of mulberry leaf meal on laying performance (26 to 38 weeks of age).

| Diet | Egg production, % | Feed intake, g/egg/day | Egg weight, g/egg | Egg mass, g/egg/day | Feed conversion ratio, g feed/g egg |
|------|-------------------|------------------------|------------------|---------------------|-----------------------------------|
| A    | 90.7a             | 114.2a                 | 60.1a            | 54.6a               | 2.08                              |
| B    | 89.2b             | 112.8b                 | 60.4b            | 53.9b               | 2.09                              |
| C    | 88.5c             | 108.3c                 | 59.8c            | 52.5c               | 2.05                              |
| D    | 79.8d             | 97.3d                  | 58.4d            | 46.9d               | 2.06                              |

SEM 0.7 0.3 0.5 0.02

Level of significance ** ** *** ns

*Supplied per kg diet: Fe, 35mg; Mn, 70 mg; Cu, 8 mg; Zn, 70 mg; I, 1 mg; Se, 0.25 mg; Cr, 0.25 mg; copper-D-pantothenate, 8 mg; D- histic acid, 0.045 mg; vitamin C, 50 mg; vitamin A, 8000 U; vitamin D3, 100,000 U; vitamin E, 30 U; vitamin K3, 2.5 mg; vitamin B1, 4 mg; vitamin B12, 2 mg; vitamin B6, 0.01 mg; niacin, 30 mg.

### Table 4. Effect of mulberry leaf meal on egg quality.

| Diet | Haugh units | Shell thickness, mm | Shell weight, g | Yolk weight, g | Albumen weight, g |
|------|-------------|---------------------|-----------------|---------------|------------------|
| A    | 76.7e       | 0.307               | 6.52e           | 14.6e         | 34.3             |
| B    | 85.3f       | 0.306               | 6.48f           | 14.7f         | 34.3             |
| C    | 88.3gh      | 0.306               | 6.33gh          | 14.7g         | 34.4             |
| D    | 91.1j       | 0.305               | 6.09j           | 14.4j         | 34.1             |

SEM 0.60 0.00 0.05 0.00

Level of significance *** ns ** ** ns

*Means within column with different superscripts are statistically different (P<0.05). ns: Statistically not significant (P>0.05).

*Statistically significant (P<0.05). **Statistically significant (P<0.01). ***Statistically significant (P<0.001). Means represent five replicates, seven birds per replicate.
Table 5. Effect of mulberry leaf meal on egg yolk colour.

| Age  | Diet | L*  | a*  | b*  | SEM | Level of significance |
|------|------|-----|-----|-----|-----|-----------------------|
| 26 weeks | A   | 68.7 | 10.7 | 76.3 | 0.1 | ns |
|       | B   | 68.7 | 10.7 | 76.2 | 0.1 | ns |
|       | C   | 68.4 | 10.4 | 76.9 | 0.1 | ns |
|       | D   | 68.6 | 10.4 | 76.5 | 0.1 | ns |
| 32 weeks | L*  | 67.8a | 12.3d | 77.6a | 0.2 | *** |
|       | a*  | 67.4b | 15.2a | 80.9b | 0.6 | *** |
|       | b*  | 67.2b | 16.1b | 82.1b | 1.1 | *** |
| 38 weeks | L*  | 67.6d | 12.1c | 77.5c | 0.5 | *** |
|       | a*  | 64.7c | 17.54b | 87.4c | 0.8 | *** |
|       | b*  | 63.5b | 17.8b | 88.3ab | 1.2 | *** |

Conclusions

The use of MLM for laying hens is possible by up to 10% without adversely affecting egg production and egg quality. Furthermore, MLM may contribute to the pigmentation of egg yolk and make the eggs more attractive to the consumer.

References

Akande, T.O., Adeyeri, M.K. Longe, O.G., Odunsi, A.A., 2007. Response of laying chickens to graded levels of Tephrosia bracteolate leaf meal fed with soybean meal or full fat soybean meal. Livestock Research for Rural Development 19:189.108.

Association of Official Analytical Chemists, 1995. Official Methods of Analysis of the Association of Official Analytical Chemists. 15th ed., Washington, DC, USA.

Commission Internationale de l’Eclairage, 1976. International Commission on Illumination, Colorimetry: Official recommendations. CIE Publ. No. 15 (E-1.3.1), Paris, France.

Moller, A.P., Biard, C., Blount, J.D., Houston, D.C., Moller, A.P., Biard, C., Blount, J.D., Houston, D.C., 2000. Evaluation and utilization of mulberry leaves (Morus alba) diets by growing goats. Trop. Grasslands 33:177-181.

Udedibie, A.B.I., 1987. Comparative evaluation of mulberry leaves (Morus alba) diets by growing goats. Trop. Grasslands 33:177-181.

Udedibie, A.B.I., Opara, C.C., 1998. Responses of laying hens to graded levels of Tephrosia bracteolate leaf meal as a feed ingredient and yolk colouring agent on the diet of layers. Int. J. Poultry Sci. 2:71-74.

Omar, S.S., Shayo, C.M., Uden, P., 1999. Voluntary intake and digestibility of mulberry (Morus alba) diets by growing goats. Trop. Grasslands 33:177-181.

Oviedo, F.J., Benavides, J.E., Vallejo, M., 1994. Evaluacion bioeconomico de un modulo agroforestal cencabrac en el tropico humedo. In: J.E. Benavides (ed.) Arboles arbostr forrajeros en America Central. Volumen I. CATIE, Turrialba, Costa Rica, pp 601-629.

Ravindran, V., Komneng, E.T., Rajaguru, A.S.B., Potter, L.M., Cherry, J.A., 1986. Cassava leaf meal as a replacement for coconut oil meal in broiler diets. Poultry Sci. 65:1720-1727.

Sanchez, M.D., 2000. Mulberry for animal production. FAO Anim. Prod. and Health Series No. 147, Roma, Italy.

Srivastava, S., Kapoor R., Thathola A., Srivastava R.P., 2006. Nutritional quality of leaves of some genotypes of mulberry (Morus alba). Int. J. Food Sci. Nutr. 57:305-313.

SPSS, 2006. Statistical Package for Social Scientists. Version 14.0. SPSS Inc., Chicago, IL, USA.

Thomas, R.L., Shepard, R.W., Moyer, J.R., 1967. Comparison of conventional and automated procedures for nitrogen, phosphorus and potassium analysis of plant material using a single digestion. Agron. J. 59:240-243.

Trigueros, R.O., Villalta, P., 1997. Evaluacion del uso de foliages deshidratado de morera (Morus alba) en alimentacion de cerdos de la raza landrace en etapa de engorde. In: Resultados de Investigacion, National Center of Agriculture, Livestock and Forestry Technology (CENTA) ed., San Salvador, El Salvador, pp 150-155.

Udedibie, A.B.I., 1987. Comparative evaluation of leaf meals of paw-paw (C. papaya), swordbean (C. gladiata), jackbean (C. ensiformis) and pigeon pea (C. cajan) as feed ingredients and egg yolk colouring agents in layers’ diets. Nigerian Journal of Animal Production 14:61-66.

Udedibie, A.B.I., Opara, C.C., 1998. Responses of growing broilers and laying hens to the dietary inclusion of leaf meal from Alchornea cordifolia. Anim. Feed. Sci. Tech. 71:157-164.

Van Soest, P.J., Wine, R.H., 1967. Use of detergents in the analysis of fibrous feeds. IV. Procedures for nitrogen, phosphorus and potassium analysis of plant material using a single digestion. Agron. J. 59:240-243.

Omar, S.S., Shayo, C.M., Uden, P., 1999. Voluntary intake and digestibility of mulberry (Morus alba) diets by growing goats. Trop. Grasslands 33:177-181.